TRANSPORT RESEARCH LABORATORY

Traffic calming — an assessment of selected on-road chicane schemes

Prepared for Driver Information and Traffic Management Division, Department of the Environment, Transport and the Regions

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Executive Summary

In 1995, sixty-nine per cent of all reported road accident casualties in Great Britain occurred in built-up areas and of these roughly one third were vulnerable (pedestrian and cyclist) road users (Department of Transport, 1996). Recent research has established a link between changes in mean vehicle speeds and changes in accident frequencies (Finch et al, 1994); a 1 mph reduction in mean speed giving a 5 per cent reduction in accident frequency. Thus, speed reducing schemes are important in tackling accidents in built-up areas. Many such schemes involve installing traffic calming engineering measures in residential areas to reduce speeds, encourage traffic onto more appropriate main roads, and to reduce accidents.

Various types of horizontal deflections have been used in traffic calming schemes to reduce the speed of traffic. Chicanes are one type of horizontal deflection, formed by building out the kerbline to narrow the carriageway, usually on alternate sides of a two lane, single-carriageway road. The buildouts may be combined with central islands and overrun areas. Drivers reduce speed to negotiate the lateral displacement in the vehicle path. There is no 'standard' chicane type but, on low flow, two-way roads, traffic may be restricted to single lane working through the chicanes.

In 1994, TRL carried out (off-road) track trials which involved monitoring the behaviour of drivers when travelling through each of a wide range of chicane types constructed on the TRL test track. This work was commissioned by the Driver Information and Traffic Management (DITM) Division of the Department of the Environment, Transport and the Regions (DETR). The trials confirmed the potential of chicanes as traffic calming measures and established relationships between the mean vehicle speeds through chicanes and the four chicane parameters: stagger length, free view width, lane width and visual restriction (Sayer & Parry, 1994).

Following the TRL chicane track trials, DITM funded a study of chicanes on British public roads. This report details this study, drawing together and examining all the available data concerning the design and effectiveness of chicanes installed on local highway authority and trunk roads over the past decade.

Data, collected from 134 highway authorities, were analysed and 49 chicane schemes, representing the seven most common chicane types, were selected for detailed study. Each scheme included between one and ten chicanes and, in all, 142 chicanes were studied. Wherever possible, the analyses considered the 33 single-lane working schemes separately from the 16 two-way working schemes, and the results of the track trials are compared with the on-road data.

For the 49 selected schemes, at least some of the following data were available: vehicle speeds, traffic flow, accidents, geometric design, signing and construction costs. Owing to differences in site characteristics, the road environment, the monitoring positions (with respect to the chicanes) and methods of data collection, there will be variability within the data and the results should be regarded as being indicative of chicanes in general, but not specific to any one chicane design.

Although the aim of the main study was to collect specific data about chicanes, more general information, obtained from a sample of local authorities and from a Seminar on Traffic Calming (at TRL in June 1994), was considered. Such issues included chicane signing and visibility, loss of parking and access, safety (pedestrian, cyclist, traffic redistribution, vehicles hitting chicane furniture and buildouts, bad weather and darkness, and emergency vehicle access), environmental (visual impact, noise and pollution), and the removal of schemes.

The report concludes the following:

- The average mean and 85th percentile speeds observed *'at'* the chicanes were 23 mph and 28 mph respectively. These each represented average speed reductions of 12 mph, compared to speeds observed before the schemes were installed.
- The average mean speed *'at'* the chicanes was substantially higher (by about 9 mph) than the average mean speed reported for vehicles travelling over 75 mm high road humps. However, it should be noted that mean 'Before' speeds at the chicane schemes were about 7 mph higher, on average, than those at road hump schemes.
- There was an inverse relationship between path angle and mean (and 85th percentile) speed *'at'* the chicane; the greater the path angle, the lower the mean speed.
- After the schemes were installed, average reductions of 7-8 mph were recorded in mean and 85th percentile speeds *'between'* chicanes. The average mean and 85th percentile speeds *'between'* chicanes were 29 mph and 31 mph, respectively.
- The average mean and 85th percentile 'After' speeds *'at'* the two-way working chicanes were about 5 mph higher than those at the single lane working chicanes. The average mean and 85th percentile 'After' speeds *'between'* the two-way working chicanes were about 7 mph higher than those at the single lane working chicanes.
- Two-way working chicanes generally had smaller path angles (by about 5^{o} on average) and higher 'Before' speeds (by about 1 to 3 mph on average) than single lane working chicanes.
- For the 13 schemes with known 'Before' and 'After' traffic flow data, flows decreased at eight schemes, increased at 3 schemes, and did not change at two schemes. On average, flows were reduced by 15 per cent at single lane working chicanes and 7 per cent at two-way working chicanes.
- Several schemes had none, or very few, injury accidents in the 'Before' period, indicating that the chicanes were not always installed as site specific accident reduction measures. Over the 17 schemes with known 'Before' and 'After' accident data, there was an overall reduction in accident frequency of 54% (41.2 to 19.0 accidents per year).
- Of the single lane working chicane schemes studied, construction costs ranged from £1000 per chicane to £8150 per chicane, and averaged £3000 per chicane.

1 Introduction

Sixty-nine per cent of all reported road accident casualties in Great Britain occur in built-up areas and of these roughly one third are vulnerable (pedestrian and cyclist) road users (Department of Transport, 1996). Recent research has established a link between changes in mean vehicle speeds and changes in accident frequencies (Finch et al, 1994); with a 1 mph reduction in mean speed giving a 5 per cent reduction in accident frequency. Thus, speed reducing schemes in built-up areas are an important element in working towards the Department of Environment, Transport and the Regions' casualty target of a one-third reduction by the year 2000, compared with the 1981-85 average. Many of these schemes involve installing 'traffic calming' engineering measures in residential areas to reduce speeds, encourage traffic onto more appropriate main roads, and to reduce accidents. For example, studies of traffic calmed '20 mph zones' have found reductions in injury accidents of 60 per cent (Webster and Mackie, 1996). These traffic calming schemes are specifically designed to help protect the most vulnerable road users in built-up areas.

Horizontal deflections (of various types) are one kind of engineering measure that has been used in traffic calming schemes to reduce the speed of traffic. Chicanes are a form of horizontal deflection, using narrowing formed by building out the kerbline, usually on alternate sides of a two lane, single-carriageway road. The buildouts may be combined with central islands and overrun areas. Drivers reduce speed to negotiate the lateral displacement in the vehicle path. On two-way roads, chicanes may be designed so that traffic is restricted to single lane working through the chicanes. At these sites, there will be additional speed reductions due to drivers slowing down to give priority to the opposing flow. Single lane working is not suitable on higher flow roads where it would cause congestion. As an alternative, two-way working chicanes with lanes separated by road markings or central islands have been devised.

Chicanes have been used for a number of years by countries on mainland Europe and to a more limited extent in Britain. However, legislation prior to the Traffic Calming Act 1992, did not appear to provide adequate powers for local authorities to construct the horizontal deflections that had been used in other countries. Subsequent to the amendment to the Highways Act 1980 by the Traffic Calming Act 1992, the Highways (Traffic Calming) Regulations 1993 (outlined in Traffic Advisory Leaflet 7/93) clarified the powers to construct horizontal deflections, following which a wide range of designs have been implemented by local authorities in England and Wales. Similar legislative changes were also made in Scotland.

There is no 'standard' chicane type and many different variants are found on the public road. Details of some designs can be found in a traffic calming 'sourcebook' (County Surveyor's Society, 1994). Chicane design and layout is affected by such factors as: the road type, the speed reduction required, the traffic flow and composition, the road width at the site, and whether it is feasible to extend the lateral deviation of the carriageway outside the existing kerbline. Chicanes have been used in 20 mph zones and also on roads with 30 mph and 40 mph speed limits, particularly in Denmark (Danish Road Directorate, 1993) and on some village trunk road traffic calming schemes in England (Wheeler et al, 1997).

Before the development of chicanes in Britain, roads were mainly calmed by using road humps (vertical deflections). Humps are effective speed controlling measures (Webster, 1993 & 1994; Webster and Mackie, 1996) but objections to them include: discomfort to drivers and passengers; claims of vehicle damage and injury to passengers and drivers; and increased maintenance and repair costs by bus, ambulance, and other emergency vehicle operators. Such objections led to the development of speed cushions (Layfield, 1994; Layfield and Parry, 1998) and renewed interest in the use of chicanes, especially on bus and emergency vehicle routes.

There is generally less passenger discomfort associated with chicanes than with road humps and it is possible to narrow the carriageway while still allowing accessibility for large vehicles and emergency vehicles by incorporating overrun areas into the chicane design. The overrun areas tend to be avoided by cars but can be used by larger vehicles and emergency vehicles. However, there are several factors that should be considered before a chicane is installed in preference to other traffic calming measures:

- Concern has been expressed about the safety of cyclists being overtaken within the chicanes. However, cyclist bypasses have been found to be popular with cyclists and are recommended at sites with high motor vehicle flows (Davies et al, 1997) and can often be incorporated into the chicane design.
- Chicanes can take up a significant amount of road space and can cause loss of on-street parking spaces. Thus, chicanes can have a much greater impact on the environment than road humps, and so their aesthetic acceptability by residents and users is important. Chicanes also need to be positioned such that residential accesses are not blocked.
- Single lane working chicanes may be associated with safety and capacity problems.
- If vehicle speeds are kept low and rapid acceleration and braking are avoided, the environmental benefits of reduced traffic speeds at chicanes may include reduced traffic noise. The absence of vertical deflection at chicanes should avoid problems of increased vehicle body noise from commercial vehicles (Abbott et al, 1995). However, there may be some increased noise if vehicles use overrun areas on chicanes and, at single lane working chicanes, there may be some noise disturbance due to vehicles braking suddenly. Also, any substantial delays to traffic queuing at the chicanes may result in increased localised vehicle exhaust emissions.

There is various advice available concerning optimal design dimensions. Publications in Britain and abroad[1]

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[1]*For example, Swedish Road Safety Office (1982), Chorlton and Hatt (1991), Lines and Castelijn (1991), Hass-Klau et al (1992), Kent County Council (1992), County Surveyor's Society (1994).*

give dimensions and design advice for horizontal deflections but generally provide only limited information as to the speed reductions that have been achieved.

However, design advice relating physical chicane dimensions to desired speeds is provided by the Danish Road Directorate (1993) and by the Department of Transport (1994). The Danish advice is based on experimental trials and measurements on the public roads (Kjemtrup, 1990) and the Department of Transport advice is based on Transport Research Laboratory (TRL) chicane track trials (Sayer and Parry, 1994).

The TRL track trials involved monitoring the behaviour of drivers as they travelled through each of a wide range of chicane types constructed on the TRL test track. This work was commissioned by the Driver Information and Traffic Management (DITM) Division of the Department of the Environment, Transport and the Regions (DETR). The trials confirmed the potential of chicanes as traffic calming measures and established relationships between the mean speed through a chicane and the four chicane parameters: stagger length, free view width, lane width and visual restriction.

Following the TRL chicane track trials, DITM funded a study of chicanes on British public roads. This report details this study, drawing together and examining all the available data concerning the design and effectiveness of chicanes installed on local highway authority and trunk roads over the past decade.

The various types of chicane scheme studied are detailed in Section 2. Sections 3 and 4 go on to describe the data collected for the schemes, relating to vehicle speeds and accidents, respectively. Section 5 highlights other general issues that arise when installing chicane schemes and Section 6 summarises and draws conclusions from the whole study.

1.1 Study objectives

The main objectives of this study were to:

- identify the types and designs of chicanes used in England
- examine the advantages and disadvantages of chicanes
- link TRL track trial data with local authority data
- determine the effectiveness of chicanes in terms of speed, flow and accident reduction
- highlight the main issues associated with chicanes.

1.2 Study method

Sixty-four County Councils, 36 Metropolitan Authorities and 34 London Boroughs returned TRL questionnaires, providing information about the location and design of chicane schemes. The different types of chicane layout present in the sample are shown in Appendix A. From the information returned, 49 chicane schemes, representing the most common chicane types were selected for further study. Each scheme included between one and ten chicanes and, in all, 142 chicanes were studied. Vehicle speed, traffic flow, accident, geometric design, signing and construction cost data were obtained for these schemes.

TRL staff also collected additional data from some of the selected schemes in Buckinghamshire, Dorset, Norfolk and Wiltshire. Chicane dimensions and vehicle speeds, flows and lateral acceleration were among the measurements made.

