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Traffic Calming

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Contents

1. Introduction

1.1 Background

1.1.1 This Local Transport Note (LTN) brings together in one comprehensive document a summary of the research commissioned by the Department for Transport (DfT, formerly the DTLR, DETR and DoT), together with research from external sources, to provide advice on the use of traffic calming measures today. It covers relevant legislation and the design, effectiveness and installation (including signing and lighting) of measures. This LTN does not aim to cover issues such as driver education or speed limit enforcement.

1.1.2 The Government White Paper *The Future of Transport: A network for 2030* (DfT, 2004a) outlines the Department's long-term strategy and investment for transport. The White Paper updates and rolls forward the policies and long-term investment programme published in the Ten Year Plan for Transport in July 2000. The Government's vision for transport is for a modern, safe, high-quality network that better meets people's needs and provides better access to services and increased choice for everyone. Sustainability and an emphasis on efficiency and value for money are important underlying principles of the strategy.

1.1.3 Many urban regeneration schemes have recognised the need to develop high-quality environments in order to help to stimulate economic activity, improve safety and reduce crime. Traffic calming can help to contribute to the urban design process. The policy document *Our Towns and Cities: The Future – Delivering an Urban Renaissance* (DETR, 2000a) sets out the broad objective of making streets in the UK both safer and more attractive in the context of urban planning. This is reinforced in *Living Spaces: Cleaner, Safer, Greener* (ODPM, 2002), which sets out the Government's vision for public spaces.

1.1.4 Today local authorities also need to take on board wider quality of life issues. The highway is an area of public space and all the existing and potential uses of that space should be considered. For example, in residential areas designated as Home Zones uses of the street may include children's play, community green space, or simply areas where people can stop and chat. In order for these uses to take place safely, traffic calming and roadspace reallocation techniques are usually required in order to reduce the speed and dominance of motorised traffic.

1.1.5 The Rural White Paper *Our Countryside: the future – A fair deal for rural England* (DETR & MAFF, 2000a) sets out how in rural areas traffic calming can help to reduce the impact of through traffic in villages and can help to make rural roads safer for recreational use by walkers, cyclists and horse riders. Encouraging recreational use of the countryside is one of the elements in supporting diversification in the rural economy in order to preserve rural services. Research by Kennedy *et al.* (2004a and 2004b) suggests that on minor rural roads designated Quiet Lanes, with few, if any, associated traffic calming measures, vehicle flows are reduced but vehicle speeds stay much the same. Vehicle speeds were already low along these roads, averaging around 30 mph. However, if a wider variety of uses, such as sketching scenic views or nature trails, were to be encouraged, additional measures may need to be taken to reduce vehicle speeds still further.

1.1.6 At the heart of the new integrated policy is the encouragement of public transport, cycling and walking, and discouragement of using the car for inappropriate journeys. Traffic calming has a significant role to play in achieving these objectives by improving the safety of (and the environment for) vulnerable road users. This LTN illustrates techniques that can be used to support the objectives to increase levels of walking and cycling set out in *The Future of Transport* (DfT, 2004a) and *Walking and cycling: an action plan* (DfT, 2004b).

1.1.7 Speed management has been reviewed as part of the plan for future mobility, resulting in the publication of *New Directions in Speed Management* (DETR, 2000b). This emphasises the importance of setting the right speed limits, determining a hierarchy of roads defined by function, providing better information to drivers and designing roads that clearly indicate by their appearance which speeds are appropriate. The Department's guidance on setting local speed limits has been reviewed, and DfT Circular 01/06 *Setting Local Speed Limits* (which replaces Circular Roads 01/93 *Setting Local Speed Limits*) was published on 8 August 2006.

1.1.8 The speed policy review recognised road humps, chicanes and other road engineering measures as currently the most effective method of reducing vehicle speeds in urban (and some rural) areas. It found that there was no evidence that, when negotiated at sensible speeds, these cause damage to vehicles. However, along strategic routes for emergency services, consideration needs to be given to the most appropriate design that can minimise delay to emergency services while at the same time reducing and controlling the speed of other vehicles. A similar consideration needs to be given to bus routes.

1.1.9 Speed management is an important part of the Government's road safety strategy, and casualty reduction targets for 2010 were set out in *Tomorrow's roads: safer for everyone* (DETR, 2000c). Traffic calming measures, where appropriate, can help in the achievement of the new ten-year casualty reduction targets, particularly for pedestrians and children. To ensure that the features themselves are not a cause of accidents, it is recommended that traffic calming schemes are subjected to safety audit reviews. However, the results of a safety audit should not dictate the final scheme. Potential risks should be identified and ameliorated where this is possible without destroying scheme objectives, but their likelihood and severity must be balanced against likely social, environmental, economic and safety benefits of the scheme as a whole.

1.1.10 Traffic calming was introduced in the UK following successful schemes in mainland Europe that had improved safety in urban areas. While road safety in the UK was, and remains, very good compared to Europe, the UK has high accident rates for vulnerable road users in towns and cities. Traffic calming reduces speeds and hence improves safety, especially for vulnerable road users.

1.1.11 Speed and accident reduction are not the only valid objectives leading to the introduction of a traffic calming scheme. Other objectives may include encouraging non-motorised users, improving the local environment and reducing community severance. All objectives should be clearly stated at the outset and should tie in with both the authorities' strategic objectives and the needs and desires of the relevant stakeholders. A traffic calming scheme can provide an opportunity for the local community to get involved in the redesign of their street: considering uses, streetscape and sense of place as well as specific measures. Local authorities may have to make difficult decisions about the type of scheme they implement: weighing factors such as the size of area to be treated, against the quality and appearance of the final scheme.

1.1.12 In making a case for installing traffic calming measures, local authorities should carry out a comprehensive appraisal of impacts of any scheme, including the social and environmental gains or losses. Cross-disciplinary teams can consider a range of views and ensure that the impacts of the scheme are fully taken into account.

1.1.13 Appendix J provides advice on how an appraisal of impacts could be prepared.

1.1.14 This LTN gives guidance on traffic calming in the UK and also contains work published from other countries where applicable. All of the traffic calming measures described have strengths and weaknesses, which are discussed in the main body of the report and summarised for road humps, speed cushions and chicanes in Appendices E, F and G respectively.

1.1.15 A summary of traffic calming measures appears in Table 1.1. Detailed information on the impact of the various measures can be found by reference to the appropriate chapters. The information on the impact on vehicle emissions is taken from Boulter *et al.* (2001).

1.1.16 The effectiveness of a scheme as a whole can be improved by selecting the most appropriate measures to meet local objectives. However, similar measures may not always give similar results. The speed reduction obtained after implementation will depend on the magnitude of the before speeds as well as the type of measures introduced, and noise or vibration levels after implementation will be affected by the local traffic composition and the soil type. It should be noted that area-wide traffic calming schemes may well include a variety of measures, and in such situations it can be very difficult to attribute speed or casualty reductions to specific measures.

Table 1.1 Summary of measures and their relative performance

Type of measure	Chapter or Section in LTN	Impact on traffic speeds * * * = largest reduction	Impact on traffic flows * * * = largest reduction	Impact on injury accidents * * * = largest reduction	Delays to emergency services * * * = shortest delay	Relative public acceptability * * * = most acceptable	Impact on vehicle emissions * * * =smallest increase		
							CO	NOx	PM
Road hump									
Round-top	4.2	* * *	* * *	* * *	*	* * *	* *	* *	* *
Flat-top	4.2	* * *	* * *	* * *	*	* * *	*	*	*
Raised junction	4.2	* * *	* * *	* * *	*	* * *	*	*	* *
Sinusoidal	4.2	* * *	* * *	* * *	*	* * *	-	-	-
‘H’ hump	4.2	* *	* * *	* * *	* *	* * *	-	-	-
‘S’ hump	4.2	* *	* * *	* * *	* *	* * *	-	-	-
Thump	4.2	* *	* * *	* *	*	* *	-	-	-
Cushion	4.2	* *	* * *	* * *	* *	* *	* *	* *	* *
Rumble device									
Area	5.1	*	*	* *	* * *	* *	-	-	-
Strip	5.1	*	*	* *	* * *	*	-	-	-
Narrowing									
Island	6.3	*	*	*	* * *	-	-	-	-
Pinch point/build-out	6.3	* to * * *	* to * *	* to * *	* * *	*	* *	* * *	* * *
Chicane									
Single lane	6.4	* * *	* *	* *	* *	*	*	* * *	*
Two-way	6.4	* *	*	* *	* *	* *	-	-	-
Gateway	7	* *	*	* *	* * *	* *	-	-	-
Mini-roundabout	8	* *	*	* *	* * *	*	* * *	* *	* *
Vehicle activated device									
Vehicle activated signs	9.1	* *	*	* *	* * *	-	-	-	
Speed cameras	9.2	* *	*	* *	* * *	* * *	-	-	
Road markings, traffic signs and furniture									
Roundels	10.2	*	*	*	* * *	* * *	-	-	
Coloured surfacing	10.2	*	*	*	* * *	-	-	-	

1.1.17 A scheme may fail to win approval from a majority of those questioned in interview surveys because residents, motorists and other road users have different priorities and it is often difficult to balance their conflicting aspirations. Acceptability may well be one of the most important considerations, as an unpopular measure may have to be removed. Effective consultation and realistic scheme objectives are therefore very important. There is no point stating that speeds will be reduced to, say, less than 20 mph, if the type of measures chosen are known not to achieve these speeds.

1.1.18 It is generally agreed that, if drivers can be persuaded, through education and enforcement campaigns, to drive more slowly and with more consideration for other road users, then traffic calming measures would not be required. Until that day arrives, however, traffic calming provides a proven and effective way of saving lives and reducing casualties.

1.1.19 Whilst most of the information contained in this LTN will apply to existing streets, it may also be helpful in determining appropriate designs for new developments.

1.1.20 Traffic signing, including road marking, is important for directing and guiding traffic of all types through and around traffic calming measures. However, it is important that sign clutter is avoided, particularly in environmentally sensitive areas. Legislation allows considerable flexibility with regard to signing requirements. For example, in 20 mph zones, the Highways (Road Humps) Regulations allow road markings for road humps to be omitted. Careful consideration, therefore, needs to be taken in the design of signing for traffic calming schemes.

