Road safety at pedestrian refuges

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Introduction. Pedestrian refuges—'Double D'-shaped traffic islands in the centre of the road, illuminated by bollards—have been extensively used for channelisation, control of traffic movement, improving the conspicuity of junctions, assisting pedestrians crossing the road, etc. This paper is based on the results of a technical study into the before-and-after personal-injury accident situation at sites in London where refuges had been installed. It must be stressed that not all the sites were treated specifically on safety grounds.

It is not, however, within the scope of this paper to include discussion on the various types of refuge/bollard constructions used, nor on the damage severity of vehicles in collision with such refuges or bollards. It is recognised that pedestrian refuges could have been used in conjunction with other street furniture and traffic management measures, and this is indicated in the paper where necessary. It is hoped that the paper will promote optimisation of the use of pedestrian refuges in various types of situation at a time when installation costs of such items of street furniture are rising rapidly.

Background

During 1974, the before-and-after accident situation at sites where pedestrian refuges had been used were investigated. It was found that the types of sites varied considerably, as did the role of the refuges. A large sample of sites was required so that sufficient sites of each type could be investigated, with the aim of highlighting the effect of various features of the role of the refuges which may have had an important effect on accidents. The London Boroughs, on request, provided details of sites which they considered suitable for the study and these have been included. Five studies were undertaken:

Study 1. Eleven uncontrolled* crossroad junctions where pairs of refuges were placed in the side road, with GIVE WAY signs to highlight the presence of an uncontrolled junction (these sites having a record of accidents involving vehicles approaching the junction on different roads).

Study 2. Sixty-two uncontrolled junctions where refuges were installed, not specifically as accident prevention measures but to assist pedestrians, channelise traffic or control traffic movement.

Study 3. Twenty-three sites where single refuges were installed on stretches of road not near junctions, for conditions similar to those cited for Study 2.

Study 4. Five sites where a series of three or more refuges were installed along a stretch of road (37 refuges in total), mainly for channelisation of two-way traffic.

Study 5. Nineteen existing Zebra crossings where pedestrian refuges were subsequently introduced. Not all the refuges were introduced because of a bad pedestrian accident problem at the crossings.

Description of study

Selection of sites. Most sites where refuges had been installed in the GLC area between January 1970 and June 1975 were included in the study. Sites were excluded if there had been major redesigning of the road involved which may have affected traffic flows or where such redesigning would have obscured the contribution the refuge made to the accident situation. Sites with before-and-after periods of less than five months were excluded from the study. No discrimination was made between sites where the refuge had been installed to prevent accidents or to improve channelisation, etc.

Time period limitations. Suitable accident data in the GLC Accident Statistics System were limited to the period January 1970 to December 1975. Seasonal variations were reduced by using data for exactly similar before-and-after calender periods, i.e. if a refuge was installed in August 1971 the 'before' data relate to the period January 1970 to August 1971 and the 'after' data to the period January 1972 to August 1973. Accident data at each site were therefore limited by proximity of the implementation date to the data limits, i.e. January 1970 or May 1975, and this limitation on the length of the before-and-after period meant that the maximum amount of data available for each site could not always be used.

Site data. Site visits were conducted to establish information about the following items at each site:

(*a*) Exact location of refuge.
(*b*) Type of site, i.e. crossroad junction, T-junction, etc.
(*c*) Number of refuges used.
(*d*) GIVE WAY signs.
(*e*) Hatch markings.
(*f*) Refuge indicator beacon.
(*g*) Type of bollard (bollards are usually constructed so that they have illuminated panels, but alternative fully-illuminated bollards made of a translucent plastic material which are illuminated in their entirety were also noted at some sites).
(*h*) Anti-skid surfacing.
(*i*) Guardrailing.
(*j*) Bus lanes.

Analysis of accidents

Selection of relevant accidents. The area selected to contain accidents of interest was defined as that being within 50 m of the refuge (in the case of an uncontrolled junction, the area constituting the junction and 50 m along each arm of the junction). A 1:1250 scale map, with the study area clearly defined, was used to assist in the precise selection and location of relevant accidents. The grid references provided for each accident by the computer accident print-out were used as a rough guide to locate the accidents on the 1:1250 scale maps. Precise locations were established by the 'inclear' locations provided by the Metropolitan Police accident report (i.e. locations defined in clear English using road names and measured distances from junctions or well-known landmarks, e.g. Honor Oak Road 50 m west of Devonshire Road).