2 Chicane layouts and schemes studied

2.1 Definitions and parameters

The critical dimensions used to describe chicanes examined within this report are shown in Figure 1 and are the same as those used by the Danish Roads Directorate (1993) and Sayer and Parry (1994):

‘a’ *free view width.* Free view width is the width (in metres), of the central gap between chicane buildouts. This can be positive or negative, if buildouts on opposite sides of the road overlap.

‘b’ *lane width.* Lane width is the average width (in metres) of the approach and exit lanes ([b1+b2]/2).

‘l’ *stagger length.* Stagger length is the distance (in metres) between the outermost points of the chicane buildouts.

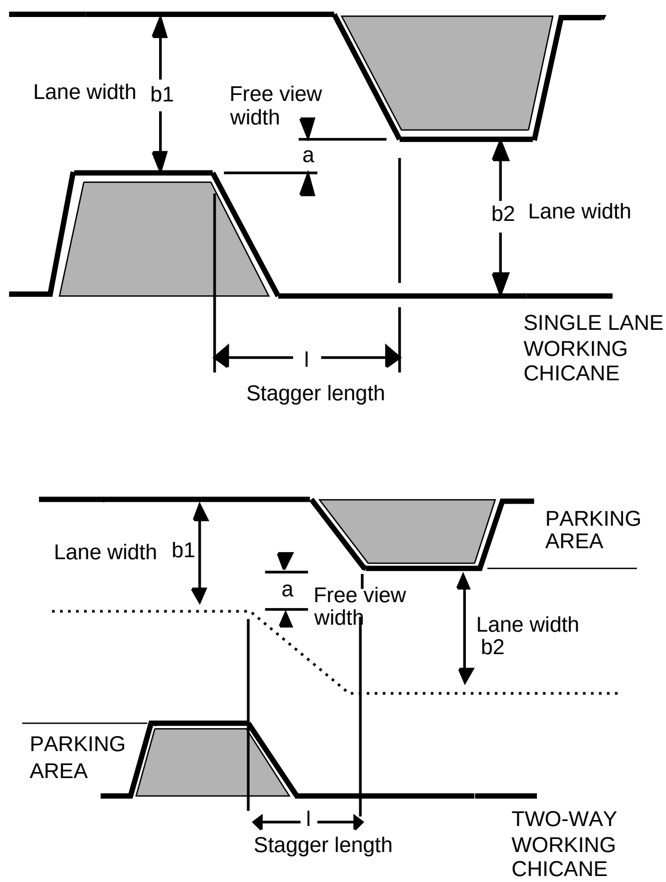


Figure 1 Definition of chicane dimensions

2.2 Chicane layouts studied

The chicane layouts selected for study represented the most common types:

Single lane working (33 schemes):

staggered buildout (deviation on entry)

(A.4a, Appendix A)

staggered buildout (deviation on exit)

(A.4b, Appendix A)

staggered buildout with overrun areas
(C.1, Appendix A)

Two-way working (16 schemes):

staggered buildout with no central island
(B.1, Appendix A)

staggered buildout with angled central island
(B.2. Appendix A)

staggered buildout with central island and overrun areas
(C.6, Appendix A)

staggered buildout with fully overrunable central island
(C.4, Appendix A)

The coding for chicane layout type used in Appendix A has been followed throughout the remainder of the Report.

2.2.1 Single lane working chicanes

Chicanes designed for single lane working allow for one direction of vehicle flow at a time. To assign priority to one particular direction, 'Priority/Give Way' signing and road marking is often found on the approaches to single lane working chicanes. Where chicanes are associated with road humps, priority is normally assigned to traffic moving away from the road hump. The location and dimensions of the 33 single lane working chicane schemes are given in Table 1. For schemes known to have more than one chicane design, each type has a one line entry in Table 1 and a type number (given in brackets). An example of a single lane working chicane scheme is displayed in Figure 2 and Plates 1 and 2.

Most of the single lane working chicanes were installed on roads subject to a 30 mph speed limit, although one scheme (scheme 27) had a 20 mph limit and another (scheme 4) had the national 60 mph limit. Twenty-two (67%) of the schemes were on residential roads, eight (24%) were on distributor roads and one (3%) was on an 'A' class road. Road width varied from 4.9 m to 10.0 m. About half of the single lane working chicane schemes were on bus routes and about one third were on routes designated for use by emergency vehicles.

Of the 33 single lane working schemes:

11 schemes had only one chicane

8 schemes had two chicanes

6 schemes had three chicanes

7 schemes had four chicanes

1 scheme had seven chicanes.

Of the 33 single lane working chicane schemes in the sample, there were 28 schemes without overrun areas; 17 with the deviation on the entry to the chicane (layout A.4a) and 11 with the deviation on the exit (layout A.4b). There were 5 schemes with overrun areas on the buildouts (layout C.1, further details in Section 2.3.3).

2.2.2 Two-way working chicanes

Two-way working chicanes provide sufficient road width for vehicles to pass through chicanes in opposite directions simultaneously. The location and dimensions of the 16 two-way working chicane schemes are shown in Table 2. For schemes known to have more than one chicane design, each type has a one line entry in Table 2 and a type number (given in brackets). Examples of two-way working chicane schemes are displayed in Plates 3 and 4.

Most of the two-way working chicanes were installed on roads subject to a 30 mph speed limit, although one scheme in Newcastle (scheme 48) had a 40 mph limit. Seven (44%) of the schemes were on residential roads, 4 (25%) were on distributor roads and 2 (13%) were on Trunk 'A' class roads. Road width varied from 4 m to 10.5 m. Almost all the two-way chicane schemes were on bus routes and about two-thirds were on routes designated to be used by emergency vehicles.

Of the 16 two-way working schemes:

3 schemes had only one chicane;

2 schemes had two chicanes;

3 schemes had three chicanes;

3 schemes had four chicanes;

1 scheme had five chicanes;

2 schemes had six chicanes;

1 scheme had eight chicanes;

1 scheme had ten chicanes.

Of the 13 schemes without overrun areas, about half had staggered buildouts with no central island (layout B.1, Appendix A) and half had staggered buildouts with an angled central island (layout B.2). Of the three schemes with overrun areas, one had a fully overrunable central island (layout C.4) and two had overrun areas on the buildouts and central islands (layout C.6, further details in Section 2.3.3).

2.2.3 Chicanes with overrun areas

Overrun areas combine, to varying degrees, vertical deflection, surface colour and texture, thereby making the overrun area appear distinct from the main area of the carriageway. Traffic Advisory Leaflet 12/93 (Department of Transport, 1993) details the design regulations for overrun areas. By encouraging most vehicles to drive on the defined area of the carriageway, overrun areas create a 'buffer' zone between the carriageway and physical obstructions such as buildouts and islands.

Overrun areas can be used with single lane working or two-way working chicanes (see Plates 5 and 6) to give car drivers the impression of a restricted carriageway width or reduced manoeuvring room. This encourages lower vehicle speeds while allowing increased manoeuvring room for larger vehicles such as lorries and buses. However, overrun areas may increase vehicle noise.

Overrun areas can be installed on buildouts and islands (see Figure 3):

- before the physical buildout or island
- after the physical buildout or island
- around the edge of an island
- on the limit or 'nib' of a buildout.

Table 1 Location and dimensions of single lane working chicanes

Scheme No.	Name	Chicane type	Limit (mph)	No. chicanes	'a' value (m)	'l' value (m)	'b1' value (m)	'b2' value (m)	Road width (m)	Em* route	Bus route	Date installed
Avon												
1	Argyle Rd [1]	C.1	30	1	1.1	8.6	3.3	4.0	6.2	No	No	11/93
1	Argyle Rd [2]	C.1	30	1	0.5	6.0	3.3	3.5	6.2	No	No	11/93
Buckinghamshire												
2	Grenville Rd	A.4a	30	2	1.9	5.9	3.7	3.7	5.5	No	No	5/92
3	Meadowcroft	A.4a	30	2	2.0	5.9	4.1	4.1	6.2	Yes	No	4/93
4	Middle Green	A.4a	60	3	2.0	5.0	3.5	3.5	5.0	No	Yes	11/93
5	Plumer Rd (1)	A.4a	30	2	1.5	5.6	3.9	3.9	6.2	No	No	N/K
5	Plumer Rd (2)	A.4a	30	1	1.3	7.6	3.8	3.8	6.1	No	No	N/K
6	Desborough St	A.4a	30	1	2.6	6.5	4.3	4.3	6.0	No	No	N/K
Central Region												
7	Stalker Ave	C.1	30	4	0.0	8.0	2.5	2.5	5.0	No	Yes	7/91
Cumbria												
8	Dalton Av (Carlisle)	A.4a	30	1	0.0	17.6	2.8	2.2	5.2	No	Yes	?/93
Dorset												
9	Maiden Castle Rd (Dorchester)	A.4a	30	2	-0.9	14.0	3.2	3.2	7.3	No	Yes	9/94
Greater London												
10	Graveney Grove (Bromley)	A.4b	30	1	2.5	5.0	5.0	4.5	7.5	No	No	1/89
11	Woodbine Grove (Bromley)	A.4b	30	1	1.0	6.5	4.5	4.0	8.0	No	No	1/89
12	Emlyn Rd (Hammersmith)	A.4a	20	4	4.4	14.0	7.2	7.2	10.0	No	No	5/94
13	Auckland Rd (Redbridge)	A.4b	30	1	0.0	8.5	4.0	4.0	8.0	No	Yes	5/89[3]
14	Coventry Rd (Redbridge)	A.4b	30	2	0.0	8.5	4.0	4.0	8.0	Yes	No	5/89[3]
15	Valentines Rd (Redbridge)	A.4b	30	1	0.0	9.0	3.5	4.0	8.0	Yes	No	5/89[3]
16	Sandy Lane (Sutton)	C.1	30	1	0.0	12.0	3.0	3.5	6.4	No	No	10/93
Greater Manchester												
17	Moss Lane (Sefton)	A.4a	30	4	1.1	9.0	3.6	3.6	6.1	No	No	10/89
Gwent												
18	Bridge St	A.4b	30	1	-	6.5	3.8	3.8	-	No	No	4/93
Hertfordshire												
19	Digswell (1)	A.4a	30	1	0.0	48.0	3.0	3.0	6.0	No	Yes	N/K
19	Digswell (2)	A.4a	30	1	-	50.0	-	-	-	No	Yes	N/K
20	Bushey Mill Ln [1]	C.1	30	2	1.0	12.0	4.0	4.0	7.0	Yes	No	6/94
20	Bushey Mill Ln [2]	C.1	30	2	-1.0	12.0	3.0	3.0	7.0	Yes	No	6/94
Kent												
21	Cobham Village	A.4b	30	3	-	12.0	-	-	-	Yes	Yes	7/93
Lancashire												
22	Charter St	A.4a	30	3	0.0	8.8	3.1	3.1	6.1	Yes	Yes	6/93
Lothian												
23	Willowbrae	A.4b	30	3	0.4	5.9	2.7	2.7	5.5	No	No	3/94
Northamptonshire												
24	Croyland Rd	A.4a	30	1	1.4	10.0	4.4	4.0	6.9	No	Yes	6/94
Norfolk												
25	Hockering Village [1]	C.1	30	2	2.0	11.0	4.0	4.0	6.0	No	No	N/K
25	Hockering Village [2]	C.1	30	2	-2.0	6.2	2.0	2.0	6.0	No	No	N/K
North Yorkshire												
26	Elmfield Rd (York)	A.4a	30	1	0.6	12.7	3.3	3.3	6.2	Yes	Yes	?/92[3]
South Yorkshire												
27	Bains Av (1) (Doncaster)	A.4a	20	1	1.5	6.2	3.5	3.5	5.5	No	Yes	3/94
27	Bains Av (2) (Doncaster)	A.4a	20	1	1.5	7.9	3.5	3.5	5.5	No	Yes	3/94
Strathclyde												
28	Peel Glen Rd (1)	A.4a	30	3	0.0	12.5	3.5	3.5	7.0	Yes	No	?/92
28	Peel Glen Rd (2)	A.4b	30	1	1.5	11.0	3.5	3.5	5.5	Yes	No	?/92