1.1.21 Having regard to all that is mentioned above, it is suggested that, as far as possible, the whole environment should be taken into account when considering the use of traffic calming measures.

1.2 Early traffic calming

1.2.1 Traffic calming was first introduced into the UK with the 1865 Red Flag Act. This restricted vehicle speeds to about 4 mph, by requiring a pedestrian to walk in front of the moving vehicle. The Red Flag Act was repealed in 1896, allowing vehicles to travel at 12 or 14 mph, depending on the local byelaws. In 1903 the Motor Car Act raised the limit to 20 mph, and in 1930 the 20 mph limit for cars and cycles was abolished. In 1934 a limit of 30 mph was introduced in built-up areas, but other roads had no speed limit until a national limit of 70 mph was introduced in 1965. Speed limits of 40 mph were introduced on some roads in 1960. In 1990, 20 mph zones were allowed, as long as suitable traffic calming measures had been installed to ensure speeds reduced to 20 mph or less. Traffic calming has so far usually been implemented by installing highway engineering measures, which do not influence the driver’s ‘state of mind’, but physically restrict the manner in which the vehicle is driven.

1.2.2 Increasingly, highway authorities are aiming to change driver attitudes, in particular their perception of the appropriate speed for the road in question. This may be done by physical changes to the streetscape: emphasising the start of a different type of area, developing a sense of place, raising awareness of other activities taking place on or adjacent to the street and changes to the ‘feel’ of the street. It may also involve driver education and awareness raising via advertising campaigns, involvement in the scheme development, speed pledges, driver training and the like. Driver education and awareness raising approaches are not covered in this LTN.

1.3 Modern traffic calming

1.3.1 Traffic calming is a useful way of controlling drivers’ speeds where speeds are either excessive and/or inappropriate for the type and use made of a road. Justification for installing traffic calming is often based on improving safety by reducing accidents. Whilst the number of accidents on residential roads is often relatively low, and usually scattered over a wide area with highly variable annual accident rates, the use of traffic calming enables an area-wide approach to be adopted to address such isolated incidents.

1.3.2 Changes in speed have been shown to bring about changes in injury accidents. A good rule of thumb is that a 5 per cent reduction in injury accidents can be expected to result from a 1 mph reduction in mean speed (Taylor *et al,* 2000). The reduction varies according to road type, and is 6 per cent for urban roads with low average speeds, 4 per cent for medium-speed urban roads or lower-speed rural main roads and 3 per cent for higher-speed urban roads or rural main roads. In some traffic-calmed areas, personal injury accidents have been reduced by 60–70 per cent following speed reductions of about 9 mph. The proportion of accidents that are fatal or involve serious injury has also been reduced (Webster, 1993a; Webster & Mackie, 1996; Barker & Webster, 2003).

1.3.3 Whilst traffic calming measures have improved safety overall, they have not always been popular. Some of the issues and limitations that have been exposed include:

- Buses – journey times can increase, as can passenger discomfort and concerns about passenger safety (especially when humps or cushions are placed at or near bus stops). There are also some concerns about increased wear to buses.

- Emergency services – physical speed-reducing measures can adversely affect the response times of emergency services vehicles. This is particularly relevant to fire and ambulance services. All services should plan routes in traffic-calmed areas with the local highway authority, so that the fastest routes are used, rather than the shortest.

- Public opinion – can be very supportive, but in some cases resistance from residents has required removal of measures. Key factors are the priority of road safety on the local agenda, the quality of the scheme design and the approach adopted for the consultation process.

- Cyclists – can find some traffic calming measures uncomfortable, particularly where measures have high upstands. Design of measures needs to take cyclists into account and, where feasible, provide encouragement in the form of cycle bypasses.

- Motorcyclists – can find some measures difficult to negotiate.

- Equestrians – reported to find that some measures, such as pinch points, have an adverse effect on their safety.

- Disabled or older occupants of vehicles, particularly those with pre-existing back conditions, can find measures, specifically but not exclusively vertical deflections, more uncomfortable and more difficult to negotiate than more able bodied persons do.

- Local environment – traffic calming measures change speed profiles and in some circumstances may lead to higher emission and noise levels. Care needs to be taken to minimise any such adverse effects by encouraging smooth driving patterns. There is also an issue with the quality of some treated areas in terms of urban design and local distinctiveness.

1.3.4 This LTN does not attempt to cover every eventuality, and local highway authorities need to ensure that an adequate duty of care is exercised and that the designs chosen do not compromise the safety of road users. Traffic Advisory Leaflets (TALs) will still be made available and new leaflets will be published as research results emerge, as will other DfT publications. Appendix A contains a list of relevant DfT advice, other publications and relevant legislation at the time of printing.

1.3.5 It should be noted that this LTN is primarily concerned with traffic calming which has been carried out in the UK. However, it has been supplemented with information from other countries where this is thought to be appropriate.

2. General considerations

2.1 Traffic calming legislation

Vertical deflections

2.1.1 The primary legislation is contained in sections 90A to 90F of the Highways Act 1980 (as amended by the Transport Act 1981). The Act (sections 90A and 90B) makes it clear that road humps can only be constructed on roads with speed limits of 30 mph or less. There are exemptions for London (see paragraph 2.1.5). There are requirements to advertise, and to consult the police (section 90C). The Act also provides assurance that road humps constructed in accordance with the regulations, or specially authorised, or constructed prior to adoption of the highway, are not treated as obstructions (section 90E).

2.1.2 The original Road Hump Regulations allowed round-top humps 100 mm high and 3.7 metres long to be installed on roads in England and Wales with a speed limit of 30 mph or less. In 1986, revised Regulations allowed humps between 75 and 100 mm high. The subsequent Hump Regulations allowed flat-top humps and round-top humps between 50 and 100 mm high. Other hump profiles were not permitted under the 1990 Hump Regulations, although local authorities were allowed to apply to the DoT for special authorisation. Since 1996, the Regulations have allowed local authorities to choose the most appropriate hump profile.

2.1.3 The Highways (Road Humps) Regulations, 1999 (Statutory Instrument 1999 No. 1025) are the current regulations setting out provisions for road humps in England and Wales. They allow local authorities to install humps (including speed cushions) on roads with a speed limit of 30 mph or less, without the need for special authorisation, provided the humps are between 25 and 100 mm high, at least 900 mm long in the direction of travel, and have no vertical face greater than 6 mm. These regulations also remove certain provisions for road humps within 20 mph zones.

2.1.4 The 1999 regulations provide local highway authorities outside London with considerable flexibility in the design and placement of road humps. However, the regulations make local highway authorities responsible for the design and placement, so authorities will need to ensure that an adequate duty of care is exercised.

2.1.5 The Greater London Authority Act 1999 allows local authorities in London to construct humps of any dimension on roads subject to any speed limit (without the need for special authorisation, but with a requirement to consult the Secretary of State). This greater freedom of action places greater responsibility on the London local authorities and Transport for London (TfL) to ensure that an adequate duty of care is exercised.

2.1.6 Humps where the height could be varied mechanically need particular consideration with regard to the safety of road users. Local authorities wishing to install such devices on the public highway are advised to consult the Department for Transport's Road User Safety Division on the need for special authorisation.

2.1.7 The use of transverse depressions in the carriageway has been suggested as an alternative to road humps, and has been tried in some countries (Hass-Klau *et al*, 1992). Their use can be better than humps in snowy conditions, but on public roads in the UK they would require special authorisation.

2.1.8 The Traffic Signs Regulations and General Directions 2002 (TSRGD) covers road markings for road humps, speed cushions and thermoplastic humps ('thumps').

Other traffic calming measures

2.1.9 The Traffic Calming Act 1992 amended the Highways Act 1980 by the addition of Sections 90G, 90H and 90I which allow works to be carried out 'for the purposes of promoting safety and preserving or improving the environment'. The 1992 Act made the first specific reference in legislation to traffic calming.

However, it does not preclude the use of other powers in the Highways Act 1980 and elsewhere under which traffic calming features can be provided.

2.1.10 Other powers in the Highways Act 1980 include: section 64 (roundabouts), section 68 (pedestrian refuges), section 75 (variations in the relative width of carriageways and footways), section 77 (alterations in the level of a highway) and section 90 (build-outs, chicanes, pinch points, gateways, islands, overrun areas and rumble devices). There is no requirement in the Act limiting the installation of these measures to roads with a 30 mph speed limit or less.

2.1.11 The Highways (Traffic Calming) Regulations 1993 and 1999 clarified the powers available to local highway authorities to construct particular measures for traffic calming purposes. The measures include gateways, pinch points, islands, overrun areas, rumble devices, build-outs and chicanes (TAL 07/93). In 20 mph zones, warning signs for these traffic calming features may be omitted. However, warning signs should be provided where appropriate for non-traffic-calming features. 'Give way' markings to assign priority at a chicane would also still be required in a 20 mph zone.

2.1.12 The regulations allow the installation of rumble devices, provided they do not exceed 15 mm in height and no vertical face exceeds 6 mm in height.

2.1.13 As with road humps, the Greater London Authority Act 1999 allows local authorities in London to construct traffic calming measures of any type on roads subject to any speed limit (without the need for special authorisation but with a requirement to consult the Secretary of State). This greater freedom of action places greater responsibility on the London boroughs to ensure that an adequate duty of care is exercised.

2.1.14 The Transport Act 2000 allows local traffic authorities to designate Home Zones and Quiet Lanes. Designation requirements are set out in the Quiet Lanes and Home Zones (England) Regulations 2006 which also enable the making of use orders and speed orders.

2.2 Traffic calming as part of local road safety strategy and local transport plans

2.2.1 Traffic calming schemes are an important element in local road safety strategies, which set out how authorities plan to tackle road traffic casualties in their area and why they believe their approach will be effective (see Appendix B). The safety strategies should include speed management to achieve safe vehicle speeds on all roads, and ensure that the speed limits set are appropriate, consistent and enforceable. Traffic calming measures should be employed to encourage both speed reduction and compliance with the limits. Particular attention will need to be given to locations where child casualties occur, including roads around schools, the routes children use to get to and from school and residential areas where they are more likely to play, walk or cycle unsupervised. The Travelling to School initiative is encouraging schools and local authorities to put in place travel plans, which may contain traffic calming measures. It may also be relevant to consider the use of traffic calming measures where there are likely to be large numbers of disabled people, such as day centres.