Personal-injury accidents were broken down into the following main categories:

(*a*) All pedestrian accidents:
  (*i*) within 50 m of or at refuge;
  (*ii*) at refuge or up to 20 m from refuge; and
  (*iii*) 20 to 50 m from the refuge.
(*b*) Vehicle accidents including subdivisions for single vehicle, nose-to-tail, crossroad type, head-on and parked vehicle accidents.
(*c*) Accidents to public service vehicle passengers.
(*d*) Fatal and serious accidents.
(*e*) Accidents occurring in wet and dark conditions.

* 'Uncontrolled' signifies the absence of signals, roundabouts or traffic control personnel. GIVE WAY signs and markings of some kind would have been present.

Table I.

Prevailing conditions		Study 1	Study 2	Study 3	Study 4	Study 5
Anti-skid surfacing	(AS)	1	1	1	—	2
Guardrail	(GR)	—	2	3	—	—
Refuge indicator beacon	(IB)	3	51	17	5	4
Fully-illuminated bollard	(FI)	1	11	11	1	—
Bus lane	(BL)	—	1	1	—	—
Hatch markings	(HM)	4	33	7	1	—
Side road refuges	(SR)	9	10	—	—	—
Pedestrian generators	(PG)	3	15	9	1	5
Pairs of refuges	(PR)	8	15	—	—	—
GIVE WAY signs on side-road	(GW)	9	[illegible]	—	—	—
Refuges for channelisation	(CH)	0	8	—	—	—
Total number of sites in study		11	62	23	5	19

Types of sites. Different conditions prevailed at each site under consideration and the number of sites affected by each particular condition is given in Table I. Types of sites included in each table of results (Tables II to X) are listed at the top of each table of results using the abbbreviations in brackets in Table I.

Accident data tabulation. To evaluate the important effects of the various types of sites and the varying role of the refuge, those sites with a distinguishing feature in common, such as hatch markings, were grouped together and the results tabulated for each group. Some of the more interesting findings are included in the 'Results' section below.

Statistical tests. There is some difficulty in attempting to combine accident data from several different test sites, when the before-and-after periods are not the same in each case. The method of analysis used in this study is based on a method devised by Tanner[1] which provides a means of combining accident data from several test sites. This method has been adapted for computational analysis, but has some residual difficulties which have not yet been fully resolved. The types of accidents tested for significance were limited to the following:

(*a*) all pedestrian accidents within 50 m of or at refuge;
(*b*) all vehicle accidents within 50 m of or at refuges; and
(*c*) all accidents within 50 m of or at junctions.

The levels of significance are interpreted in Tables II to X by:

* 10%: Indicative
** 5%: Significant
*** 1%: Significant

Results

The main findings of the study are as follows:

Study 1 (Table II, at junctions for safety)
(*1*) For all 11 sites, total accidents decreased by 55 per cent and vehicle accidents decreased by 59·2 per cent.
Study 2 (Tables III to V, at junctions not specifically for safety)
(*1*) For all 62 sites, pedestrian accidents rose by 29·3 per cent.
(*2*) For 33 sites where hatch markings were also used, vehicle accidents decreased by 36·5 per cent.
(*3*) For eight sites where refuges were provided for channelisation of turning vehicles, vehicle accidents decreased by 73·7 per cent.

Study 3 (Tables VI to VIII, single refuges not at junctions)
(*1*) For all 23 sites, there were no significant changes.
(*2*) For 10 sites where refuges were fitted with fully-illuminated bollards, vehicle accidents decreased by 61·5 per cent.
(*3*) For nine refuges in the vicinity of pedestrian generators, accidents decreased overall by 52·4 per cent.
Study 4 (Table IX, series of refuges)
(*1*) For all sites, there were no significant changes.
Study 5 (Table X)
(*1*) At 19 Zebra crossings with refuges introduced vehicle accidents involving single or parked vehicles increased by 100 per cent.

Conclusions

The provision of refuges, which are often thought of as being a facility for pedestrians, has been found, somewhat surprisingly, to reduce vehicle accidents but to increase pedestrian accidents. For accidents at junctions (Studies 1 and 2) it appeared that significant accident reductions could be identified only for those cases where the purpose of the refuge was very clearly established. Examples of such purposes were provisions of the refuge specifically on road safety grounds, reinforcement of the refuge with hatch markings, or provision of the refuge for channelisation of vehicular traffic.