Table 1 Continued

Warwickshire												
29	Whittleford Rd	A.4a	30	2	0.2	12.0	2.8	2.8	5.5	Yes	Yes	4/94[3]
West Midlands												
30	Heath Town (1) (W'hampton)	A.4a	30	4	0.0	14.0	3.5	3.5	7.0	No	No	7/94
30	Heath Town (2) (W'hampton)	A.4a	30	3	1.5	9.0	3.5	3.5	5.5	No	No	7/94
West Yorkshire												
31	Lindley Moor Rd (Calderdale)	A.4b	30	1	0.0	13.0	3.0	3.0	5.5	Yes	Yes	N/K
32	Queen Elizabeth Rd (1) (Wakef'ld)	A.4b	30	1	-	30.0	3.0	3.0	5.5	Yes	Yes	9/92
32	Queen Elizabeth Rd (2) (Wakef'ld)	A.4b	30	1	1.0	26.0	3.0	3.0	5.6	Yes	Yes	9/92
32	Queen Elizabeth Rd (3) (Wakef'ld)	A.4b	30	1	0.0	25.0	3.0	3.0	4.9	Yes	Yes	9/92
32	Queen Elizabeth Rd (4) (Wakef'ld)	A.4b	30	1	1.0	49.5	3.0	3.0	4.9	Yes	Yes	9/92
Wiltshire												
33	Oaksey (1)	A.4b	30	1	1.9	14.3	3.8	3.6	5.8	Yes	Yes	6/94
33	Oaksey (2)	A.4b	30	1	1.6	13.3	3.6	3.6	5.5	Yes	Yes	6/94
33	Oaksey (3)	A.4b	30	1	2.1	13.5	3.7	4.1	5.5	Yes	Yes	6/94

*Emergency vehicle route
[1]*Chicane dimensions not including overrun areas*
[2]*Chicane dimensions including overrun areas*
[3]*Chicane subsequently removed*
N/K = Not Known

Not to scale: All dimensions in metres

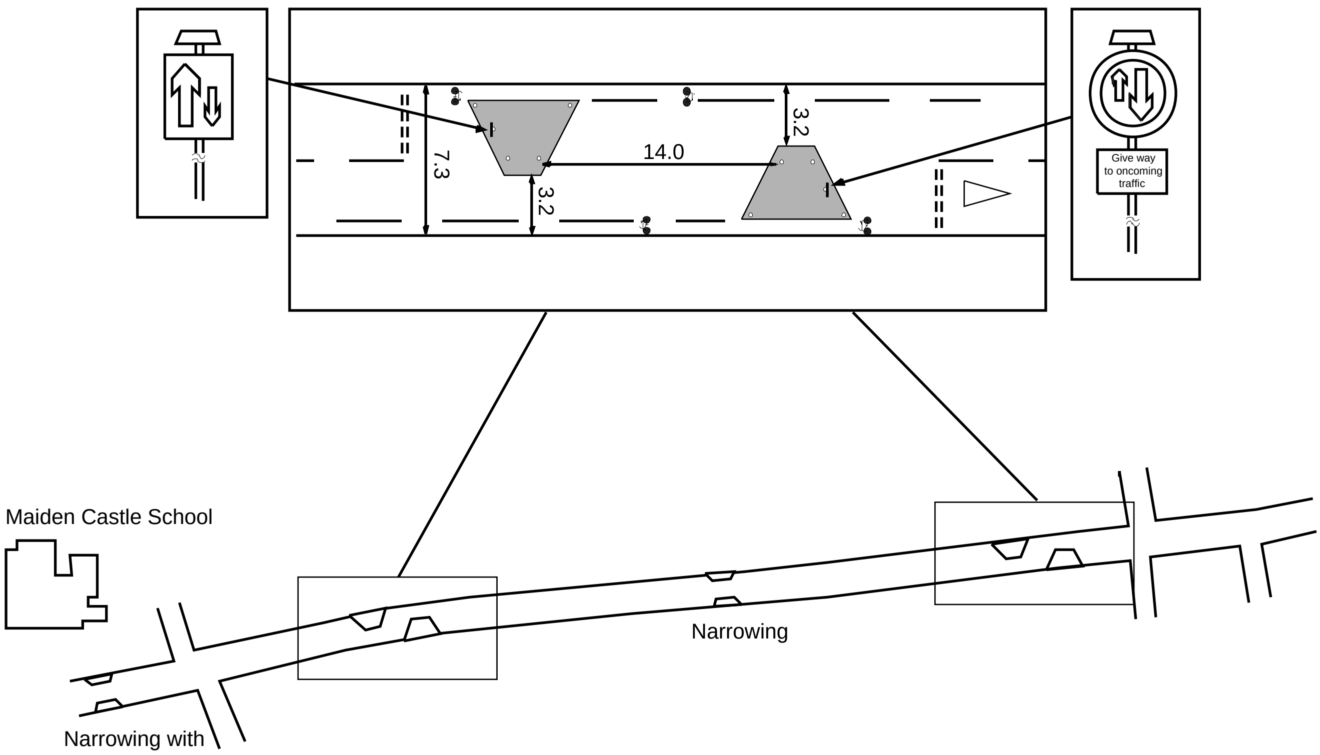


Figure 2 Layout of single lane working chicanes at Maiden Castle Road (Scheme 9)

Plate 1 Example of a single lane working chicane with cycle lane bypass: Scheme 9, Maiden Castle Road

Plate 2 Example of a single lane working chicane: Scheme 5, Plumer Road

Table 2 Location and dimensions of two-way working chicanes

Scheme No.	Name	Chicane type	Limit (mph)	No. chicanes	'a' value (m)	'1' value (m)	'b1' value (m)	'b2' value (m)	Road width (m)	Em* route	Bus route	Date Installed
Cambridgeshire												
34	Cherry Hinton (1)	B.1	30	1	4.5	3.5	2.0	2.5	6.0	Yes	Yes	5/93
34	Cherry Hinton (2)	B.2	30	1	1.0	7.5	2.0	2.0	5.5	Yes	Yes	5/93
34	Cherry Hinton (3)	B.2	30	1	2.0	12.0	2.7	2.7	5.5	Yes	Yes	5/93
35	Fen Ditton	B.1	30	4	5.0	9.0	3.0	3.0	7.0	Yes	Yes	6/92
36	A47, Thorney (1) wb	C.6	30	1	1.5	15.6	3.8	3.2	7.4	Yes	Yes	5/95
36	A47, Thorney (2) eb	C.6	30	1	1.8	11.8	2.8	3.3	7.4	Yes	Yes	5/95
36	A47, Thorney (2) wb[1]	C.6	30	1	2.2	31.0	3.7	6.0	7.4	Yes	Yes	5/95
36	A47, Thorney (2) wb[2]	C.6	30	1	0.2	25.8	3.0	2.8	7.4	Yes	Yes	5/95
Devon												
37	Beaumont Rd (1) (Plymouth)	B.1	30	2	2.5	17.5	2.5	2.5	6.0	No	Yes	5/91
37	Beaumont Rd (2) (Plymouth)	B.2	30	6	1.2	13.6	3.0	3.0	6.0	No	Yes	5/91
38	Budshead Rd (1) (Plymouth)	B.2	30	5	1.0	14.0	3.0	3.5	6.0	No	Yes	3/91
38	Budshead Rd (2) (Plymouth)	B.2	30	5	1.5	12.0	3.5	3.0	6.0	No	Yes	3/91
39	Sweetbrier Lane (Exeter)	B.1	30	5	1.15	9.5	3.0	2.5	5.5	No	Yes	6/93
Gloucestershire												
40	King Edward Av	B.1	30	4	1.5	7.0	2.1	2.1	7.0	No	No	3/94
Greater London												
41	Woodcote Valley Rd (Croydon)	B.1	30	6	2.5	22.5	2.5	2.5	5.5	Yes	No	1/94[3]
42	Kidbrooke Park (Greenwich)	B.1	30	1	3.5	7.0	3.3	3.3	9.5	No	Yes	2/90
43	Central Av (Hillingdon)	C.4	30	1	-1.5	5.0	2.0	2.0	4.0	Yes	Yes	9/93
Greater Manchester												
44	Littleton Rd (1) (Salford)	B.1	30	1	4.0	48.0	3.5	3.5	8.0	Yes	Yes	5/93
44	Littleton Rd (2) (Salford)	B.1	30	1	4.5	42.5	3.5	3.5	10.0	Yes	Yes	5/93
Leicestershire												
45	Strasbourg Dv (Leicester)	B.2	30	3	0.95	8.0	3.0	2.75	7.3	Yes	Yes	N/K
Norfolk												
46	Norwich Rd [1] (Cromer)	C.6	30	3	0.0	23.2	3.3	3.0	-	Yes	Yes	3/95
46	Norwich Rd [2] (Cromer)	C.6	30	3	-0.5	12.8	2.75	3.0	-	Yes	Yes	3/95
Tyne and Wear												
47	Armstrong Rd (Newcastle)	B.2	30	1	1.3	9.6	1.9	3.0	10.5	Yes	Yes	1/92
48	Hexham Rd (1) (Newcastle)	B.2	40	1	1.0	11.0	3.0	3.0	8.5	No	Yes	3/94
48	Hexham Rd (2) (Newcastle)	B.2	40	1	0.7	12.5	3.0	3.0	8.5	No	Yes	3/94
48	Hexham Rd (3) (Newcastle)	B.2	40	1	1.0	8.5	3.0	2.5	8.0	No	Yes	3/94
West Midlands												
49	Berry St (1) (Coventry)	B.2	30	1	0.0	16.4	3.0	3.4	-	Yes	Yes	N/K
49	Berry St (2) (Coventry)	B.2	30	1	1.4	15.4	3.5	3.5	-	Yes	Yes	N/K

*Emergency vehicle route
[1]Chicane dimensions not including overrun areas
[2]Chicane dimensions including overrun areas
[3]Chicane subsequently removed
N/K = Not Known
wb = westbound
eb = eastbound

Plate 3 Example of a two-way working chicane: Scheme 37, Beaumont Road

Plate 4 Example of a two-way working chicane: Scheme 36, A47 Thorney

Plate 5 Example of a single lane working chicane with overrun areas: Scheme 20, Bushey Mill Lane

Plate 6 Example of a two-way working chicane with overrun areas: Scheme 46, A149 Cromer

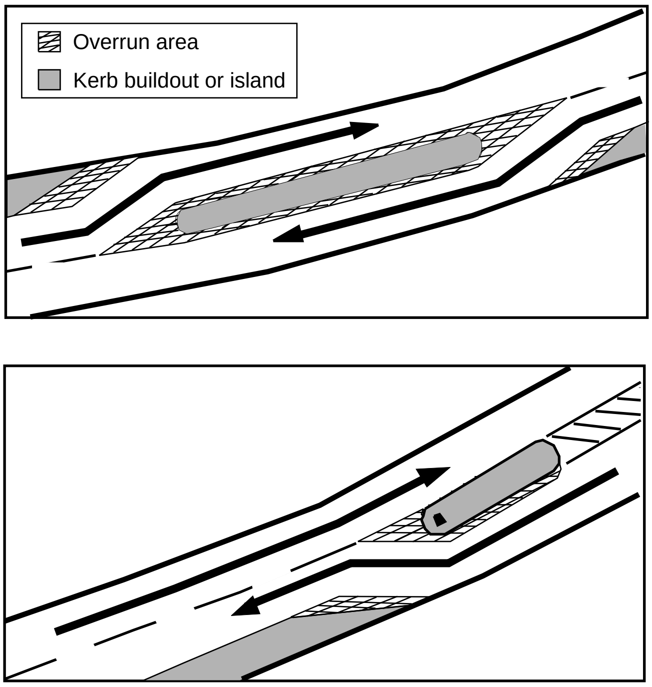


Figure 3 Location of overrun areas on chicanes

Islands, in the schemes studied, have been constructed so that they were fully, or just partly, overrunable.

Overrun areas were installed on five of the single lane working, and three of the two-way working chicanes studied. Most of the overrun areas sloped upwards from the running carriageway to the kerbs or buildouts. At the edge of the road the overrun areas could be up to 75 mm above the main carriageway, but where the overrun areas met the main carriageway, the upstands were less than 6 mm high. The six different designs of overrun area identified were:

i red surface treatment with hatch markings, overrun area bounded by raised 'rib lines' at Thorney (scheme 36)

ii raised kerbing (25 mm) with block infill at Sandy Lane (scheme 16), Hockering Village (scheme 25) and Norwich Road (scheme 46)

iii raised asphalt (25 mm) suitable for large vehicles to overrun at Bushey Mill Lane (scheme 20)

iv raised kerbing (60 mm, splayed kerb) with block paving infill at Stalker Avenue (scheme 7)

v raised kerbing (75 mm, type KC2) with block infill, alternate units laid on side/on end for uneven paving. Described as an 'Anti pedestrian overrun area' at Argyle Road, Bristol (scheme 1)

vi raised 'crocodile back' island, block infill with uneven paving at Central Avenue, Hillingdon (scheme 43).

Overrun areas were used extensively on the A149, Norwich Road, at Cromer in Norfolk (scheme 46), which consisted of 3, two-way working chicanes with islands. The overrun areas were installed around the chicane buildouts and islands. Figure 4 displays a general plan of the scheme.