2.2.2 Local road safety strategies should be considered in the context of urban safety management. Traffic calming schemes that are installed on a piecemeal basis may create problems, particularly if road hierarchies and strategic routes have not been brought together as outlined in the guidelines from the Institution of Highways and Transportation (IHT, 1990 & 1997).

2.2.3 Local road safety strategies are incorporated into Local Transport Plans (DfT, 2004c). These have been introduced as the system of allocating resources for local transport capital expenditure. They are designed to cover all forms of transport as well as co-ordinate and improve local transport provision.

2.2.4 In assessing the potential impact of alternative area-wide traffic calming schemes, the use of *Safe*NET (Burrow, 1999) may be helpful. This is a program that can predict the likely effects on safety of a scheme, taking account of possible changes in traffic patterns.

2.2.5 It is helpful for authorities to contribute local safety data to the MOLASSES project. This project, initiated by the County Surveyors' Society (CSS), is able to assess different treatments in relation to specific accident problems. The aim is to give individual authorities a better idea of the effectiveness of different types of scheme. The traffic calming measures used in the plans can be evaluated by following the procedures given in the RoSPA manual (2002). Progress reports of the MOLASSES project has been produced (Mackie, 1997; Gorell & Tootill, 2001). The web site (www.trl.co.uk/molasses) dedicated to MOLASSES enables local authorities to submit information and queries.

2.3 Use of traffic calming for security purposes (e.g. anti-terrorism)

2.3.1 Amendments to the Highways Act 1980 and Roads (Scotland) Act 1984 (traffic calming works regulations) made by the Civil Contingencies Act 2004 (part 3, schedule 2) now enable local authorities to introduce traffic calming for the purposes of slowing down traffic in the vicinity of potentially vulnerable or sensitive sites where a security threat has been identified. The blend of any (preferably self-enforcing) traffic calming and vehicle restraint measures (bollards, blockers etc) can better manage the risk from penetrative attacks by hostile vehicles (vehicle bombs etc). Vehicle restraint measures can be less substantial (and therefore typically more aesthetically pleasing) if the speed of approaching hostile vehicles is reduced. Traffic calming and restraint measures may accompany new traffic regulation measures introduced either temporarily or permanently through Anti-Terrorist Traffic Regulation Orders (ATTROs).

2.3.2 ATTROs are made using sections 22C or 22D of the Road Traffic Regulation Act 1984 as amended by the Civil Contingencies Act 2004 (part 3, schedule 2, part 3). ATTROs should typically be used sparingly and only when prompted by the direct involvement of the local police Counter Terrorism Security Advisor (CTSA) and highways or traffic experts from the National Security Advice Centre (NSAC) whose contact details are available through the Traffic Management Division of the DfT. A list of crash-tested products and systems for such security uses is available from the same experts, along with advice on the implementation of any such measures.

2.4 Consultation

Initial consultation

2.4.1 Highway Authorities have a statutory duty to consult the police (Highways Act 1980) when road hump schemes are proposed for a road or area (TAL 03/94) and they must also post notices in the street and in local papers advertising the scheme. The 1999 Highways (Road Hump) Regulations require consultation with the fire service, ambulance service and organisations representing those who use the road. This would include the residents' organisations and the bus operators, but it may also include haulage or agricultural organisations in certain areas. It is also recommended that the consultation process does not just cover the statutory duties requirements, but that authorities should open up a dialogue with all interested parties (including pedestrians, disabled people, cyclists' groups and, where appropriate, equestrians) to try to ensure that there is a consensus in favour of the scheme. For disabled people see Laria guidance (www.laria.gov.uk).

2.4.2 In recent years, the London Ambulance Service has raised concerns that traffic calming may have a detrimental effect on ambulance response times. A regular dialogue has been established to determine the nature of their concerns and assist with possible solutions.

2.4.3 As a result, the Department has revised its Traffic Advisory Leaflet *Fire and Ambulance Services - Traffic Calming: A Code of Practice* (TAL 1/07). The revised leaflet re-emphasises the need for local authorities to establish at an early stage of scheme design a meaningful dialogue with the emergency services affected by the schemes.

2.4.4 Highway authorities also have a statutory duty to consult the police when traffic calming (other than road humps) measures are proposed under the Highways (Traffic Calming) Regulations 1999. The authority must also consult organisations or groups who use the road or others who are likely to be affected by the traffic calming work. Whilst these regulations are less prescriptive than the hump regulations, it is suggested that authorities may use the same overall consultation procedure as for road humps for all traffic calming schemes.

2.4.5 The consultation with road users should include Network Rail if road humps (or other traffic calming measures) are proposed to be installed near a level crossing. The concern in this instance relates to any blocking back of traffic that might occur on to the level crossing, particularly at automatic half-barrier crossings. A minimum distance of 20 metres is required between a level crossing and a road hump, but local circumstances may require greater spacing.

2.4.6 When considering the use of schemes that are not fully self-enforcing, attention should be paid to the consultation provisions of the Crime and Disorder Act 1998 regarding the level of police enforcement that might be required to ensure significant reductions in speed (see paragraph 3.2.10).

2.4.7 Local authorities need to take account of the Planning Policy Guidance given in PPG 13 (DETR, 2001a). This aims to integrate land use planning and transport so as to provide more sustainable transport choices, promote accessibility and reduce the need to travel, especially by car. Within town centres, priority should be given to people over motor traffic: here local authorities should actively consider traffic calming together with the reallocation of road space to promote safer walking and cycling, and to give priority to public transport. Home Zones should be used as a model for new residential areas, encouraging low car speeds or even car-free areas where there is sufficient alternative access. In established residential areas, traffic management tools need to be used creatively to support traffic calming. Consideration should be given to the use of 20 mph zones and Home Zones, where applicable.

2.4.8 It is important that, before finalising a scheme, designers review the likely effects on vehicle generated noise, vibration, exhaust emissions and air quality. These environmental issues are discussed for individual traffic calming measures within each of Chapters 4 to 8 of this document. The Environment Act 1995 and the Air Quality Regulations 1997 require local authorities to examine air quality. Where concentrations of pollutants exceed those given in the National Air Quality Standards, steps must be taken to reduce the concentration. As far as possible, the designers of a traffic calming scheme should try and mitigate any detrimental effects on noise, ground-borne vibrations and air quality.

Subsequent consultation

2.4.9 The amount of subsequent consultation needed will depend on the degree of detail given in the initial consultation of the type and location of the traffic calming measures. Where possible, the schemes should be modified to meet local concerns. The local authority should consider all objections to a scheme, but it is important that any modifications to a scheme do not significantly compromise the overall safety strategy.

2.5 Routes for buses

2.5.1 Bus routes are an important part of any integrated transport system, and it is therefore important that the bus operators are consulted before a traffic calming scheme is implemented. Issues of relevance to bus operators include the likely impact of traffic calming measures on passenger comfort (especially older passengers) and patronage, drivers' health, bus journey times and vehicle maintenance costs (Trench & Ball, 1995). The viability of the service may also need consideration.

2.5.2 TfL has issued guidelines on traffic calming measures, which give a bus operator's point of view (TfL, 2005). Information regarding articulated buses was based on trials carried out on behalf of TfL (Greenshield *et al.*, 2004). The CSS together with the Confederation of Passenger Transport (CPT) have published a similar document (CSS, 1997). These organisations are generally supportive of the use of horizontal deflections on bus routes but have strong reservations about the use, in terms of number and type, of vertical deflections, particularly round-top humps.

Measures modified or developed to cater for buses

2.5.3 Road humps constructed to the maximum permitted height (100 mm) have elicited comments from bus operators about passenger and crew discomfort and increased maintenance costs for vehicles. Some of these objections can be overcome by using humps with lower heights (75 mm) and shallower on/off ramp gradients (1:15), as recommended by the Department (see Chapter 4). Studies of traffic calming schemes using 75 mm high humps have found that they can provide large reductions in traffic speeds, and have been introduced with only a few adverse comments from the bus operators (Webster, 1995b; Webster & Layfield, 1996). However, recent anecdotal evidence suggests that opposition to road humps from bus companies may be increasing.

2.5.4 For flat-top humps (Fig. 2.1), the shallower the gradient of the on/off ramps, the lower the speed reduction. Trials by local authorities indicate that gradients of about 1:15 were noticeably more comfortable than gradients of 1:10, but little further gain was obtained with gradients of 1:15 and 1:20. This suggests that 1:15 would be a suitable compromise to obtain reasonable speed reduction without excessive discomfort (TAL 02/96). TfL recommends an off-gradient of 1:20 (TfL 2005). The length of plateau between the on and off ramps may also affect driver and passenger discomfort. However, the relationship between plateau length and passenger discomfort is less well documented, the results are not so consistent and may depend on the bus type and suspension of the vehicle. Most bus companies prefer a plateau length of at least 6 metres, which can accommodate the wheel base of most buses in the UK. TfL recommends a 12.5 metre length for articulated buses and buses greater than 15 metres in length (TfL 2005).

2.5.5 In test track trials of 75 mm high hump profiles, the discomfort experienced by bus passengers increased substantially as crossing speeds increased from 15 to 20 mph. At speeds below 15 mph, the average discomfort experienced by passengers in a mini-bus was higher than that for the other the types of bus tested. In these trials, a 3.7 metre long round-top hump profile was found, on average, to be more comfortable for all bus types tested than a flat-top hump with a 6 metre long plateau and on/off ramp gradients of 1:13 (Sayer *et al.*, 1999).

2.5.6 Bus operators are recommended to encourage drivers to cross humps at 15 mph or less to minimise discomfort. For some combinations of bus type and hump profile, a steady speed of 15 mph may be appropriate along roads where humps are present.

2.5.7 When humps are constructed on inclines of about 1:10, buses can ground at the front or the rear, depending on if they are going up or down hill. 'Uphill' ramp gradients of 1:15 used on inclines of 1:10, and shallower ramp gradients (of up to 1:35) for steeper inclines, have been found to be satisfactory. 'Downhill' ramp gradients of between 1:10 and 1:13 appear to be satisfactory. The 'uphill' ramp is defined as the first ramp encountered when a vehicle is travelling uphill, and the 'downhill' ramp is the first ramp encountered when a vehicle is travelling downhill.