Similarly, for provision of single refuges not at junctions, it was possible to identify significant reductions in vehicle accidents when the refuges were fitted with fully-illuminated bollards, and it was possible to identify overall significant reductions in accidents where the refuges were provided in the vicinity of pedestrian generators.

The results regarding strings of refuges, not at junctions, will disappoint those who felt that this means of largely dividing the road was a safe and cheap alternative to provision of crossing facilities at specific points. In particular, previous studies have shown that Pelican crossings, although expensive, can produce significant accident reductions if they are associated with anti-skid surfacing and guardrails.

The sample size for the study on Zebra crossings appears to have been too small to produce worthwhile significant information. The only effect which was found to be significant was the doubled incidence of accidents involving single or parked vehicles within 50 m of a Zebra crossing when a refuge had been provided. One may surmise that this is due to the narrower road space available for motorists to take avoiding action.

In many cases refuges are provided not for road safety purposes, but to help pedestrian convenience. The evidence of this study is that such provision may, in some instances, be at the expense of the safety of pedestrians.

Considerations for future use

(*1*) Pedestrian refuges used in conjunction with GIVE WAY signs, enabling additional signs to be erected in the centre of the road, are extremely effective at promoting the conspicuity of a junction.
(*2*) Where refuges are used for channelisation purposes, hatch markings used where necessary improve the safety of the sites significantly.
(*3*) Where refuges are placed near junctions, particular attention should be paid to positioning so that pedestrian/vehicle conflict is not aggravated.
(*4*) Where single refuges are placed along stretches of road, fully-illuminated bollards appear to assist conspicuity of the refuge and promote channelisation of the traffic.

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REFERENCE

[1] TANNER, J. C. A problem in the combination of accident frequencies. *Biometrika*, **45**, parts 3 and 4, pp. 331–342.

The author's address: 51 Canterbury Avenue, Ilford, Essex.

Table II. *Study 1:* 11 uncontrolled junctions, with two refuges and two GIVE WAY signs to assist conspicuity
Conditions AS1, GR–, IB3, FI1, BL–, HM4, SR9, PG3, PR8, GW9, CH–.

Type of accident	Before	After	%change
Total pedestrian within 50 m	11	8	− 27·3
Pedestrian within 20 m	11	8	− 27·3
Pedestrian within 20–50 m	—	—	—
Fatal and serious pedestrian within 50 m	—	1	—
All vehicles within 50 m	98	40	− 59·2***
Single vehicle within 50 m	2	2	—
Nose-to-tail within 50 m	4	1	− 75·0
Crossroad within 50 m	88	27	− 69·3
Head-on and parked vehicle within 50 m	4	10	+150·0
Public service passenger within 50 m	—	1	—
Total fatal and serious within 50 m	18	6	− 66·7
Total in wet conditions within 50 m	34	16	− 52·9
Total in dark conditions within 50 m	36	10	− 72·0
Total within 50 m	109	49	− 55·0***

The average number of months in before-and-after period: 26·5

Table III. *Study 2:* 62 uncontrolled junctions, with one or more refuges
Conditions AS1, GR2, IB51, FI1, BL1, HM33, SR10, PG15, PR15, GW6, CH8.

Before	After	%change
41	53	+ 29·3*
30	34	+ 13·3
11	19	+ 72·7
8	10	+ 25·0
113	101	− 10·6
5	9	+ 80·0
31	21	− 32·3
50	45	− 10·0
32	25	− 21·9
7	3	− 57·1
38	29	− 23·7
53	41	− 15·1
50	55	+ 10·0
161	157	− 2·5

Average number of months in before-and-after period: 17·4

Table IV. *Study 2:* 33 uncontrolled junctions, with refuges and hatch markings
Conditions AS–, GR–, IB24, FI4, BL1, HM33, SR1, PG4, PR6, GW1, CH8.

Before	After	%change
21	26	+ 23·8
14	17	+ 21·4
7	9	+ 28·6
3	5	+ 66·7
63	40	− 36·5
5	7	+ 40·0
17	8	− 57·9
23	11	− 52·2
16	14	− 12·5
—	1	
24	15	− 37·5
22	22	—
25	28	+ 12·0
84	67	− 20·2

Table V. *Study 2:* 8 uncontrolled junctions, with refuges specifically for channelisation of turning vehicles
Conditions AS–, GR–, IB5, FI–, BL–, HM8, SR–, PG–, PR2, GW–, CH8.