No complaints concerning excessive noise generation from vehicles overrunning such areas were reported by the local highway authorities.

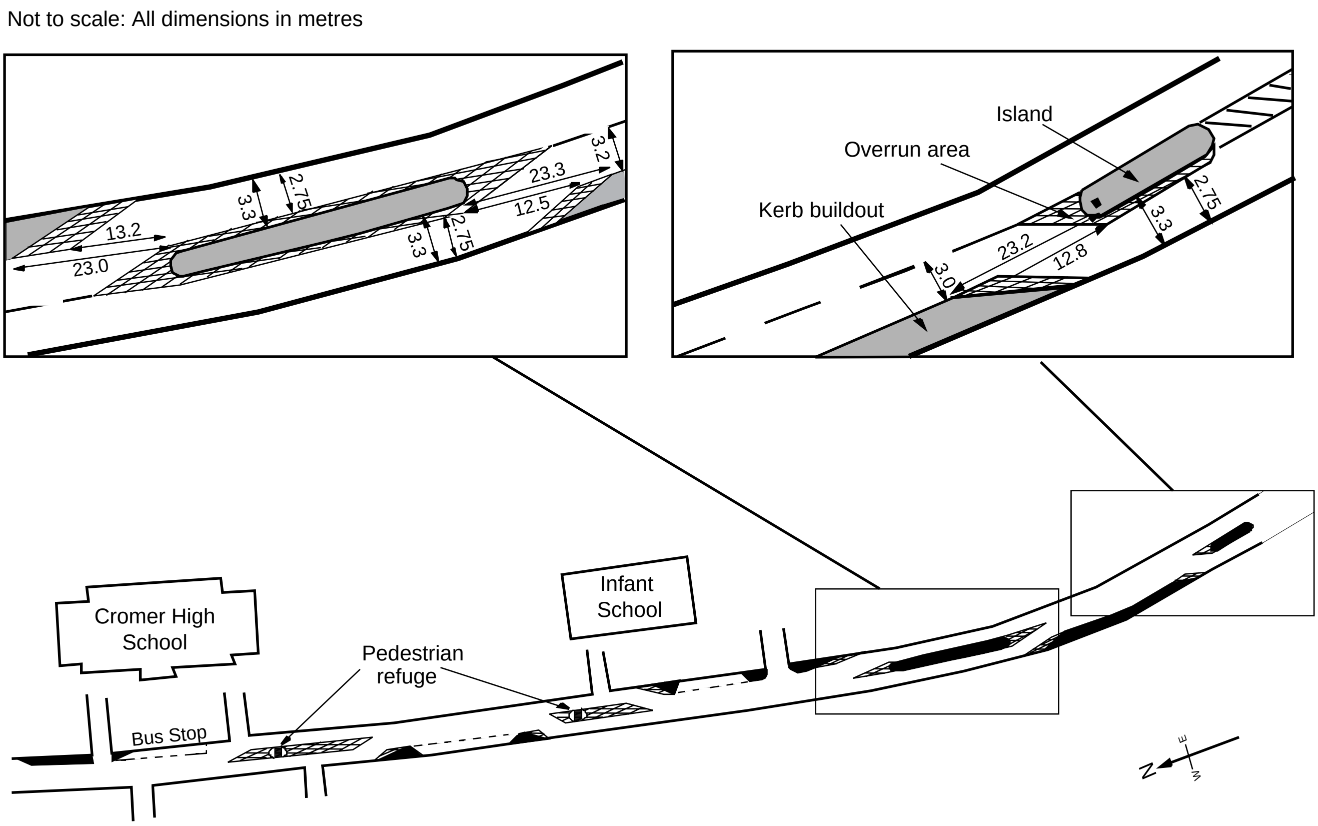


Figure 4 General site plan of two-way working chicanes with overrun areas A149, Norwich Road (Scheme 46)

3 Traffic speeds

Vehicle speed information was received as part of the data returned from several local authorities. The data consisted of mean and 85th percentile speeds measured before and after installation at locations *'at'* and/or *'between'* individual chicanes or groups of chicanes. It is not known whether speeds were recorded for traffic in one direction only or if speeds for both directions of flow were averaged. Vehicle speeds were measured independently by TRL at four additional schemes.

Vehicle speeds were generally measured with either hand held radar meters or automatic speed detectors. Owing to differences in site characteristics, the road environment, the monitoring positions (with respect to the chicanes) and methods of data collection, there will be variability within the data and the following results should be regarded as indicative only.

3.1 Speeds 'at' chicanes

Table 3 gives the mean and 85th percentile speeds at single lane working and two-way working chicanes, together with the chicane dimensions and including the 'path angle' (the angle through which the carriageway is displaced, see Section 3.1.3).

An overall reduction of approximately 12 mph was recorded *'at'* the chicanes in both mean and 85th percentile speeds; speeds through the chicanes were reduced to an overall average of about 23 mph and 28 mph, respectively.

The overall average mean speed through the chicanes (23 mph) was substantially higher than the average speed reported for vehicles travelling over road humps. Webster and Layfield (1996) found the overall average mean speed over 75 mm high flat-top and round-top humps to be 13 mph and 15 mph respectively. However, it should be noted that mean 'Before' speeds at the chicane schemes were about 7 mph higher than those at the 75 mm high hump schemes.

3.1.1 Vehicle speeds 'at' single lane working chicanes

The mean and 85th percentile 'Before' speeds at single lane working chicane sites, for which speed data was available, ranged from 28 mph to 40 mph (3 schemes) and 29 mph to 50 mph (5 schemes), respectively. After the chicanes were installed, mean speeds *'at'* the chicanes reduced to an average 21 mph (8 schemes) and 85th percentile speeds reduced to an average 26 mph (8 schemes). These results did not include data from Elmfield Avenue (scheme 26). At this site a speed cushion was installed within the chicane and the mean speed (12 mph) was substantially lower than at other single lane working chicane schemes.

Mean speeds at three of the four schemes (excluding scheme 26) with 'Before' and 'After' data showed that mean speeds fell on average by approximately 12 mph, see Table 3. Eighty-fifth percentile speeds at the five schemes with 'Before' and 'After' data fell, on average, by about 14 mph. The largest reduction in vehicle speeds was observed at Bushey Mill Lane (scheme 20) with a 21 mph reduction in mean speed from 40 mph to 19 mph, and a 29 mph

Table 3 Traffic speeds *'at'* chicanes, with chicane dimensions and path angle

Scheme No	*Road*	*Mean speed (mph)* 'at' *'Before'*	*'After'*	*Difference*	*85%ile speed (mph)*'at' *'Before'*	*'After'*	*Difference*	*'a'value (m)*	*'l'value (m)*	*Avg lane width (m)*	*'path angle' (degrees)*
Single lane working											
1	Argyle Rd[1]	-	-	-	29	25	-4	1.1	8.6	3.65	16.5
5	Plumer Rd	-	18.5	-	42	23	-19	1.3	7.6	3.8	18.2
9	Maiden Castle Rd	-	19	-	-	22.5	-	-0.9	14.0	3.2	16.3
12	Emlyn Rd	-	20.9	-	-	-	-	4.4	14.0	7.2	11.3
20	Bushey Mill Ln[1]	40	19	-21	50	21	-29	1.0	12.0	4.0	14.0
21	Cobham Village	28	24	- 4	34	29.5	-4.5	-	12.0	-	-
25	Hockering Village[1]	-	21.5	-	-	29.2	-	2.0	11.0	4.0	10.3
26	Elmfield Ave[2]	26	12	-14	-	-	-	0.6	12.7	3.3	12.0
29	Whittleford Rd	35	23	-12	41	30	-11	0.2	12.0	2.8	12.2
33	Oaksey	-	22.5	-	-	28	-	1.8	13.4	3.75	8.3
Average		34.3	21.1	-12.3	39.2	26.0	-13.5	1.4	11.6	4.1	13.4
Two-way working											
36	A47 Thorney[1]	45.1	32.9	-12.2	51.7	38.3	-13.4	1.65	15.8	3.4	6.3
37	Beaumont Rd	33	27	- 6	37	32	-5	1.2	13.6	3.0	7.5
38	Budshead Rd	35.6	27.1	-8.5	40.4	31.4	-9	1.25	10.75	3.25	10.5
39	Sweetbrier Ln	-	-	-	37	32	-5	1.15	9.5	2.75	9.6
45	Strasbourg Dr	38	21	-17	41	25	-16	0.95	8.0	3.9	13.5
46	Norwich Rd[1]	38	24.5	-13.5	44	29	-15	0.0	23.2	3.15	7.7
Average		37.9	26.5	-11.4	41.9	31.3	-10.6	1.0	13.9	3.1	8.9
Overall Average		36.9	23.1	-11.8	40.7	28.3	-11.9	1.2	12.5	3.6	11.5

[1]*Chicane dimensions including overrun areas as carriageway.*

[2]*Results not included in calculations, scheme located near a 'give way' junction, speed cushions installed within the chicane.*

reduction in 85th percentile speed from, 50 mph to 21 mph. The size of the reduction was likely to have been partly attributable to the scheme having had the highest known 'Before' speeds.

3.1.2 Vehicle speeds 'at' two-way working chicanes

At the two-way working schemes identified in Table 3 for which data were available, mean and 85th percentile 'Before' speeds ranged from 33 mph to 45 mph (5 schemes) and 37 mph to 52 mph (6 schemes), respectively. After the chicanes were installed, mean speeds *'at'* the chicanes reduced to an average of 27 mph (5 schemes) and 85th percentile speeds reduced to an average of 31 mph (6 schemes).

Mean and 85th percentile speeds at the schemes with known 'Before' and 'After' data fell on average by 11 mph (5 and 6 schemes, respectively). 85th percentile speeds *'at'* chicanes fell, on average, by 11 mph (6 schemes).

The overall average mean and 85th percentile 'After' speeds at the two-way working chicanes were about 5 mph higher than those at the single lane working chicanes. Some of this difference may be due to the generally smaller path angles (see Section 3.1.3), or to the generally higher 'Before' speeds (about 3 mph on average) observed at the two-way working schemes.

3.1.3 Effect of path angle on vehicle speed

Mean and 85th percentile speeds through the chicane were related to chicane dimensions in the form of path angle.

The angle through which the carriageway is displaced at a chicane has been defined as the 'path angle'. It is derived from the horizontal deflection created by chicane buildouts and the length of road over which the sideways movement takes place, ie. the 'stagger length' or 'l' value (see Figure 5). 'Path angle' is indicative of vehicle paths through chicanes, with higher path angles resulting in higher angles of lateral displacement, leading to greater reductions in speed.

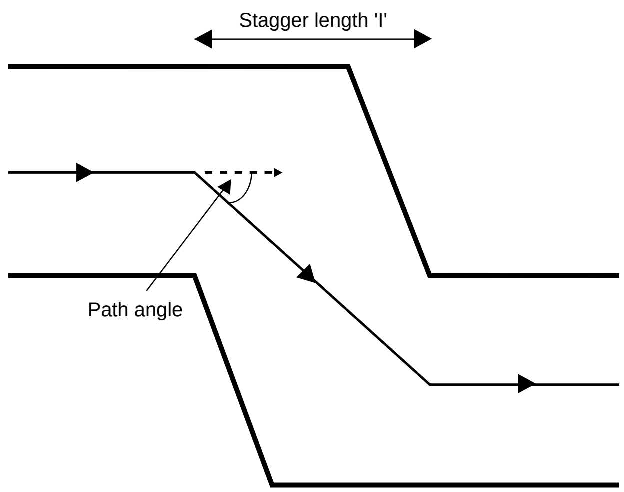


Figure 5 Definition of 'path angle'

Path angle is calculated as follows:

$$\text{Path angle} = \text{Tan}^{-1} \frac{(\text{average lane width - free view width})}{\text{stagger length}}$$

Figures 6a and 6b display mean and 85th percentile speeds at chicanes plotted against 'path-angle'. The data points in Figures 6a and 6b represent average values for all known speeds collected at specific schemes (e.g. at scheme 33, Oaksey Village, speeds and dimensions have been combined and averaged for both directions of flow at chicanes 2 and 3).