2.5.8 The ground clearance of low-floor buses is generally similar to other buses. However, there can be greater overhang at the front and rear, which may cause grounding for some vehicles when crossing humps at inappropriate speeds. Trials at the Transport Research Laboratory (TRL) involving a low-floor single-deck bus travelling over 75 mm high humps did not find any grounding problems at speeds up to 20 mph.

2.5.9 One-way streets with bus routes can benefit from having humps with shallower off-ramps (1:20 compared to 1:15) which can reduce passenger discomfort over the hump (Webster & Layfield, 1996).

2.5.10 When humps are used on bus routes, it may not be appropriate to locate them close to bus stops, as buses going over the humps could jolt standing passengers sufficiently to cause them to fall.

2.5.11 Articulated buses have been used in other parts of Europe for some time, and in Sweden speed cushions (Fig. 2.2) are the preferred type of road hump for this type of bus. The numbers of this type of bus are increasing in the UK, for example in London, and therefore special attention may be necessary if they are intended to operate along a route with traffic calming.

2.5.12 Speed cushions are an alternative form of vertical deflection device. Originally introduced in Germany, they are intended to cause less interference than road humps to larger vehicles, such as buses and some emergency vehicles (see Chapter 4). They

Fig. 2.1 Bus trials over flat-top humps

Fig. 2.2 Bus trials over cushions

comprise raised areas positioned in the carriageway, which limit the vertical deflection of large vehicles with wide track widths by allowing them to straddle the measures.

2.5.13 On-road trials of speed cushion schemes have found that passengers in large buses are likely to experience low levels of discomfort, provided the buses straddle the cushions (Layfield & Parry, 1998). Bus passenger discomfort increased when buses did not straddle the cushions, and was similar to that measured when crossing 75 mm high humps. A study of 34 UK speed cushion schemes found that generally the bus companies were very supportive of the use of speed cushions. Cushions should be placed away from bus stops and at sufficient distance from junctions to allow buses room to align and straddle the cushions. Vehicles parked adjacent to cushions can also make it difficult for buses to straddle the cushions.

2.5.14 It may be appropriate to consider introducing waiting restrictions where speed cushions are used, in order to ensure that buses can be aligned to straddle the cushions evenly. When considering the use of waiting restrictions, it is important to ensure that these will cover situations when parking may cause problems, such as evenings and weekends. Physical measures such as build-outs and refuges (see paragraphs 6.3.5 and 6.3.10) should be considered in these circumstances.

2.5.15 Some cushion schemes were found to be suitable for large single and double deck buses, but unsatisfactory for smaller mini-buses and ambulances because of discomfort experienced by passengers in those vehicles. Reducing the cushion width to 1600 mm reduces the levels of discomfort in mini-buses and ambulances, but is likely to result in higher crossing speeds for cars.

2.5.16 The principle of the 'combi' or 'H' hump (Fig. 2.3) was developed in Denmark. Trials showed that it was possible to design a combined hump, with two longer, shallower outer profiles to take the tyres of buses, and a shorter inner profile to take cars. The dimensions of the profiles were chosen to minimise differences in car and bus speeds. 'H' humps, and a further development termed the 'S' hump, have been used in Fife (paragraph 4.2.10) and Northampton (see Chapter 4). The mean speed of buses over these humps was about 16.5 mph. This was about 3 to 6 mph slower than average car speeds. Replacement of 1800 mm wide speed cushions in Northampton with an 'S' hump increased the mean speed of cars by 1.5 mph to 19 mph and reduced the mean speed of buses by 2.5 mph to 16.5 mph. These average speeds are about 6 mph higher than the average speeds obtained with 75 mm high round-top and flat-top humps.

2.5.17 Chicanes on bus routes (Fig. 2.4) may cause discomfort by throwing passengers sideways if the buses are driven through them at unsuitable speeds. Chicanes need to be designed so that there is sufficient room for buses and other large vehicles to manoeuvre through them without excessive delay, and at the same time have a speed reducing effect on smaller vehicles such as cars (see Chapter 6). This can be done by the use of overrun areas which give car drivers the impression of a restricted carriageway width but allow additional manoeuvring room for larger vehicles (See Chapter 5). However, it is possible that overrun areas may lead to discomfort for bus passengers.

Fig. 2.3 Bus on H hump

Fig. 2.4 Bus in chicane

2.5.18 Footway build-outs (Fig. 2.5) at bus stops can be incorporated into road layouts where a series of horizontal realignments is used to reduce speeds. General advice on the design of build-outs can be found in *Traffic Calming Techniques* (IHT & CSS, 2005).

2.5.19 The introduction of a new traffic calming scheme may also be an opportunity for improving bus conditions, for example by altering kerb heights or improving waiting areas. This type of work may cost relatively little but improve relationships with bus companies.

Fig. 2.5 Chicane of pedestrian refuge and sheltered parking

Effects of traffic calming measures on bus drivers

2.5.20 Concerns have been raised about the effects on back pain or injury of driving over humps on a regular basis. However, it is difficult to identify any extra effects due to road humps in addition to those resulting from general driving. Evidence has been found by Jarvis & Giummara (1992) suggesting that poorly maintained roads may well result in vertical accelerations in buses regularly exceeding those generated by slowly crossing over road humps.

2.5.21 A review of the effects of humps on professional drivers, bus passengers and those with a mobility impairment (Webster, 1998a) showed that very little published information on this subject was available. However, it was clear that the potential problems to professional drivers were being minimised by better designs and information.

2.5.22 As a result of continued concerns, the Department commissioned further research to examine the impact on drivers and vehicles of repeatedly crossing road humps. The results of this research are discussed in paragraphs 4.5.24–4.5.26 and reported in full in TRL Report 614 (Kennedy *et al*., 2004e).

2.5.23 It is important that professional drivers and their employers are aware of the steps that should be taken to minimise the effects of continuous crossing of road humps and other traffic calming features. A booklet is available from the Health and Safety Executive (1996) which gives guidance to employers on reducing back pain to drivers. The advice is general, but it covers the main areas of seating posture, suspension seats, choosing the right vehicle for the task, ensuring tyre pressures are correct, varying work patterns and, crucially, keeping speeds low when crossing vertical deflections (e.g. a road hump).

2.6 Routes for emergency service vehicles

2.6.1 There is concern that the cumulative effect of the growing number of traffic calming schemes could compromise the ability of fire and ambulance service operators to meet the required response times. There have also been suggestions that traffic calming features might unwittingly lead to increased patient discomfort, or cause damage to equipment carried in ambulances or fire appliances. As a result, some emergency services submit blanket objections to all traffic calming schemes, without discussing them with local authorities.

2.6.2 Some fire services have fixed strategic routes through cities and towns in order to reach their destinations. Local authorities should adopt an Urban Safety Management strategy to determine the current and possible future functional hierarchy of main roads, local distributor roads and access roads. Continuing dialogue over the years has led to a mutual appreciation of aims and concerns, and has enabled a number of authorities to relate their road safety strategy to the fire services' strategic routes.

2.6.3 From this, a Code of Practice on arrangements for consulting on proposals to introduce traffic calming measures was agreed by the Joint Committee on Fire Brigade Operations, the Department of Health's Ambulance Policy Advisory Group, the Local Authority Associations and the Department for Transport, Local Government and the Regions (DTLR) (TAL 03/94) in 1994.

2.6.4 This states that the local authority might reasonably be expected to agree with the fire and ambulance services strategic routes from base stations to all parts of a town or city. More severe speed reduction measures should not be used on these routes. A minimal number of road humps, or other types of vertical or horizontal deflection measures, could be considered for these routes. In these circumstances, road humps, for instance, should not be sited closer than 100 metre intervals, and should have a maximum height of 75 mm. Where raised junctions are used, it can be an advantage to use shallower gradients of between 1:15 and 1:20.

2.6.5 Speed cushions (see Chapter 4) can be an alternative to full width road humps and have been supported by a number of fire and ambulance services operating in areas where they have been installed. Road trials have indicated that, because of reduced discomfort, 'urgent' crossing speeds for fire appliances over speed cushions could be 10–20 mph higher than over road humps (Layfield & Parry (1998). If there is a route that fire appliances or ambulances use frequently, then it would seem advisable to use cushions no wider than 1600 mm (TAL 01/98). As with bus operators, fire and ambulance operators are concerned about parking in the vicinity of the cushions, which can prevent the cushions being straddled evenly.

2.6.6 It is important that the views of the local emergency services are taken into consideration. It should be noted that the type and age of fire engines or ambulances used within a local authority area may influence the type and dimension of measures that are acceptable to the local services. Thus the acceptability of measures may vary across the UK.

2.6.7 The emergency services cannot always drive slowly over road humps when they are on an emergency call, and therefore it is essential that they know the safe maximum speed that they can negotiate the humps or speed cushions in a particular road. This safe speed will depend largely on the type of emergency vehicle, the experience and skill of the driver and the level of discomfort that can be tolerated.

2.6.8 If possible, the local authority should consider creating additional access routes for emergency vehicles, for example where an estate has received area-wide traffic calming. This approach has been trialled in Hull, where response times (and the number of humps to be traversed) were cut by the introduction of an additional access controlled by rising bollards.

2.6.9 There is little quantitative evidence relating to the delays imposed on emergency services by traffic calming. Coleman (1997) described a study in the United States in which an assessment was made of the effects of traffic calming measures on the response of fire service vehicles. Depending on the type of fire vehicle and the desirable speed response, the delays imposed by roundabouts and road humps were between about 1 and 10 seconds. A limited trial in the UK (Boulter *et al*, 2001) with a fire tender and a road circuit containing a mixture of measures (flat-top humps, speed cushions and chicanes) found delays of about 1.4 seconds per measure.

2.7 Vulnerable road users

Pedestrians

2.7.1 Walking has a major role in transport and the government wants walking to be easier, more pleasant and safer than it is now. Advice to local authorities is given in TAL 02/00 (*Framework for a* *local walking strategy*). The Department has also published an action plan which sets out a series of measures to promote, and improve provision for, walking and cycling (DfT, 2004b). The Department has carried out a public consultation on a draft LTN on walking and cycling and expects to publish it in 2007. The most important problem is inappropriate vehicle speed. Reducing speed, particularly in residential areas and along busy pedestrian routes, can reduce accidents significantly and make injuries much less severe. Speed can be tackled in a number of ways. Traffic calming, education and publicity all play their part. Ultimately, however, it is the responsibility of the driver to be aware of pedestrians and drive at a speed that is within the speed limit and appropriate to the conditions.