Type of accident	Before	After	%change
Total pedestrian within 50 m	—	1	—
Pedestrian within 20 m	—	—	—
Pedestrian within 20–50 m	—	1	—
Fatal and serious pedestrian within 50 m	—	—	—
All vehicles within 50 m	19	5	− 73·7***
Single vehicle within 50 m	1	2	+100·0
Nose-to-tail within 50 m	2	1	− 50·0
Crossroad within 50 m	9	—	−100·0
Head-on and parked vehicle within 50 m	7	2	− 71·4
Public service passenger within 50 m	—	—	—
Total fatal and serious within 50 m	1	—	−100·0
Total in wet conditions within 50 m	5	3	− 40·0
Total in dark conditions within 50 m	4	2	− 50·0
Total within 50 m	19	6	− 68·4***

Table VI. *Study 3:* 23 sites with single refuges not at junctions
Conditions AS1, GR3, IB17, FI11, BL1, HM7, SR–, PG9, PR–, GW–, CH–.

Before	After	%changes
15	11	− 26·7
4	10	+150·0
11	6	− 45·4
4	2	− 50·0
31	25	− 19·3
1	6	+500·0
15	5	− 66·6
5	7	+ 40·0
10	7	− 30·0
—	1	—
7	1	− 85·7
12	6	− 50·0
14	12	− 14·3
46	37	− 19·6

Average number of months in before-and-after period. 17·9

Table VII. *Study 3:* 10 sites with refuges not at junctions, with fully-illuminated bollards
Conditions AS1, GR1, IB7, FI11, BL1, HM2, SR–, PG3, PR–, GW–, CH–

Before	After	%change
7	9	+ 28·6
1	5	+400·0
6	4	− 33·3
3	1	− 66·7
13	5	− 61·5*
—	2	—
6	—	−100·0
1	1	—
6	2	66·7
—	—	
3	5	− 66·7
5	2	− 60·0
6	5	− 16·7
20	14	− 30·0

Table VIII. *Study 3:* 9 refuges not at junctions, in vicinity of pedestrian generators
Conditions AS–, GR4, IB6, FI1, BL–, HM5, SR–, PG11, PR–, GW–, CH–.

Type of accident	Before	After	%change
Total pedestrian within 50 m	7	3	− 57·1
Pedestrian within 20 m	2	2	—
Pedestrian within 20–50 m	5	1	− 80·0
Fatal and serious pedestrian within 50 m	1	—	−100·0
All vehicles within 50 m	14	7	− 50·0
Single vehicle within 50 m	1	3	+200·0
Nose-to-tail within 50 m	8	2	− 75·0
Crossroad within 50 m	2	—	−100·0
Head-on and parked vehicle within 50 m	3	2	− 33·3
Public service passenger within 50 m	—	—	—
Total fatal and serious within 50 m	2	1	− 50·0
Total in wet conditions within 50 m	5	1	− 80·0
Total in dark conditions within 50 m	5	4	− 20·0
Total within 50 m	21	10	− 52·4*

Table IX. *Study 4:* 5 sites with three or more refuges along stretches of road (37 refuges in total)
Conditions AS–, GR–, IB5, FI1, BL–, HM1, SR–, PG1, PR–, GW–CH–.

Before	After	%change
12	13	+ 8·3
7	9	+ 28·6
5	4	− 20·0
3	1	− 66·7
35	34	− 2·9
4	6	+ 50·0
9	13	+ 44·4
5	8	+ 60·0
17	7	− 58·8
—	4	—
7	6	+ 11·1
9	10	− 30·4
23	16	− 14·3
47	51	+ 7·8

Average number of months in before-and-after period 14·2

Table X. *Study 5:* 19 existing Zebra crossings at which refuges were introduced
Conditions AS2, GR–, IB4, FI–, BL–, HM–, SR–, PG5, PR–, GW–, CH–.

Before	After	%change
56	37	− 33·9
22	16	− 27·3
14	11	− 21·4
20	10	− 50·0
13	11	− 15·4
61	63	+ 3·3
9	18	+100·0*
33	24	− 27·3
29	21	− 27·6
21	24	+ 14·3
7	3	− 57·1
38	20	− 47·4
31	36	+ 16·1
124	103	− 16·9

Average number of months in before-and-after period 20·7 (single or parked vehicles accidents within 50 m were specially tested for significance)