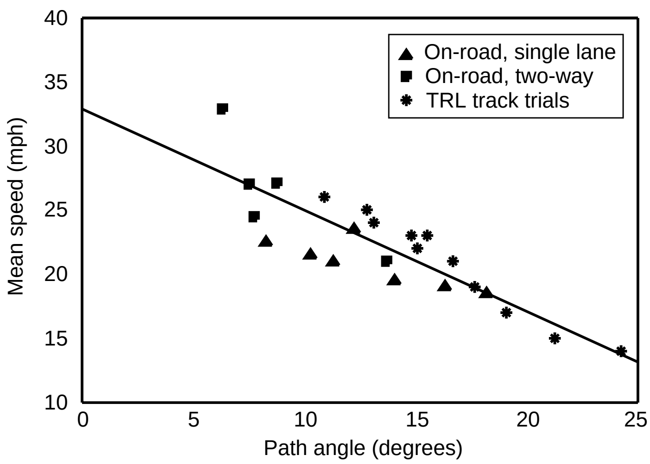


Figure 6a Mean speed against chicane 'path angle'

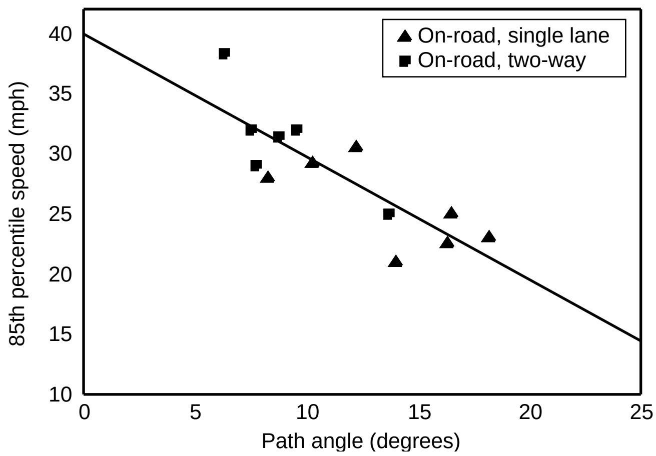


Figure 6b Eighty-fifth percentile speed against chicane 'path angle'

Figure 6a displays an inverse relationship between path angle and mean speed, suggesting that an increased path angle leads to a reduction in speed. In general, at on-road schemes, path angles of greater than 15° should reduce speeds *'at'* the chicane to a mean value of less than 20 mph. Path angles of less than 10° may allow speeds with mean values of 25 mph or more.

Figure 6b displays the inverse relationship between path angle and 85th percentile speeds. Path angles of about 10° can be expected to allow speeds with 85th percentile values of over 30 mph, whereas path angles of 15 to 20^o would be expected to result in speeds with 85th percentile values of between 20 and 25 mph.

In general, path angles were observed to be greater at single lane working chicanes than at two-way working chicanes, resulting in lower speeds at single lane sites.

In Figure 6a, speed data collected from chicane trials on the TRL test track, at chicanes with 3.5 m lane widths (Sayer and Parry, 1994), are compared to on-road speed data (average lane widths about 3.5 m). Overall, the TRL trial data showed a similar relationship for mean speed against path angle to that of on-road schemes. Mean speeds *'at'* chicanes in the TRL chicane trials were, however, approximately 3-4 mph higher than at on-road schemes with similar path angles. Two possible explanations for the higher speeds observed on the track are that the track chicanes gave drivers a wider field of view than is generally the case for on-road chicanes, and that the sample of drivers in the track trial had the opportunity to become familiar with the chicanes, which may have encouraged them to drive slightly faster.

Results from the TRL chicane trials indicated that lane width was also a factor in influencing vehicle speed. In general, a chicane with a larger lane width allowed slightly greater vehicle speeds than a chicane with the same path angle, but a lesser lane width. Drivers generally chose the minimum feasible angle of displacement through a chicane for their width of vehicle.

3.1.4 Vehicle speed and lateral acceleration

The lateral acceleration experienced by a vehicle and driver moving through a chicane can be described as the change in forces experienced by these bodies in the horizontal plane, as the chicane is negotiated. Kjemtrup (1990), suggested that vehicle speeds through a chicane may be influenced by the level of lateral acceleration experienced by drivers.

The vehicle speed chosen by drivers for a specific chicane may be linked to an 'acceptable' level of lateral acceleration which is roughly constant for all chicanes. In tests in Denmark, Kjemtrup found that 85th percentile speeds through chicanes were likely to produce a 'staggering acceleration' of about 0.7g. The staggering acceleration was determined by adding together the absolute value of horizontal acceleration to the left and to the right.

TRL staff measured lateral acceleration at chicane schemes 5, 9, 33 and 46 using a small estate vehicle and a logging device containing two ±2g accelerometers. One accelerometer was positioned in the front nearside footwell, the other was held firmly against the nearside door. Lateral acceleration measurements were collected over a range of realistically attainable speeds (15 mph, 20 mph, 25 mph or 30 mph), in both directions, through each chicane. Sets of 3 to 5 runs were made at each speed in each direction. A radar gun was used to monitor the test vehicle speed.

Figure 7 shows the values of lateral acceleration (sum of absolute values of horizontal acceleration to the left and to the right) plotted against vehicle speed for each of the four schemes. As expected, lateral acceleration increased with increasing speed.

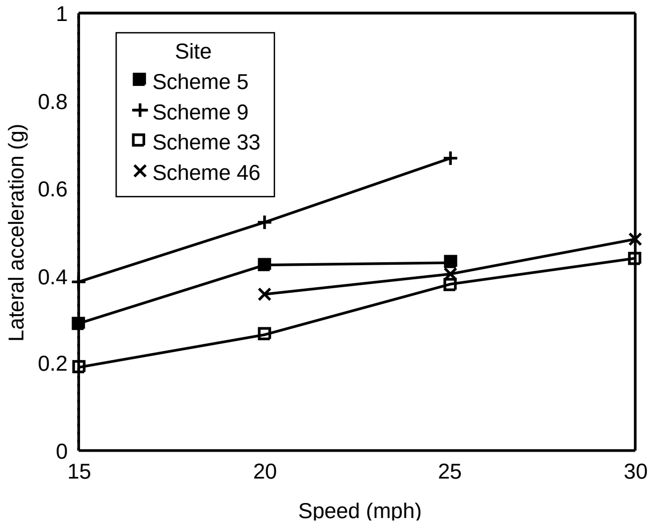


Figure 7 Increase in lateral acceleration with vehicle speed for individual chicanes

Table 4 gives the observed 85th percentile 'After' speeds at these four chicane schemes and the value of lateral acceleration for these 85th percentile speeds extrapolated from on-site measurements, as given in Figure 7. For example, the Maiden Castle Road chicane (scheme 9) with an observed 85th percentile speed of 22.5 mph relates to an 'extrapolated' lateral acceleration level of 0.6g, according to Figure 7.

Table 4 Eighty-fifth percentile speed *'at'* chicanes with associated lateral acceleration

Scheme No.	*Road name*	*85th percentile speed (mph)*	*Predicted lateral acceleration (from Fig.7) (g)*
5.	Plumer Road	23	0.43
9.	Maiden Castle Road	22.5	0.60
33.	Oaksey	28	0.32
46.	Norwich Road	29	0.45

The results in Table 4 suggest that the lateral accelerations experienced when driving at 85th percentile speeds were less than that found by Kjemtrup and that there was no one consistent value of lateral acceleration at all chicanes.

3.2 Speeds 'between' chicanes

Speed data were collected by local authorities at points *'between'* chicanes for 12 schemes. The small set of data, and variability in the speed measurement locations, prohibited the development of a reliable speed spacing relationship for chicanes.

Vehicle speeds *'between'* chicanes will be influenced by the speeds of vehicles travelling *'at'* chicanes; the distance between successive measures; and the 'Before' speeds. For a given chicane type and spacing, the highest vehicle speeds *'between'* chicanes are likely to be observed on the roads which have the highest 'Before' speeds.

After the schemes were installed, average reductions of 7-8 mph were recorded in both mean speeds (7 schemes) and 85th percentile speeds (10 schemes); speeds between the chicanes were reduced to an overall average of 29 mph and 31 mph, respectively.

The overall reduction in mean and 85th percentile speeds between chicanes was higher for the single lane working schemes (12 mph, over 4 schemes) than for the two-way working schemes (6 mph, over 6 schemes). This difference may be due to differences in speeds *at* the single lane and two-way working chicanes (about 5 mph); differences in chicane spacing (not known); and differences in 'Before' speeds (about 1 mph for the schemes shown in Table 5). After scheme installation, the overall mean and 85th percentile speeds between single lane working chicanes were 23 mph and 27 mph, respectively. The corresponding speeds between two-way working chicanes were 31 mph and 34 mph, respectively.

Information on the spacing between chicanes was not readily available and thus a speed spacing relationship could not be established. However, it is considered likely that vehicle speeds between chicanes would follow a similar relationship to that for road humps. Further research would, however, be required to verify this. Relationships have been derived for 100 mm high round top humps, 100 mm high flat top humps (Webster, 1993), 75 mm high round top humps, and 75 mm high flat top humps (Webster and Layfield, 1996).

4 Accidents

Injury accident data (covering 1.5 to 7.5 years) were available for twelve single lane working and five two-way working chicane schemes (see Table 6). The low number of 'Before' accidents at several schemes suggested that not all the chicanes were installed as site specific accident reduction measures.

Accident frequencies were reduced at ten of the chicane schemes, were unchanged at four schemes, and increased at three schemes. There was an overall reduction in accident frequency of 54% (41.2 to 19.0 accidents per year).

A Wilcoxon test, on the change ('less', 'same', 'more') in injury accident frequency at the 16 schemes indicated that an overall reduction in accident frequency was statistically significant at the 5 per cent level.

Whilst the results are encouraging, it should be noted that the reduction in accident frequency may have been influenced by factors other than speed reduction (eg. reduction in flow, publicity, national legislation, annual and seasonal differences resulting from different data collection periods etc). In addition, this study has not looked at the types of accident at chicane schemes. It is possible that while reducing the overall accident frequency, the installation of chicanes may increase some types of accident (eg. single vehicle - collision with chicane buildout or central island). In the sample of schemes which are the subject of this report, accident severities, on average, were reduced after the schemes were installed. However, it is known that fatalities have been reported at some chicane schemes.

5 Other issues

5.1 Traffic flows

The decision whether to install single lane working or two-way working chicanes will be influenced by the level of expected traffic flow. Single lane chicanes are suited to low flow roads, whereas two-way working chicanes are generally necessary where traffic flows are high.

At single lane working chicanes, opposing flows of vehicles may cause delays during peak periods. However, periods of lower flow may allow a 'racing line' to be taken through a relatively 'open' chicane, with little sideways

Table 5 Mean and 85th percentile speed *'between'* chicanes

Scheme		*Mean speed (mph) between*			*85%ile speed (mph) between*		
No	*Road*	*'Before'*	*'After'*	*Difference*	*'Before'*	*'After'*	*Difference*
Single lane working							
9.	Maiden Castle Rd	-	-	-	35	26	9
12.	Emlyn Rd	-	20	-	35	26	9
20.	Bushey Mill Ln	40	29	11	50	32	18
28.	Peel Glen Rd	30	17.7	12.3	34	20.3	13.7
33.	Oaksey	-	26.7	-	-	31	-
Average		35	23.4	11.7	38.5	27.1	12.4
Two-way working							
34.	Cherry Hinton	38	30	8	42	34	8
37.	Beaumont Rd	-	-	-	37	34	3
38.	Budshead Rd	35.6	31.9	3.7	40.4	35.7	4.7
40.	King Edward Ave	32	24	8	36	27	9
41.	Woodcote Valley Rd	37	36	1	42	40	2
45	Strasbourg Dr	38	30.5	7.5	41	33	8
46.	Norwich Rd	-	31	-	-	35	-
Average		36.1	30.5	5.6	39.7	34.1	5.8
Average, all schemes		35.8	29.2	7.4	39.2	31.1	8.4

Table 6 Personal injury accidents at chicane schemes

Scheme No.	Road	'Before' Accidents (F.Ser.Sli)	Months	Acc/yr	'After' Accidents (F.Ser.Sli)	Months	Acc/yr	Change acc/yr
Single lane working								
2.	Grenville Rd	1 (0.0.1)	36	0.3	0 (0.0.0)	36	0.0	Less
3.	Meadowcroft	0 (0.0.0)	36	0.0	0 (0.0.0)	21	0.0	Same
7.	Stalker Ave	3 (0.0.3)	36	1.0	0 (0.0.0)	36	0.0	Less
8.	Dalton Ave	1 (0.0.1)	60	0.2	0 (0.0.0)	24	0.0	Less
10.	Graveney Gr	0 (0.0.0)	36	0.0	2 (0.0.2)	48	0.5	More
17.	Moss Lane	2 (0.0.2)	36	0.7	2 (0.0.2)	21	1.1	More
18.	Bridge St	0 (0.0.0)	36	0.0	0 (0.0.0)	21	0.0	Same
22.	Charter St	24 (0.3.21)	90	3.2	2 (0.0.2)	10	2.4	Less
28.	Peel Glen Rd	12 (0.4.8)	35	4.1	0 (0.0.0)	30	0.0	Less
30.	Heath Town	0 (0.0.0)	36	0.0	0 (0.0.0)	18	0.0	Same
31.	Lindley Moor Rd	0 (0.0.0)	48	0.0	0 (0.0.0)	34	0.0	Same
32.	Queen Elizabeth Rd	7 (1.2.4)	48	1.8	1 (0.1.0)	29	0.4	Less
Two-way working								
35.	Fen Ditton	17 (2.3.12)	36	5.7	4 (0.0.4)	24	2.0	Less
37.	Beaumont Rd	16 (0.5.11)	36	5.3	9 (0.4.5)	36	3.0	Less
38.	Budshead Rd	31 (0.8.23)	36	10.3	4 (0.1.3)	36	1.3	Less
42.	Kidbrooke Pk	38 (N/K)	60	7.6	25 (N/K)	36	8.3	More
47.	Armstrong Rd	2 (0.0.2)	24	1.0	0 (0.0.0)	24	0.0	Less
Total		154		41.2	49		19.0	-54%

F = Fatal injury accident
Ser = Serious injury accident
Sli = Slight injury accident

deflection. At single lane working chicane schemes with relatively low flows, the severity of the chicane deflection will be crucial in achieving speed reductions. It is possible that during periods of low flow, vehicle speeds will increase, if drivers accelerate to ensure they reach the chicane before opposing vehicles.