2.7.2 It has been shown (Webster & Mackie, 1996) that pedestrian accidents were reduced by 63 per cent where 20 mph zones were introduced in the UK. Dutch research also indicates that area-wide traffic calming measures can have a positive effect on pedestrian safety. However, site-specific measures (narrowings and median islands) have been found to be less effective in terms of numbers and severity of pedestrian injuries (Dijkstra & Bos, 1997).

2.7.3 In siting traffic calming measures, consideration should be given to existing and likely pedestrian flows and movements, remembering that pedestrians frequently cross the road where it is most convenient for them to do so. Judgements will need to be taken on the extent to which pedestrians are likely to use the measures to help them cross the road (Sections 2.9 and 2.10).

2.7.4 Where an island is likely to be used as a pedestrian crossing facility, a pedestrian refuge should be considered. Dropped kerbs and tactile surfacing should be used for any formal crossing point. Since an upstand of more than 6 mm may interfere with the movement of people in wheelchairs, DfT advice (DETR, 1998b) is that, as far as possible a flush surface should be provided between the footway and carriageway.

2.7.5 If a traffic island is used which requires vehicles to make a relatively sharp deflection, drivers may concentrate their attention on this manoeuvre and be less aware of nearby pedestrians (see Chapter 6). It may therefore be necessary to introduce additional features to discourage the use of the traffic island for pedestrian crossing purposes, or if possible to ensure the island is sited away from pedestrian desire lines. Dropped kerbs should not be provided at traffic islands.

2.7.6 Entry treatments can provide improved side road crossing facilities for pedestrians. Build-outs reduce the width of the road that pedestrians have to cross. Kerb-to-kerb flat-top road humps, *with a maximum height of 100 mm to be legal*, can provide a level crossing facility. At some locations, this may not be possible and the level of the footway may need to be dropped slightly to align with the top of the humps. Where the width of the carriageway is maintained over the entry treatment, pedestrian refuges can be provided to assist crossing movements.

2.7.7 A pedestrian crossing can be combined with a hump to form a 'humped crossing', provided the hump has a flat profile for the crossing and extends to the kerb (Fig. 2.6). The design and implementation of pedestrian crossings (Zebra, Pelican, Puffin and Toucan) are described in LTNs 01/95 and 02/95, and TALs 04/98 and 01/01. Various types of ramps can be used, including the 'H' and 'S' humps described in Chapter 4. Triangular markings (diagram 1062, TSRGD 2002) are not a requirement for raised Zebra and Pelican crossings and may be omitted (normally where traffic speeds are at or below 20 mph). Road humps must not be used within the controlled zones of Zebra, Pelican, Toucans or Puffin crossings, though, if centrally located, a road hump may extend into these areas. Speed cushions should be located away from positions where pedestrians are likely to cross the road, so that the chances of pedestrians tripping over them are minimised.

2.7.8 Where traffic speeds are low, it has been observed that some motorists give way to pedestrians crossing the road at locations that are not formal pedestrian crossing facilities. For example, this was noticed from an early stage at kerb-to-kerb road humps in Burnthouse Lane, Exeter, and it commonly occurs at the road humps in the Shenley Road town centre traffic calming scheme in Borehamwood. Studies of informal crossing places in the Historic Core Zone scheme in Shrewsbury have shown that about 20 per cent of drivers gave way to pedestrians as they were about to cross the road. This relatively high proportion was probably due to low traffic speeds (mean speed about 10–15 mph), high pedestrian flows (about 400 per hour) and the frequency of appropriate crossing places.

Fig. 2.6 Humped pelican and zebra crossings

2.7.9 Research carried out for the Department indicated that drivers are more likely to give way to pedestrians waiting at informal crossings when:

- there were more pedestrians waiting to cross;
- a higher proportion of pedestrians were accompanied by young children;
- the site had higher vehicle flows;
- the road was either one-way or had a central refuge;
- there were other humps as part of the scheme, and;
- there was no formal crossing (Wheeler et al., 2003).

2.7.10 If kerb-to-kerb, flat-topped humps are used away from town centres, at locations where the pedestrian flows are low, the uncertainty of the status of the informal crossing place may give rise to concern by pedestrians, particularly if the humps are widely spaced and the vehicle approach speeds are relatively high.

2.7.11 Area-wide traffic calming can do much to reduce the numbers of accidents involving child pedestrians. It has been shown (Webster & Mackie, 1996) that child pedestrian accidents were reduced by 70 per cent after the introduction of 20 mph zones in the UK.

2.7.12 Traffic management and traffic calming schemes can form part of school travel plans developed for Safer Routes to Schools schemes. Speed enforcement and raising driver awareness of school travel issues were two of the recommendations of the School Traffic Advisory Group established by the Government in 1998.

2.7.13 Further references giving policy and technical advice on walking can be found in TAL 04/05.

Disabled people

2.7.14 Advice on catering for disabled users may be found in *Inclusive Mobility: A Guide to Best Practice on Access to Pedestrian and Transport Infrastructure* (DfT, 2002). This gives advice on a range of features requiring consideration, including street furniture, signs, guardrailing etc. Advice on tactile paving at crossings is given in *Guidance on the Use of Tactile Paving Surfaces* (DETR, 1998b). This contains details of the patterns to be used and their layout at various locations including refuges, humped crossings and side road entries. Traffic calming can be of great benefit to disabled people, not least by the reduction in traffic speeds. Kerb-to-kerb flat-top humps will assist wheelchair users when crossing roads. It is important that traffic calming has regard to 'inclusive design principles to ensure disabled people have equal access opportunities as others'.

Cyclists

2.7.15 By reducing the speed, dominance and at times the volume of motor vehicles, traffic calming can benefit cyclists. In older towns and cities where space is at a premium, traffic calming is an appropriate means of facilitating cycling, as lower speeds and flows can lessen the need to separate cyclists from motor traffic (IHT, 1996). It has been shown (Webster & Mackie, 1996) that cyclist accidents and child cyclist accidents were reduced by 29 per cent and 48 per cent respectively after the introduction of 20 mph zones.

2.7.16 Local authorities should view traffic calming schemes as an opportunity to improve conditions for cyclists. This means consulting with local cyclists' organisations and considering in detail cyclists' needs and opportunities, incorporating specific measures where appropriate (see Section 2.4). The Institution of Highways and Transportation publication *Guidelines for Planning and Design of Cycle-Friendly Infrastructure* (IHT, 1996) includes detailed advice on cyclists and traffic calming. Guidelines for cycle audit and cycle review are given in IHT et al., 1998 and summarised in TAL 07/98.

2.7.17 *A Cycling Bibliography* (TAL 03/05), which is updated regularly, is available from DfT. It gives many references that may be useful for those considering a traffic calming scheme.

2.7.18 Any of the physical means employed to slow motor traffic have the potential to create problems for cyclists. Cyclists are more vulnerable to any lack of attention to detail in design of traffic calming measures than are occupants of motor vehicles. Care should be taken to ensure that cyclists are not endangered by such schemes.

2.7.19 A consultation exercise carried out by Gibbard *et al*. (2005) found that many respondents felt that narrowings were a serious safety issue for cyclists and constituted 'major obstructions' on vital cycling routes. When carriageway width is reduced, motorists tend to pass cyclists with less clearance. Pinch points can make matters worse because motorists sometimes accelerate to overtake cyclists ahead of them. In doing so, they may leave insufficient clearance when passing and cut in too early. Unless cyclists can bypass a narrowing, or supplementary calming features are introduced around it, riders can feel threatened by having to squeeze through a gap shared with passing motor vehicles.

2.7.20 The extent to which motorists will overtake cyclists within a narrowing will vary depending on the characteristics of the site. It should be expected that at least 70 per cent of drivers will attempt to overtake a cyclist within or close to a narrowing that is 3.5 metres wide (TAL 01/97). Gaps of 2.75–3.25 metres can be inhibiting for cyclists, as motorists may attempt to overtake them despite the lack of sufficient clearance to do so safely.

2.7.21 A cycle bypass should be the first option where a narrowing is introduced on a road subject to a speed limit of 30 mph or more. The bypass channel should be wide enough to accept a mechanical sweeper (1.5 metres). If this cannot be achieved, a maintenance regime should be established which ensures that they are regularly hand swept.

2.7.22 Traffic Advisory Leaflet 01/97 *Cyclists at Road Narrowings* sets out the following principles of good design for cycle bypasses:

- bypasses for cyclists should be at least 1.5 metres wide (though over very short lengths a minimum width of 1.0 metres may be acceptable) and should be preferably straight through, not kinked;
- cyclists should be guided towards the cycle bypass by a cycle lane, established in advance of the point at which the carriageway begins to be narrowed;
- access to the bypass should be kept clear of parked vehicles;
- cyclists should have easy access back onto the main carriageway, preferably designed so that they do not have to give way on rejoining the main traffic flow;
- maintenance requirements for cycle bypasses should be considered from the outset, because of the likely accumulation of debris, and arrangements for regular sweeping will need to be made.

2.7.23 Where a cycle bypass meeting the above criteria is provided, it will not be necessary to allow sufficient space for a motorist to pass a cyclist within the all-vehicle lane. A reduced running lane width can thus be accommodated, resulting in lower motor vehicle speeds. In this situation, care must be taken to ensure that motor vehicles are not forced to enter mandatory cycle lanes as a result of the road layout. Average speeds at or below 25 mph have been measured at narrowings 3 metres wide or less (Davies *et al.*, 1997a).

2.7.24 If adequate width for a cycle bypass cannot be found, a cycle lane will be the next best solution, preferably with a minimum width of 1.5 metres to ensure that motor vehicles pass cyclists at a safe distance. If possible, cycle lanes should be 2 metres wide, because drivers tend to pass cyclists more closely where cycle lanes exist (Gibbard *et al.*, 2005). An advisory lane of adequate width is usually preferable to a narrower mandatory lane. If space will only permit the provision of significantly substandard width cycle lanes, other traffic calming measures (such as vertical deflections) should be considered to reduce the speed of vehicles approaching the narrowings (Reid *et al.*, 2005).

2.7.25 If a cycle lane is being introduced along the whole of a route that includes narrowings, it is preferable not to locally reduce the width of the cycle lane in the vicinity of the narrowing. If this cannot be avoided, the cycle lane should be narrowed gradually, with the narrowing of the cycle lane completed before the carriageway width starts to reduce. If space is available away from the carriageway, a cycle track is a useful means of bypassing a series of narrowings. Where average speeds are below 20 mph, cyclists and motorists should be able to share space comfortably, as the maintenance of low speeds reduces the need for specific provision for cyclists.

2.7.26 Although a cycle lane through a narrowing is unlikely to discourage drivers from overtaking cyclists at this point, it may still be of value, as it can serve to increase the separation width between cyclists and the overtaking vehicles. Cycle lanes may also aid speed reduction by making the all-purpose lane narrower. Cyclists travelling uphill will gain particular benefit from a cycle lane, as they tend to wobble more at reduced speeds. Downhill cyclists don't need the same level of provision because the speed differential between cyclists and motorists may be small or non-existent. In addition, a cyclist travelling downhill, and therefore relatively quickly, will generally be more visible to motorists waiting at side roads if they stay in the middle of an all-purpose lane. A cycle lane here may not only serve little purpose, but it would encourage a cyclist to use the nearside of the carriageway, thereby reducing his conspicuity.

2.7.27 Islands do not have to be centrally positioned relative to the carriageway. An offset island may be used, for example to provide protection for a cycle lane or introduce a cycle bypass.

2.7.28 Vertical deflection is more a matter of comfort. Where road humps are used, the choice of materials and the smoothness of transition are particularly important. Upstands at the joint between the road surface and the bottom of the on/off ramp should be avoided. This aspect is particularly critical at side road entry treatments where cyclists may be turning. If upstands cannot be avoided, they must be less than 6 mm to comply with the Highways (Road Humps) Regulations 1999 (although even 6 mm upstands can be uncomfortable for cyclists). Ideally, where road humps are situated at or near junctions, the humps should be set back, so two-wheeled vehicles can complete any turning manoeuvre before negotiating the hump. Where flat-topped humps are intended as informal crossings for pedestrians across side roads, the needs of cyclists should be balanced against undue deviation for pedestrians.

2.7.29 The ramps of some humps and raised junctions can be uncomfortably steep for cyclists, although it is the abrupt transitions between the horizontal and sloping surfaces that cause the greatest difficulties. Flat-top humps with a capping of different material can present an upstand at the top of the slope, which creates discomfort and a possible hazard for cyclists. Local highway authorities should ensure that cyclists can negotiate road humps with minimal discomfort by maintaining a smooth transition between horizontal and sloping surfaces. A properly constructed sinusoidal curve profile is particularly good in this respect (see paragraph 4.2.6).

2.7.30 Test track trials (Fig. 2.7) of different profile humps, all 75 mm high, indicated that the 3.7 metre long sinusoidal hump was the most comfortable for cyclists. However, the difference in discomfort between the sinusoidal and round-top humps was not large, and local authorities would need to consider the cost effectiveness of achieving the sinusoidal profile (TAL 09/98). The 8 metre long flat-top hump with 1:13 straight on/off ramp gradients was the least comfortable (for cyclists) of all the humps tested. Some cyclists complained about the double jolt they felt crossing the hump (Sayer *et al.*, 1999).

Fig. 2.7 Cyclist involved in track trials of humps

2.7.31 The results of the trials indicate that the use of flat-top humps with straight ramps should be kept to a minimum on routes used by substantial numbers of cyclists (i.e. only in conjunction with pedestrian crossing facilities or at side road entry treatments). It may be preferable at these locations to use 'S' humps.

2.7.32 Cyclists will normally be expected to use the shallower outer profiles of the 'H' and 'S' humps (see Chapter 4). However, care is needed with the 'H' hump to ensure that any drainage gully located near the foot of this ramp is placed and constructed so that it does not interfere with the smooth passage of cyclists (see paragraph 4.2.8).

2.7.33 Most cyclists avoid speed cushions and ride between the cushions and the nearside kerb or between two cushions, but care should be taken to ensure that their longitudinal and transverse profiles do not endanger the stability of cyclists where avoidance is not possible. The side ramp gradients should be no steeper than 1:4, and the on/off ramps no steeper than 1:8 (see Chapter 4). The same considerations apply as for road humps, i.e. there should be a smooth transition between horizontal and sloping surfaces with no upstands and they should be clearly marked on the leading slopes. The gap between the lower edges of adjacent cushions should preferably be 1000 mm and not less than 750 mm. The gap between the lower edge of a cushion and the nearside kerb should be no less than 750 mm (1000 mm preferred). Waiting restrictions may be required to allow riders to pass between the kerb and the nearside cushion rather than have to pull out to the centre of the carriageway.

2.7.34 It is important that road humps of all types are properly maintained, not only because this may limit their effectiveness, but also because a damaged surface could cause a cyclist or motorcyclist to lose control. An example of the type of damage that can be caused to a cushion is given in Figure 2.8.

2.7.35 Rumble devices were not previously recommended for urban areas because of the noise they generated. However, research commissioned by the Department led to the development of a new traffic calming surface, known as rumblewave, which produces noise and vibration within vehicles without additional external noise (see Chapter 5). For cyclists, however, measures that merely induce audible and vibratory signals in a motor vehicle can have a significant effect on comfort. Where rumble

Fig. 2.8 Damage to a speed cushion

devices are used, it is recommended that a gap of 750–1000 mm is provided between the edge of the rumble device and the kerb or verge. The vertical faces of the rumble devices should not exceed 6 mm, to comply with the Highways (Traffic Calming) Regulations 1999. Surface treatments should not be so harsh as to threaten cyclists' safety or cause them undue discomfort. Surfaces should be skid resistant in wet and dry weather, and there should be a smooth transition between surface treatments and the adjacent road surface. Textured surfaces comprising granite setts with bevelled edges, cobbles and other types of blockwork designed for aesthetic appeal can be uncomfortable for cyclists and slippery in wet weather.

2.7.36 Roads closed to prevent rat-running by motor vehicles can offer lightly-trafficked routes for cyclists. It is recommended that cycle gaps should always be provided at these locations. Cycle gaps should be at least 1 metre, and preferably 1.5 metres, in width. They should be situated either in the centre of the road closure or at both kerb sides to enable cyclists to turn into and out of the closed road (see TAL 08/86). Where the road is closed by posts or bollards, these should be clearly visible after dark. Hatching, cycle logos, kerbing and bollards on the approach to the gap can help minimise the risk of obstruction by parked vehicles.

Motorcyclists

2.7.37 Motorcycling has an important role to play within the transport system, and trends show that it is becoming increasingly popular in the UK. Motorcycles behave and use the road very differently to four-wheeled vehicles, and riders face hazards that are not apparent to car drivers. Motorcycles, however, offer a number of benefits for riders in so far as they can provide an affordable alternative to the car, giving independence and mobility, and widening employment opportunities, especially where public transport is limited. They can also provide quicker travel for riders in congested traffic conditions.

2.7.38 Motorcyclists are classed as one of the most vulnerable road users in the road user hierarchy. The Department published the Government's Motorcycling Strategy in February 2005 (DfT, 2005a). The aim of the strategy is to address a wide range of issues which will ensure that motorcycling is facilitated as a choice of travel within a safe and sustainable transport network. Following on from this, the Institute of Highway Incorporated Engineers published *Guidelines for Motorcycling – improving safety through engineering and integration* (IHIE, 2005). This document was developed with the help of a number of organisations, including the DfT. The purpose of the guidelines is to demonstrate the role motorcycling can play in an integrated transport system as well as assist highway and traffic engineers in delivering a safe and efficient road environment for all road users. These guidelines highlight the hazards and good practice that engineers, planners and road safety officers should follow to improve the road environment for motorcyclists in order to reduce casualties.

2.7.39 Given the design and handling characteristics of motorcycles, and the relative lack of protection of riders against injury, motorcyclists are more vulnerable than most other road users to:

- unexpected changes in alignment or layout;
- unusual treatment and traffic arrangements;
- complex decision-making tasks imposed by layouts;
- inadequate warning;
- misleading or conflicting information;
- inadequate delineation and guidance;
- substandard visibility;
- an unforgiving roadside environment.

2.7.40 Injury accidents involving motorcyclists have been shown to be reduced by 70 per cent following the installation of 20 mph zones (Webster & Mackie, 1996), but it is still important that the calming measures introduced follow good design practice. Specific design issues for motorcyclists relating to traffic calming measures include the visibility of road humps and speed cushions (see Chapter 4), rumble devices (see Chapter 5) and kerb build-outs at narrowings and chicanes (see Chapter 6). Visibility of measures and their associated signs and markings is likely to be particularly important where a measure is the first of a series of physical traffic measures to be encountered and is not located within a 20 mph zone (where such measures might be expected).

2.7.41 Speed cushions can present stability problems for motorcyclists, and test track trials (Fig. 2.9) have established that the gradient of the side ramps on speed cushions should not be greater than 1:4. It is also important that road humps and

Fig. 2.9 Track trials involving a solo motorcyclist (left) and a moped

Fig. 2.10 Track trials involving motorcyclist with sidecar

speed cushions are properly maintained, because a damaged hump or cushion could cause a rider to lose control. An example of the type of damage that can be caused to a cushion is given in Figure 2.8.

2.7.42 It is important for motorcyclists that rumble devices (see Chapter 5) have adequate skid resistance, are located away from the final braking area on the approach to a hazard, and have no vertical face greater than 6 mm. Some motorcyclists may avoid the rumble devices by using the drainage or cyclist gap between the kerb and the edge of the rumble device. There is some evidence to suggest that rumble strips should not be used on bends with a radius of less than 1000 metres because of possible danger to motorcyclists (TAL 11/93).

2.7.43 Track trials with motorcycle and sidecar (Fig. 2.10) combinations when crossing road humps conforming to the recommended dimensions indicated no handling problems but higher levels of rider or passenger discomfort than for solo motorcyclists (Sayer *et al.*, 1999). However, motorcycle and sidecar combinations need to cross speed cushions at relatively slow speeds (i.e. below 20 mph) because above this speed they can become unstable.