Flow levels are anticipated to be less crucial to the performance of two-way working chicanes with physical divisions between opposing flows, such as design types B.2 to B.4 and C.3 to C.6. Flow movements through such chicanes are mainly limited by the physical dimensions of the chicane. During periods of high flow delays may occur if high volumes of large vehicles are present, although delays produced by large vehicles may be reduced by the provision of overrun areas.

For single lane working chicanes, advice in terms of maximum levels of vehicle flow ranges from 'not more than 3000 vehicles per day' (Danish Road Directorate, 1993), to 'between 4000 and 8000 vehicles per day' (Kent County Council, 1994). Advice in 'Civilised Streets' (Hass-Klau et al, 1992) suggested that the maximum vehicle flow for most types of chicane was '600 vehicles per peak hour'.

Vehicle flow data were available for 11 single lane working and 6 two-way working local authority chicanes (see Table 7). Different flow counting periods were used, with only some local authorities recording 'Before' data. Consequently, few comparisons can be made between the results. However, it is apparent that the schemes studied represented roads with a broad range of traffic flows. Daily flows ranged from 1000 to about 8000 vehicles for single lane working and 1000 to 11000 for two-way working.

For the 13 schemes shown in Table 7 with known 'Before' and 'After' data, flows decreased at eight schemes, increased at 3 schemes, and did not change at two schemes. On average, flows were reduced by 15 per cent at single lane working chicanes and 7 per cent at two-way working chicanes. The largest decrease in flow (of 55 per cent) was at Peel Glen Road (scheme 28).

5.2 Driver behaviour at overrun areas

Driver behaviour at overrun areas was assessed at two of the two-way working chicanes on the Norwich Road, Cromer, (scheme 46, Figure 4). Observations were made of the paths of approximately 300 northbound (downhill) vehicles through the first and third chicanes on Norwich Road.

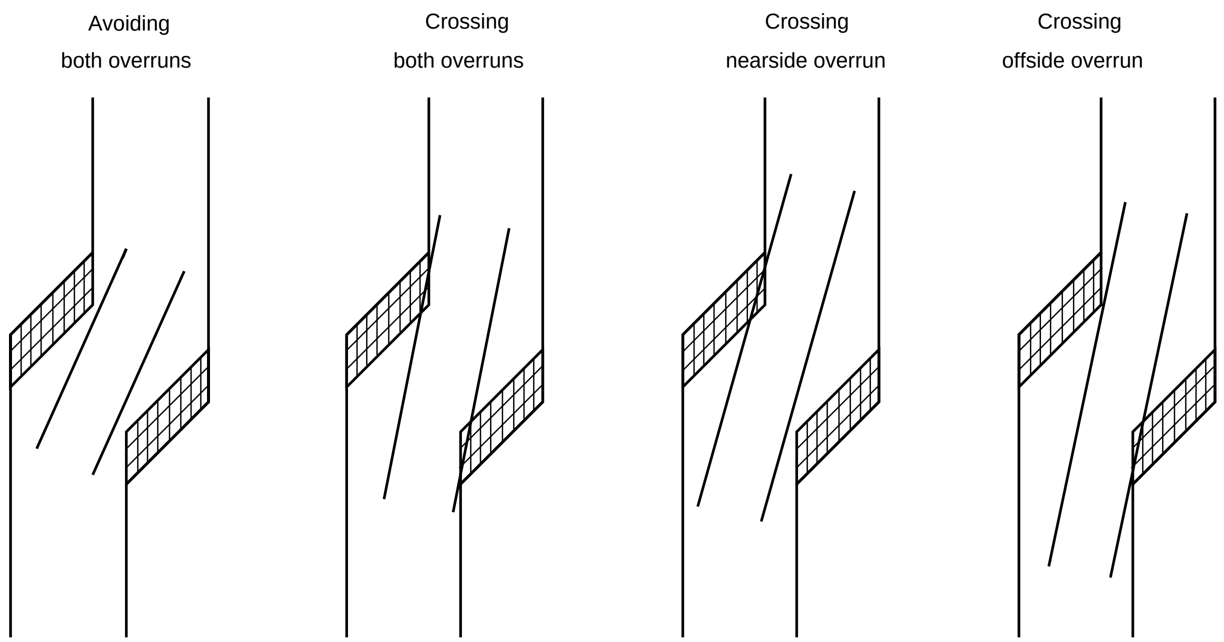
Figure 8 displays the relative percentages of vehicles crossing or avoiding overrun areas. Cars were judged to have avoided the overrun area unless a whole tyre mounted the overrun. Vehicles clipping either edge of the overruns were not counted as having crossed the overrun areas. The first and third chicanes (northbound direction) had similar dimensions but there were differences in the road alignment which probably accounted for the differences in the proportions of vehicles crossing the overrun areas. The first chicane was on a right hand bend while the second chicane had a relatively straight approach.

On average, about half the cars avoided the overrun areas at the two chicanes. Most of the remainder used the nearside overrun areas. A small proportion of cars used the offside overrun areas around the central islands.

Approximately 10 per cent of all vehicles were either large vans or lorries. All observed lorries used at least one, if not both (nearside and offside) overrun areas, with the nearside overrun areas being used most. Most large vans used the overrun areas in a similar way to lorries. All pedal cycles and motorcycles observed, avoided the overrun areas.

Table 7 Chicane installation and traffic flow

Scheme No.	*Name*	*'Before' flow*	*Length of count*	*Road width (m)*	*Per cent flow change*
Single lane working					
1	Argyle Rd	1253	24 hours	6.2	Not known
2	Grenville Rd	1141	12 hours	5.5	-44
9	Maiden Castle Rd	2524	24 hours	7.3	Not known
13	Auckland Rd	1206	12 hours	8.0	+11
16	Sandy Lane	136	peak hour	6.4	+12
19	Hertford Rd	7750	16 hours	6.0	Not known
20	Bushey Mill Lane	480	peak hour	7.0	-12
28	Peel Glen Rd	576	peak hour	5.5	-55
29	Whittleford Rd	12594	Not known	5.5	-11
32	Queen Elizabeth Rd	3000	24 hours	5.6	-10
33	Oaksey Way	1000	12 hours	5.5	Not known
Two-way working					
34	Cherry Hinton	1278	peak hour	5.5	-24
35	Fen Ditton	10615	10 hours	7.0	-6
37	Beaumont Rd	3900	Not known	6.0	-10
38	Budshead Rd	1100	16 hours	6.0	0
40	King Edward Ave	664	peak hour	7.0	0
41	Woodcote Valley Rd	850	peak hour	5.5	+12



	Avoiding both overruns	Crossing both overruns	Crossing nearside overrun	Crossing offside overrun
1st chicane	63%	6%	19%	12%
3rd chicane	32%	4%	64%	0%

Northbound (downhill)

Figure 8 Behaviours at overrun areas (all vehicles) A149, Norwich Road (Scheme 46)

5.3 Costs

Compared to road humps, chicanes cover larger areas and may need carriageway realignment, installation of areas of buildout and central islands, additional lighting (including illuminated bollards), modifications to drainage, additional signs, and the use of environmentally acceptable materials.

The construction costs of single lane and two-way working chicanes are given in Tables 8 and 9. The single lane working chicane construction costs in Table 8 ranged from about £1000 to £8000 with an average cost of approximately £3000 per chicane. Variations in costs are to be expected. For example, construction materials vary in type and cost; signing, marking and street lighting also differ from scheme to scheme as does the quantity of materials used.

Many of the two-way working chicanes shown in Table 9 were installed as part of schemes involving various traffic calming features and the separate construction costs of the chicanes were not available. In Tables 8 and 9, signing costs have, in some cases, been stated separate from total scheme cost or the costs of chicane construction. At these schemes, signing costs varied between £400 and £2600.

5.4 Signing and visibility

High levels of signing at chicanes (particularly with single lane working priority systems) may disorientate and confuse drivers and create a heightened sense of environmental degradation. On the other hand, too little signing at single lane working chicanes may cause uncertainty, confusion and conflict between opposing flows of vehicles.

Warning of chicanes has sometimes been provided by the use of signs such as in Plate 7. However, such signs would need to be specially authorised by the Department of the Environment, Transport and the Regions.

At single lane working chicanes, a priority direction should be shown by road markings conforming to the Traffic Signs Regulations and General Directions Diagram No. 1003 (TSRGD, 1994), to mark a ‘Give Way’ line for non priority traffic. Signs conforming to TSRGD Diagram No. 615 and No. 811 (priority-working arrows), should be used where additional emphasis is required for the one way priority working system (see Plates 5 and 8). The 1994 signing regulations require signs conforming to TSRGD Diagram No. 615 and No. 811 to be used in conjunction with signs conforming to TSRGD Diagram No. 615.1 and No. 811.1, reading ‘Give Way to oncoming vehicles’, and ‘Priority over oncoming vehicles’ respectively.

The triangular ‘Give Way’ junction sign should *not* be placed alongside ‘Give Way’ road markings at chicanes. This sign is reserved for use at ‘Give Way’ junctions only. The use of ‘Give Way’ road markings (TSRGD Diagram No. 1003) on both approaches to a single lane working chicane is not recommended. The arrangement is of doubtful legality and may create confusion between drivers (see Traffic Advisory Leaflet 9/94).

There is less conflict between opposing flows of vehicles at two-way working chicanes, so less signing is required than at single lane working schemes. However, two-way working chicanes are generally installed on roads with relatively high vehicle speeds, so signing and visibility of buildouts is important if drivers are to be given ample time to react to the presence of a chicane.

The Highways (Traffic Calming) Regulations require that buildouts or islands in the carriageway should be made conspicuous to drivers. There should always be adequate street lighting in the areas around chicanes. It may be appropriate to provide keep left/right arrows on posts or bollards located on buildouts or islands. Road markings such as hatching will help to define a driving path through chicanes, guiding drivers around buildouts and islands. Marker posts may be placed on buildouts and central islands to heighten the visibility of the feature. The over-use of such features may degrade the appearance of the

Table 8 Approximate cost of single lane working chicanes

Scheme no.	*Name*	*Chicane type*	*Cost per chicane £s*	*Notes*
1.	Argyle Road	C.1	3800	Signing £1000 extra
2.	Grenville Road	A.4a	2500	
4.	Middle Green	A.4a	1650	
7.	Stalker Avenue	C.1	1250	
8.	Dalton Avenue	A.4a	1300	Signing £600 extra
9.	Maiden Castle Road	A.4a	1550	Two chicanes, signing £1400 extra
13.	Auckland Road	A.4b	8150	
14.	Coventry Road	A.4b	8150	
15.	Valentines Road	A.4b	8150	
16.	Sandy Lane	C.1	1100	Signing £400 extra
17.	Moss Lane	A.4a	2500	
19.	Digswell	A.4a	2000	Two chicanes, signing £500 extra
21.	Cobham Village	A.4b	4650	Three chicanes, signing £2600 extra
22.	Charter Street	A.4a	1150	Signing included
23.	Willowbrae	A.4b	1550	
27.	Bains Avenue	A.4a	1150	Two chicanes, total cost of scheme £29,000
28.	Peel Glen Road	A.4a	3750	
29.	Whittleford Road	A.4a	2000	Two chicanes, removal costs £2500
31.	Lindley Moor Road	A.4b	3000	Signing £2500 extra
33.	Oaksey Village	A.4b	7650	Three chicanes, signing £1500 extra

Table 9 Approximate cost of two-way working chicanes

Scheme no.	*Name*	*Chicane type*	*Cost per chicane £s*	*Notes*
34.	Cherry Hinton	B.1	N/K	Three chicanes, total cost of calming scheme £250000
35.	Fen Ditton	B.1	N/K	Four chicanes, total cost of calming scheme £48000
37.	Beaumont Road	B.1, B.2	N/K	Eight chicanes, total cost of calming scheme £99000
38.	Budshead Road	B.2	10000	Ten chicanes
39.	Sweetbrier Lane	B.1	4000	Five chicanes
40.	King Edward Avenue	B.1	N/K	Four chicanes, total cost of calming scheme £60000
41.	Woodcote Valley Road	B.1	1500	Six chicanes, signing costs £1500
47.	Armstrong Road	B.2	2000	
48.	Hexham Road	B.2	2000	Signing costs £500
49.	Berry Street	B.2	N/K	Total cost of calming scheme £90000

N/K = not known

chicane. The use of a chevron sign warning of a deviation in the carriageway at buildouts is not appropriate as this sign is more commonly associated with sharp bends in an un-narrowed carriageway.

5.5 Local authority experience

Although the aim of the main study was to collect specific data about chicanes, a summary of more general information, obtained from a sample of local authorities and from a Seminar on Traffic Calming (at TRL in June 1994) is given below. It is stressed that the comments below are general observations only, and are somewhat subjective.

5.5.1 Loss of parking and access

Some chicanes take up a considerable amount of longitudinal space, and may be unsuitable in streets where a significant amount of on-street parking takes place. Where no alternatives to kerbside parking exist, loss of roadside parking and reduced access for loading, unloading, and access to private driveways, chicanes may prove unacceptable.

5.5.2 Safety

Section 4 of this report suggested that chicanes may improve safety. The following points consider several separate safety issues:

- By displacing flows away from residential areas, keeping traffic on main routes and reducing ‘rat running’, chicanes can help improve safety on the roads where they are installed. The installation of single lane working chicanes appears to have a positive effect in reducing traffic flow and in altering the way in which traffic uses a road network.
- Pedestrian safety may be improved, not only as a result of a reduction in vehicle speeds and flow but as a result of reduced carriageway crossing distances at the build-out points.
- The safety of cyclists is important too. At chicanes where carriageway widths are particularly narrow and/or cycle flows are high, separate cycle lanes may be needed (Plate 8). Cyclist bypasses have been found to be popular with cyclists and are recommended at schemes with high motor vehicle flows (Davies et al, 1997; Institution of Highways & Transportation, 1995).
- The possibility of cars hitting chicane furniture or buildouts is an important safety concern (Plate 9) and although the frequency of vehicle/pedestrian accidents may fall, the frequency of vehicle/vehicle or vehicle/street furniture accidents may increase. Non-pedestrian accidents are less likely to result in personal injury and may not be reported to (or recorded by) the Police.
- Poorly illuminated or poorly signed chicanes can become hazards during bad weather (including snow) or the hours of darkness. Chicanes need to be placed to allow drivers time to reduce speed and, if necessary, to stop for oncoming traffic. At some schemes, visibility had been improved using black and white kerbs and reflective panels on planters.
- Other safety issues include considering emergency vehicle access to residential areas and the safety of the people and equipment carried on the vehicles. Vehicles crossing vertical deflections at speed could cause loose equipment to be dislodged causing inconvenience, equipment damage and/or injury to personnel. This is less likely to occur with vehicles at chicanes.

5.5.3 Environmental

In environmentally sensitive areas such as town centres, attention to chicane design, construction, materials and appearance are important (Plate 10). While chicane buildouts offer the opportunity to use vegetation and planting, residents may object to the general visual intrusion of these.

Traffic calming reduces vehicle speeds and it is likely that vehicles with loose equipment and a high degree of ‘body-rattle’ generate less noise passing through chicanes than when travelling over road humps. However, chicanes which create high levels of vehicle stop-starting, acceleration and braking noise can be as unacceptable as the noise created by high speed traffic (ie. the state of affairs before the chicane was installed). Large numbers of stop-start movements may also increase localised vehicle exhaust emissions.

Plate 7 Sign warning of a chicane ahead, with supplementary ‘reduce speed now’ plate, at Scheme 20, Bushey Mill Lane

Plate 8 Example of signing at a single lane working chicane with cycle bypass: Scheme 20, Bushey Mill Lane

Plate 9 Damage to a bollard at a chicane, Great Hollands, Bracknell

Plate 10 Example of a chicane incorporating planters: Scheme 8, Dalton Avenue

5.5.4 Public attitudes towards chicane schemes

No specific public attitude surveys were carried out as part of this study. However, in a review of public attitudes studies, Webster (1998) found that attitudes towards traffic calming schemes including horizontal deflections were very variable with approval rates ranging from 18 per cent to 89 per cent. On average, traffic schemes including horizontal deflections were less acceptable (59 per cent approval) than schemes consisting mainly of road humps (72 per cent approval). The results from individual surveys comparing the effectiveness and acceptability of different traffic calming measures indicated that chicanes were perceived to be less effective and were less popular than road humps.

5.5.5 Removal of chicane schemes

Of the 49 schemes detailed in this report, 6 are known to have been removed. In one case the residents disapproved of the scheme and in another case local, elderly road users were confused by the scheme and its signing. The reasons for removing the other schemes are thought to be related to problems arising from poor design or installation errors.

6 Summary and conclusions

1 In 1995, sixty-nine per cent of all reported road accident casualties in Great Britain occurred in built-up areas and of these roughly one third were vulnerable (pedestrian and cyclist) road users (Department of Transport, 1996). Recent research has established a link between changes in mean vehicle speeds and changes in accident frequencies (Finch et al, 1994); a 1 mph reduction in mean speed giving a 5 per cent reduction in accident frequency. Thus, speed reducing schemes are important in tackling accidents in built-up areas. Many such schemes involve installing traffic calming engineering measures in residential areas to reduce speeds, encourage traffic onto more appropriate main roads, and to reduce accidents.

2 Various types of horizontal deflections have been used in traffic calming schemes to reduce the speed of traffic. Chicanes are one type of horizontal deflection, formed by building out the kerbline to narrow the carriageway, usually on alternate sides of a two lane, single-carriageway road. The buildouts may be combined with central islands and overrun areas. Drivers reduce speed to negotiate the lateral displacement in the vehicle path. There is no ‘standard’ chicane type but, on low flow, two-way roads, traffic may be restricted to single lane working through the chicanes.

3 In 1994, TRL carried out (off-road) track trials which involved monitoring the behaviour of drivers when travelling through each of a wide range of chicane types constructed on the TRL test track. The trials confirmed the potential of chicanes as traffic calming measures and established relationships between the mean vehicle speeds through chicanes and the four chicane parameters: stagger length, free view width, lane width and visual restriction (Sayer & Parry, 1994).

4 Data, collected from 134 highway authorities, were analysed and 49 chicane schemes, representing the seven most common chicane types, were selected for detailed study. Each scheme included between one and ten chicanes and, in all, 142 chicanes were studied. Wherever possible, the analyses considered the 33 single-lane working schemes separately from the 16 two-way working schemes.

5 For the 49 selected schemes, at least some of the following data were available: vehicle speeds, traffic flow, accident, geometric design, signing and construction costs. Owing to differences in site characteristics, the road environment, the monitoring positions (with respect to the chicanes) and methods of data collection, there will be variability within the data and the results should be regarded as being indicative of chicanes in general, but not specific to any one chicane design.

6 The average mean and 85th percentile speeds observed *‘at’* the chicanes were 23 mph and 28 mph respectively. These each represented average speed reductions of 12 mph, compared to speeds observed before the schemes were installed. The average mean speed *‘at’* the chicanes was substantially (about 9 mph) higher than the average speed reported for vehicles travelling over 75 mm high road humps. However, it should be noted that mean ‘Before’ speeds at the chicane schemes were about 7 mph higher than those at road hump schemes.

7 The data indicated an inverse relationship between path angle and mean (and 85th percentile) speeds, suggesting that the greater the path angle, the lower the speed. In general, at on-road schemes, path angles of greater than 15^{o} should reduce mean speeds *‘at’* the chicane to less than 20 mph. Path angles of less than 10^{o} may allow mean speeds of 25 mph or more. Path angles of 15 to 20^{o} would be expected to result in 85th percentile speeds of between 20 and 25 mph, whereas path angles of about 10^{o} can be expected to allow 85th percentile speeds of over 30 mph. The TRL trial data showed a similar relationship, even though the mean speeds in the TRL trials were 3-4 mph higher than *‘at’* on-road chicanes with similar path angles.

8 After the schemes were installed, average reductions of 7-8 mph were recorded in mean and 85th percentile speeds *‘between’* chicanes. The average mean and 85th percentile speeds observed *‘between’* the chicanes were 29 mph and 31 mph, respectively. Information on the spacing between chicanes was not readily available. However, it has been reported that vehicle speeds between road humps are, on average, about 7 mph higher at hump spacings of 140 m than at hump spacings of 20 m and it is likely that vehicles speeds *‘between’* chicanes would follow a similar relationship.

9 Comparisons were made between two-way working chicane schemes and single lane working chicane schemes, wherever possible. The average mean and 85th percentile ‘After’ speeds *‘at’* the two-way working chicanes were about 5 mph higher than those at the single lane working chicanes. The average mean and

85th percentile 'After' speeds *'between'* the two-way working chicanes were about 7 mph higher than those at the single lane working chicanes. These differences may be due to the two-way working chicanes generally having smaller path angles (by about 5^o on average), higher 'Before' speeds (by about 3 mph on average *'at'* chicanes; about 1 mph *'between'* chicanes), or larger spacing between consecutive chicanes (not known).

10 The vehicle speed chosen by drivers for a specific chicane may be linked to an 'acceptable' level of lateral acceleration, constant for all chicanes. In tests in Denmark, Kjemtrup (1990) found that 85th percentile speeds through chicanes were likely to produce a 'staggering acceleration' of about 0.7g. Experiments in the present study indicated that the lateral accelerations experienced when driving at 85th percentile speeds were less than those found by Kjemtrup and that there was no one consistent value of lateral acceleration at all chicanes.

11 For the 13 schemes with known 'Before' and 'After' traffic flow data, flows decreased at eight schemes, increased at 3 schemes, and did not change at two schemes. On average, flows were reduced by 15 per cent at single lane working chicanes and 7 per cent at two-way working chicanes.

12 Injury accident data (covering 1.5 to 7.5 years) were available for seventeen chicane schemes. Several schemes had none, or very few, accidents in the 'Before' period, indicating that the chicanes were not always installed as site specific accident reduction measures. Accident frequencies were reduced at ten of the chicane schemes, unchanged at four schemes, and increased at three schemes. There was an overall reduction in accident frequency of 54% (41.2 to 19.0 accidents per year).

13 Vehicles travelling through two chicanes with overrun areas and similar lane widths were studied. There were differences in behaviour at the two chicanes but, on average, about half the cars avoided the overrun areas. Most of the remainder used the nearside overrun areas. A small proportion of cars used the offside overrun areas around the central islands. All observed lorries used at least one, if not both (nearside and offside) overrun areas with the nearside overrun areas being used most. All pedal cycles and motorcycles observed, avoided the overrun areas.

14 Compared to road humps, chicanes take up more road space, may involve carriageway realignment and installation of buildouts and central islands, additional lighting (including illuminated bollards), modifications to drainage, additional signs, and the use of environmentally acceptable materials. They would, therefore, be expected to cost more to install. Of the single lane working chicane schemes studied, construction costs ranged from £1000 per chicane to £8000 per chicane, and averaged £3000 per chicane. Wide variations in costs are to be expected. For example, construction materials vary in type and cost; signing, marking and street lighting also differ from scheme to scheme as does the quantity of materials used.

15 Although the aim of the main study was to collect specific data about chicanes, more general information, obtained from a sample of local authorities and from a Seminar on Traffic Calming (at TRL in June 1994), was considered. Such issues included chicane signing and visibility, loss of parking and access, safety (pedestrian, cyclist, traffic redistribution, vehicles hitting chicane furniture and buildouts, bad weather and darkness, and emergency vehicle access), environmental (visual impact, noise and pollution), and the removal of schemes.