Equestrians

2.7.44 Equestrians are especially vulnerable to inconsiderate drivers. Traffic calming measures that reduce the speed, dominance and in some cases the volume of motor vehicles have the potential to benefit the ridden, led or driven horse. Where routes identified for traffic calming are likely to be used by equestrians, the views of the British Horse Society and/or local riding groups should be sought.

2.7.45 If gateways are to be used, care should be taken to avoid blocking verges, as this could mean equestrians moving onto the carriageway, where they may be less safe.

2.7.46 Where roads are proposed to be closed, consideration should be given to whether access for equestrians can be provided.

2.7.47 Reports have been received by the British Horse Society of horses tripping on round-top humps. Similarly, there is anecdotal evidence of horse riders feeling threatened by the use of road narrowings. There is no research to substantiate this, but it emphasises the need to consult with owners and/or manager of any riding stables in the immediate vicinity of a proposed traffic-calming scheme.

2.8 Road lighting

2.8.1 Road lighting can reduce injury accidents by about 30 per cent during the hours of darkness (Cornwell & Mackay, 1972).

2.8.2 The road hump regulations requirements for road lighting of road hump schemes, other than in 20 mph zones, are that the lighting should extend over the length of the road containing the humps. This must consist of at least three street lamps placed not more than 38 metres apart from each other, or the lighting should comply with the British Standard (BS 5489, 1992). (Although not referred to in the regulations, European Standard BSEN 13021_2:2003 is relevant.)

2.8.3 Chicanes and narrowings should be conspicuous in both day and night-time conditions for drivers, and there should always be adequate street lighting in the areas around chicanes (Howard, 1998). Regular checks may be needed to ensure that damage has not occurred to the chicane or lighting. The local highway authority should satisfy itself that the lighting is to the standard required for the introduction of any new traffic calming features.

Institution of Lighting Engineers

2.8.4 The following has been extracted, with the permission of the Institution of Lighting Engineers, from Technical Report 25 on lighting for traffic calming features (ILE, 2002). It is based on lighting performance measures specified in the British and European Standard for Road Lighting, which is in preparation.

'(a) Relevant documents when determining appropriate lighting levels are:

- BS 5489 – 1: 2003 Code of practice for the design of lighting for roads and public amenity areas.
- BSEN 13201:2003 – 2 Road lighting, Part 2: Performance requirements
- BSEN 13201:2003 – 3 Road lighting, Part 3: Calculation of performance
- BSEN 13201:2003 – 4 Road lighting, Part 4: Methods of measuring light performance.

(b) Horizontal deflections, where one direction of traffic is given priority over the other, may be considered as conflict areas as described within BSEN13201. Drivers approaching the feature need to be able to identify its layout and be able to make such judgements as necessary concerning driver priority, the intended actions of oncoming drivers, and how to safely navigate the feature. Lighting providing good colour rendering of the correct class will help the drive to make such judgements.

(c) For vertical deflections the lighting should comply with the required class within BS5489 and BSEN 13201 providing good overall and longitudinal uniformity.

(d) Column locations shall be chosen to aid maintenance operations without causing undue obstructions.

(e) Where colour is used to improve conspicuity of any traffic calming feature then it is important that the lamp used to light the road will reveal the colours correctly at night.'

2.8.5 Where flat-top road humps are used to form a pedestrian crossing place, then the lighting should be such as to ensure drivers can be aware of pedestrian movements or intentions. If colour is used to improve the conspicuity of any road hump, street lamps providing a good colour rendering should be considered.

2.9 Monitoring of a scheme

Before installation

2.9.1 A local authority should carry out some monitoring before a scheme is installed, so that the results can be used in the initial planning and consultation stages to highlight any safety or vehicle speed problems (DTLR, 2001a). Appendix C1 gives a scheme assessment framework, and Appendix C2 gives an example of priority factors to be considered when traffic calming schemes are competing for funding. This will include the determination of the number of injury accidents in the proposed area in the last three years (the minimum period that should be used). Both the mean and 85th percentile vehicle speeds, together with vehicle flows, should be measured at strategic points determined by the highway authority's local experience. These speeds, combined with knowledge of the expected speed reducing effect of the particular traffic calming measures, can be used to estimate the speeds after the calming has been installed (see Chapters 4–9). Pedestrian crossing counts would be relevant near schools and shops. The total amount of monitoring of any scheme is likely to be determined by the number, length and type of roads being calmed, as well as by the available budget.

2.9.2 Consultation with residents could include an attitude survey (see Section 2.10). The type of survey would depend on the size and the nature of the scheme, i.e. if it contained 'novel' traffic calming measures, then it would probably need to be quite comprehensive. The purpose of the survey and the questions should always be made clear to the people answering the questions.

2.9.3 Consideration should be given to the environmental impact of the scheme in terms of changes in noise, ground-borne vibrations and air quality. These impacts can be expensive to monitor, and at the outset a judgement should be formed whether the effects can be reasonably estimated from information provided in Chapters 4–8. The magnitude of the traffic flow, the proportion of commercial vehicles and buses, and the type of traffic calming measures introduced will affect the changes in these parameters and the magnitude of any beneficial effects or nuisance (see Chapters 4–8).

After installation

2.9.4 The monitoring that follows installation of the scheme should ideally have the same pattern as the before monitoring (CSS *et al.*, 1994), so that the effectiveness of the measures in terms of safety and speed reduction can be demonstrated. The public needs to be made aware of the results of the scheme and whether or not the objectives have been achieved (Scottish Executive, 1999b).

2.9.5 Many local authorities make it a practice to provide feedback to local residents, and some authorities have found it useful to publish information about their traffic calming schemes in a variety of ways (Chorlton *et al.*, 1991; Kent County Council, 1992 & 1996). There are now many web sites; a comprehensive directory of local government web sites, from county council to town and parish councils, is available at:

http://www.tagish.co.uk/tagish/links/localgov.htm.

Dissemination of the results of a traffic calming scheme may improve its public acceptability and also improve trust in the local authority.

2.9.6 Monitoring is valuable in developing a body of knowledge on traffic calming schemes. Much of the guidance given in this LTN is based on information provided by a large number of local authorities.

2.10 Public attitudes to schemes

2.10.1 Vertical and horizontal deflections are important tools for highway authorities because they can be used to control speeds and consequently reduce accidents. However, it is increasingly clear that the success of such schemes is not only determined by objective measures of their effect (on speed, flows and accidents) – subjective assessment is also important.

2.10.2 If measures are introduced that the local public does not like, then they soon become discredited. Indeed, examples of situations exist where pressure from local communities (resulting, for example, from noise being generated by vehicles crossing measures) has led to the removal of measures. Clearly this is not a cost-effective way to proceed: it is far better to be able to estimate the likely public reaction to the scheme before it is installed. Design advice can then be provided so that schemes have a better chance of acceptance and situations likely to prove unpopular can be avoided.

2.10.3 A review of published literature describing 45 studies of public attitudes to traffic calming schemes (Webster, 1998b), found the overall percentage of respondents who approved of the schemes, across all the reviewed studies, was 65 per cent. This varied according to the types of measures in the schemes: 72 per cent for schemes including road humps, 53 per cent for schemes including speed cushions and 59 per cent (but particularly variable) for schemes including horizontal deflections.

2.10.4 Surveys that provided direct information on the relative popularity of different measures indicated that round-top road humps were the most popular measure, followed by flat-top road humps and table junctions, speed cushions, chicanes and mini-roundabouts in descending order. For example, in Havant (TAL 02/99) three-quarters of the respondents thought that the hump at the pedestrian crossing was effective and few thought it had disadvantages or caused problems. The speed cushions, although considered effective by over half those interviewed, were widely criticised, as they were thought to damage cars and encourage vehicles to be driven on the adjacent verges. Only one-third of those interviewed thought that the mini-roundabouts were effective, with almost half criticising them on the grounds that they were ignored or not used properly.

2.10.5 Comparisons between objective measures of the effectiveness of schemes (where they were made) and public reactions to those schemes indicated that there was no relationship between the magnitude of measured reductions in speed, flow and safety and the percentage of respondents who thought that these things had been affected. For example, the results from a study of a scheme in Costessey (Wheeler *et al.*, 1998) showed that local residents were disappointed with the scheme because they were still concerned about vehicle speeds (only 28 per cent thought speeds had been reduced). In fact, there had been a substantial reduction in mean speeds within the village (7–10 mph), although not to below the speed limit of 20 mph.

2.10.6 It would seem that the results of public attitude surveys are useful in establishing overall approval levels of traffic calming schemes, in identifying the relative popularity of individual measures and any problems associated with them. Where a scheme is implemented to achieve quality of life objectives, public attitude surveys are useful to identify wider impacts of the scheme, such as sense of place, changes in the fear of crime, community cohesion, etc. However, public attitude surveys cannot be a substitute for objective measures of the effectiveness of a scheme. Perceptions of changes in speeds, flow and safety, which might appear on the face of it to be easy to judge, are relatively poor. Changes in the environmental measures of ground vibration, noise and air pollution are even more difficult to assess subjectively.

2.10.7 The appearance of calming measures is very important to residents. Using temporary materials initially to construct chicanes can prejudice acceptance of the proposals where the finish is unattractive. Careful attention should be paid to the choice of materials, whether temporary or permanent. Advice from conservation officers, urban designers or landscape architects may assist in producing more acceptable designs. It may be helpful if residents can be given some impression of the permanent scheme by reference to similar schemes elsewhere. Simulation of the scheme is a possibility, but, although simulation is getting cheaper, it can still be expensive.

2.10.8 The perception of traffic calming can be enhanced by taking care with quality and visual aspects. This is illustrated by the following quotes from the United States (Lewis, 1998) and Canada (Drdul & Skene, 1994):

> 'You can use cement barriers and orange barrels and call it traffic calming but if you use nice bricks and planters, it will be better accepted.'
>
> '...on the other hand, traffic calming is a real art and I'd hate to see it get so standardised that we'd lose creativity in making our cities the best they can be.'
>
> 'Don't expect to solve every problem.'