16 The work detailed in this report has brought together information relating to the effects of installing chicanes which will be valuable in maximising the benefits of future installations. This information not only identifies the advantages of chicanes but also highlights possible pitfalls - lessons learnt from practical experience. The specific data analyses provide an overall picture of the effectiveness of the most common types of chicane scheme. The results, summarised above, indicate that chicane schemes are effective at achieving speed reductions both *'at'* and, to a slightly lesser extent, *'between'* chicanes. The data collected were not comprehensive and, in general, detailed comparisons between different chicane types were not possible. However, single lane working chicanes were found to achieve slightly greater speed reductions than two-way working chicanes. The overall reduction in accident frequency (over 17 schemes) was estimated at 54%. Whilst this result is encouraging, it should be noted that the data related to different periods, accident frequencies were generally small at each scheme, and any reduction may have been influenced by factors other than speed reduction (eg. reduction in flow, publicity, national legislation, annual and seasonal differences resulting from different data collection periods etc), or by the 'regression to the mean' effect.

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Appendix A: Chicane layouts identified

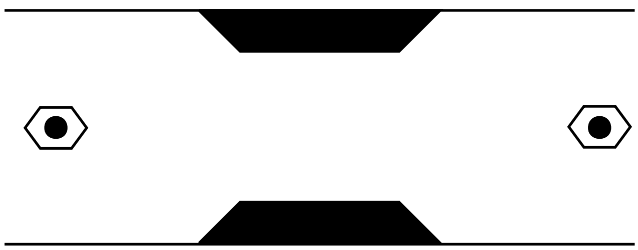
From the information returned by local authorities, the following designs of chicanes were identified. Designs have been grouped into the three categories: single lane working, two-way working, and chicanes with overrun areas.

Single lane working chicanes

A.1 Carriageway narrowing on one side, to one lane width.
(deviation limited to only one lane)

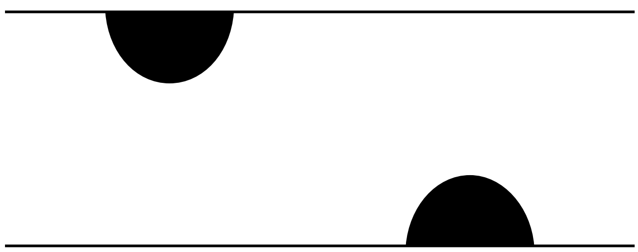
A.2 Carriageway narrowing on one side with central island on approach.
(deviation limited to only one lane)

A.3 Carriageway narrowing on both sides with central island on both approaches.

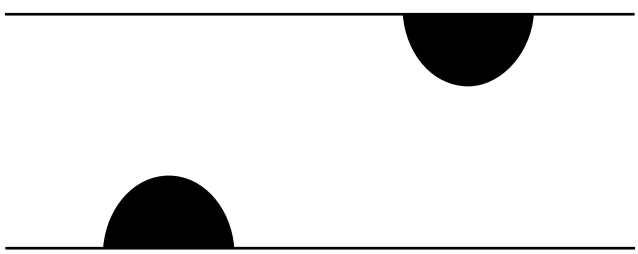


A.4 Staggered buildouts.

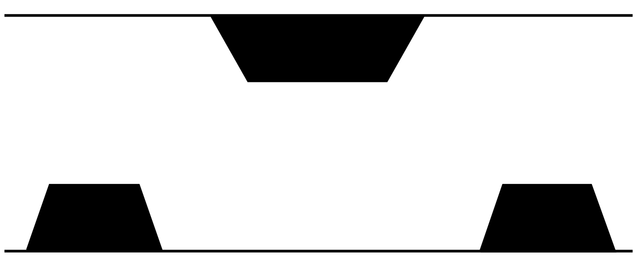
A.4a First buildout on nearside.
(deviation on entry)



A.4b First buildout on offside.
(deviation on exit)

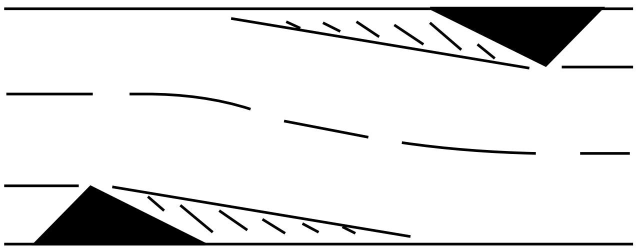


A.5 Staggered carriageway narrowings.

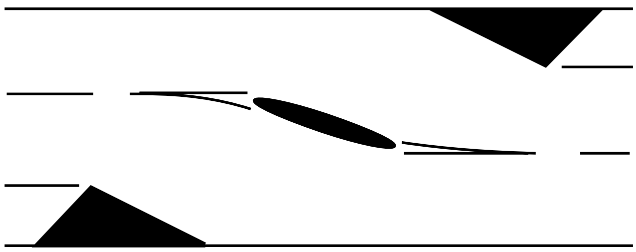


Two-way working chicanes

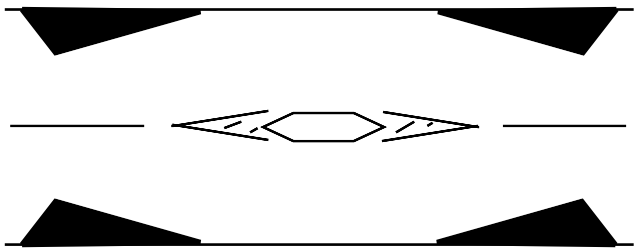
B.1 Staggered buildouts with no central island.



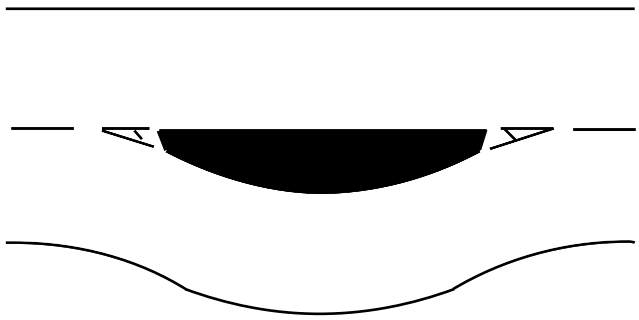
B.2 Staggered buildouts with angled central island.



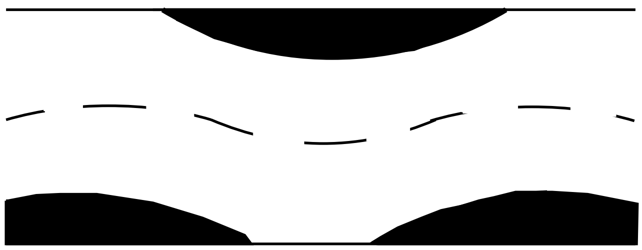
B.3 Carriageway narrowings either side of central island.



B.4 One lane affected by central island.

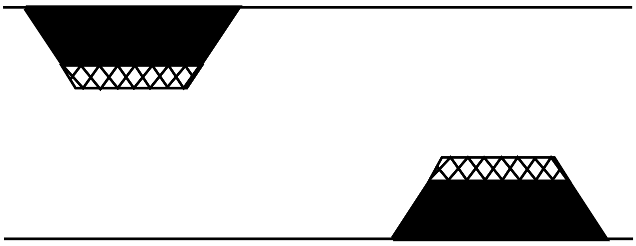


B.5 Buildouts without central islands.

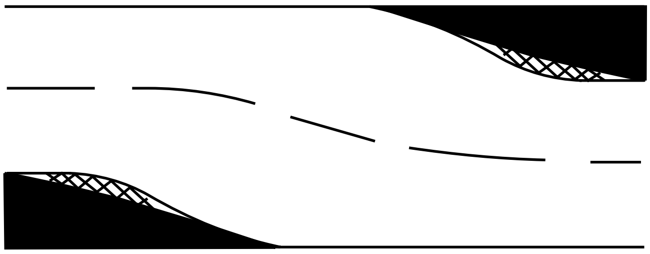


Chicanes with overrun areas

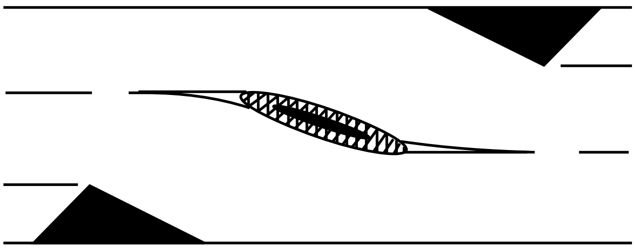
C.1 Single lane working with staggered buildouts.
(overrun areas on buildouts)



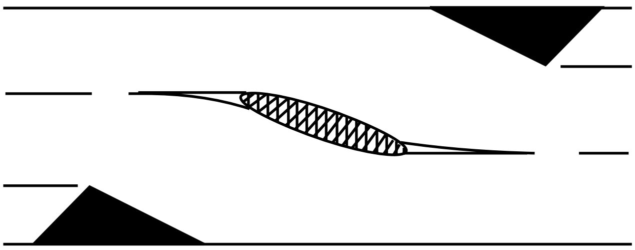
C.2 Two-way working with staggered buildouts.
(overrun areas on buildouts)



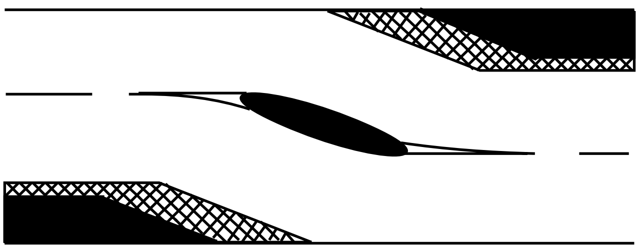
C.3 Two-way working with staggered buildouts and central island, overrun area on island.



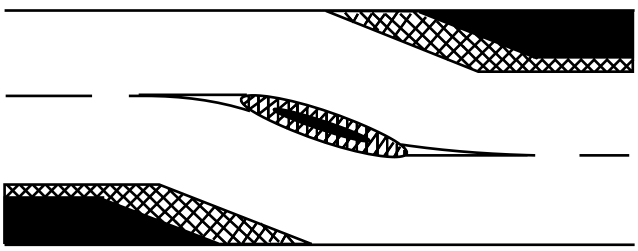
C.4 Two-way working with staggered buildouts and central island, island fully overrunable.



C.5 Two-way working with staggered buildouts and central island, overrun areas on buildouts.



C.6 Two-way working with staggered buildouts and central island, overrun areas on buildouts and island.



Abstract

Various types of horizontal deflections have been used in traffic calming to reduce the speed of traffic. The results in terms of effectiveness and public acceptability have not always been successful. Chicane trials on the TRL test track (1994), confirmed the potential of chicanes as traffic calming measures and established relationships between mean speed and chicane dimensions. Further work was commissioned by the Driver Information and Traffic Management (DITM) Division of the Department of the Environment, Transport and the Regions (DETR) to study chicane installations on the public roads.

This Report describes a variety of on-road chicane schemes in terms of design and location, speed reduction and accident reduction. The speed reductions at these schemes were compared with those from the TRL trials and relationships between mean speed and ‘path angle’ have been developed. Local authority experience was used in compiling advice and raising issues relating to good and bad practice in the design and installation of chicanes.

Related publications

TRL312 *Traffic calming - speed cushion schemes* by R E Layfield and D I Parry. 1998 (*In preparation*)

TRL311 *Traffic calming - public attitude studies: a literature review* by D C Webster. 1998 (price code H, £30)

TRL241 *Cyclists at road narrowings* by D G Davies, T J Ryley, S B Taylor and M E Halliday. 1997 (price code I, £32)

TRL238 *Traffic calming on major roads: the A47 trunk road at Thorney, Cambridgeshire* by A H Wheeler. P G Abbott, N S Godfrey, S M Phillips and R Stait. 1997 (price code L, £40)

TRL215 *Review of traffic calming schemes in 20 mph zones* by D C Webster and A M Mackie. 1996 (price code H, £30)

TRL186 *Traffic calming - road hump schemes using 75 mm high humps* by D C Webster and R E Layfield. 1996 (price code H, £30)

PR103 *Vehicle and traffic noise surveys alongside speed control cushions in York* by P G Abbott, S M Phillips and R E Layfield. 1995 (price code E, £20)

PR102 *Speed control using chicanes - a trial at TRL* by I A Sayer and D I Parry. 1994 (price code F, £23)

PR101 *Speed at ‘thumps’ and low height road humps* by D C Webster. 1994 (price code G, £28)

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PR18 *Road humps for controlling vehicle speeds* by D C Webster. 1993 (price code J, £35)

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