2.10.9 The popularity of the town centre traffic calming within the Bypass Demonstration Project schemes was assessed using before and after attitude surveys (Social Research Associates, 1999). The results showed that people react favourably to quieter environments, wider footways, lower traffic speeds and easier crossings. The most favourable responses were from people with mobility impairments, cyclists, and adults accompanied by children. The common factor is that in a traffic calmed environment less attention is required to cope with traffic and noise; there is more footway space and generally less to worry about. (See also paragraph 3.6.)

2.10.10 Appendix D gives an outline of the considerations that should be taken into account when assessing public attitudes. It is important to bear in mind that public opinions and the product of physical measurements may not always agree. For example, the overall measured speeds may be reduced, yet the occasional 'speeder' may lead people to believe that there has been no worthwhile effect. The means that can be used to involve the community are wide-ranging, and there is no one approach that is most effective. A combination of methods is usually best, with the aim of engaging all sectors of the community, particularly groups who are often under-represented in the decision-making process – for example children, young people, people with disabilities and people from ethnic minority groups. It is important to carry out monitoring in order to check whether the views of the residents reflect the actual conditions; merely showing residents plans of proposals may not be enough.

2.10.11 The following good practice recommendations have been made (Scottish Executive, 1999b):

- the purpose of the proposed scheme needs to be clearly communicated to local residents and all interested parties;
- the extent to which scheme design can be modified needs to be made explicit;
- the location of the measures and their appearance needs to be clearly explained;
- data requirements and effective monitoring need to be established before design begins;
- some education about the use and purpose of the measures should be communicated;
- feedback and monitoring needs to be maintained throughout the design and implementation;
- every effort should be taken to involve the local community in the design process;
- a comprehensive consultation plan should be designed and implemented throughout the scheme development and its first year of operation;

- community groups should be used where they exist;
- communities should be kept informed of results such as speed, flows and accidents.

2.11 Impact of traffic calming schemes on street activity

2.11.1 There is some evidence that traffic calming schemes can have a positive effect on the independent mobility of children, but less evidence that they have substantially affected the amount of walking or cycling by adults. Whilst 20 mph zones reduce vehicle speeds, children should still not be encouraged to play in the carriageway unless local conditions are appropriate.

2.11.2 A before and after study (1996–97) by TRL on the impact of a traffic calming scheme in Crawley on child pedestrians (aged 8 to 11) found that the proportion of children who walked or cycled had increased (56–69 per cent). Children were more likely to be unaccompanied by an adult (59–73 per cent) but it was not clear from the responses that this was due to the calming measures. There was no difference in the proportion of children visiting friends, and little difference in the proportion of children playing outside (about 80 per cent) or the frequency of outdoor play. However, about half the parents or carers reported that the traffic calming scheme had made a difference to their child's use of the roads.

2.11.3 A study of traffic calmed areas in Brighton, Leicester, Sheffield and York was carried out as part of the Feet First initiative, set up by Transport 2000 with support from local authority associations and the DfT. Interview surveys indicated that there were gains in independent mobility of children, with more children being allowed to play in the street, travel to school and visit local shops without direct adult supervision. There was also evidence that pedestrians felt safer crossing the road as a result of traffic calming, and that motorists were more likely to let pedestrians cross. There was little evidence that traffic calming had increased the amount of walking by adults, with most respondents saying that the number of journeys made on foot remained the same (Taylor & Tight, 1996).

2.11.4 A study of the community impact of traffic calming schemes in Scotland (Scottish Executive, 1999b) found similar responses from interview surveys. Again the responses varied among schemes, with 4–28 per cent of residents saying that they walked more; 4–15 per cent that they cycled more; and 0–46 per cent saying that they allowed their children to cycle, play out or walk more. Counts were not taken to substantiate the claims of increases. Elsewhere, when similar comments were made, increases in cycling or walking were not recorded.

2.11.5 A study of urban street activity in six English 20 mph zones has been undertaken (Allott & Lomax, 2001; TALs 12/00 and 03/01). Responses from interview surveys varied among the zones studied; with 25–60 per cent of respondents stating they were more likely to allow their children to play in the street following zone implementation. Unfortunately, this change in parental attitudes was not translated into a measured change in activity. Results showed that, in the areas studied, the introduction of 20 mph zones generally had little effect on the levels of walking, cycling or the numbers of children playing in the streets.

2.12 Environmental impact of traffic calming schemes

2.12.1 Before implementing any new traffic calming scheme, the full impact should be evaluated. Although reducing vehicle speeds and personal injury accidents will often be the main aim, it should not be the only consideration. The needs of non-motorised users have already been discussed in this chapter; the other main area is environmental impact.

2.12.2 Environmental impact can cover a range of areas, including air quality, visual and landscape quality, cultural heritage, flora and fauna, drainage, social cohesion, economic impacts and overall quality of life. It will not be practical or necessary to carry out an in-depth assessment for each of these factors, but each should be considered at the outset. Where it is expected there will be a significant impact on any of these factors, a more in-depth analysis should be undertaken, and the predicted negative impacts weighed against predicted benefits.

3. Traffic-calmed areas

Sections 3.1 to 3.5 deal with shared road space and traffic calming on roads with different speed limits, working up through the road hierarchy. The guidance in these sections is generally applicable to both urban and rural areas.

3.1 Shared road space

3.1.1 The shared road space concept originated in the Netherlands as 'woonerven'. Drivers or riders of motor vehicles are required to travel at walking pace within woonerven and to make allowance for the possible presence of pedestrians and children at play (ANWB, 1980). Research in the Netherlands has shown that their effectiveness in reducing accidents is no better than within 30 km/h (20 mph) zones. However, the creation of a woonerf can lead to an improvement in the quality of life which is particularly appreciated by children, elderly people and mothers with children (SWOV, 1985).

3.1.2 Experience from the Netherlands indicates that there are some key factors to consider in the creation of shared space streets:

- traffic flows should be relatively low, with either the origin or destination of most traffic to be within the residential area;
- the scheme should be difficult to drive through quickly, with speed reduction measures closely spaced;
- the physical appearance of the street should be changed;

3.1.3 Consideration should be given to:

- the manner in which on-street parking is catered for and how any unsatisfied demand will be met;
- reducing the width of the route that can be used by vehicles and the provision of passing places for opposing vehicles;
- the accessibility by emergency service and maintenance vehicles;
- the level of street lighting;
- the location and marking of children's play areas (ANWB, 1980; CROW, 1998).

3.1.4 The needs of disabled people require consideration. Some form of demarcation between pedestrian-only space and shared space may be desirable, to reduce feelings of insecurity for some pedestrians, particularly those who are visually impaired (Chorlton *et al.*, 1991).

3.1.5 Changing traditional roads into shared space was previously uncommon in Britain, apart from in town centre shopping precincts. Until relatively recently, there have only been a small number of examples in this country where local authorities have applied the shared space concept to existing residential streets, e.g. Wolverhampton, Leicester, Luton and Plymouth (Chorlton *et al.*, 1991; Hass-Klau *et al.*, 1992; Hall *et al.*, 1992). One reason for this is likely to be the high cost of redesigning and paving the street surface.

3.1.6 At the time of publication of this LTN, advice on the size and design of shared road space in new residential developments is given in Design Bulletin 32 (DOE, 1992) and its companion guide *Places, Streets and Movement* (DETR, 1998a) which partially superseded it. The Design Bulletin says, 'As a general guide, it is suggested that shared surface roads may serve up to around 25 dwellings in a cul-de-sac and around 50 dwellings where junctions with roads with footways are located at each end of the shared surface'. It should be noted that both these documents are expected to be entirely superseded by the *Manual for Streets* in spring 2007. Dutch advice on the design of residential woonerven does not specify the number of houses, but recommends low traffic flows (fewer than 100 motor vehicles per peak hour) and maximum street lengths of 400 to 600 metres (CROW, 1998).

Fig. 3.1 Morice Town Home Zone

3.1.7 The shared road space concept in Britain has been given greater emphasis through the development of Quiet Lanes and Home Zones, where objectives for improving and maintaining the quality of life for local residents should take precedence over general objectives to ease traffic movements. In Quiet Lanes and Home Zones the whole of the public space is shared by people and vehicles alike, and motorists can expect to find people using the whole of the road for a range of activities. It is therefore important that the speed of vehicles is low enough to satisfy the local authority that any permitted activities may be enjoyed safely by people of all ages and abilities.

3.1.8 In England and Wales the Transport Act 2000 gave local traffic authorities the powers to designate roads within their control as Quiet Lanes or Home Zones. The Quiet Lanes and Home Zones (England) Regulations 2006 came into force on 21 August 2006. These enable local traffic authorities in England to make use orders or speed orders and will specify procedures for this and for designation of roads as Quiet Lanes or Home Zones.

3.1.9 In Scotland, local traffic authorities were given the power to designate roads within their control as Home Zones under the Transport (Scotland) Act 2001. The Home Zones (Scotland) (No. 2) Regulations 2002 define a series of steps that local traffic authorities must follow during the creation of a Home Zone. It should be noted that the Quiet Lane initiative does not include Scotland.

Home Zones

3.1.10 The Government's Transport White Paper *A New Deal for Transport: Better for Everyone* published in 1998 recognised the value of Home Zones in improving places where people live andplay. In 1999, the Department (DfT) began a pilot programme with nine local authorities in England and Wales to monitor the implementation of Home Zones in existing residential areas. The aim of this research programme was to examine the extent to which traffic management measures and techniques introduced under available UK legislation can change the way a street is used, so that motorists are aware that they should give informal priority to other road users.
A number of research reports have been published that provide an evaluation of the pilot schemes (Layfield *et al*., 2003; Layfield *et al*., 2005; Tilly *et al*., 2005; and Webster *et al*., 2005).

3.1.11 In April 2001, the Prime Minister announced a £30m challenge fund to encourage the development of new Home Zone schemes in England. As well as creating a substantial increase in the number of Home Zones in England (Fig. 3.1), the Challenge was intended to improve the level of knowledge of what makes a good Home Zone. The Home Zones Challenge came to an end on 31 March 2005. Of the 61 schemes selected for funding, 59 have been implemented, though, as a result of public votes, two schemes were not taken beyond the public consultation stage.

3.1.12 In the right places, Home Zones have potential to transform the quality of life in our local communities and give residents a sense of liberation

Fig. 3.2 Quiet Lane

to enjoy their community. By restoring the balance between traffic and people living in a street, Home Zones can bring down vehicle speeds, reduce crime and bring communities together, making streets safer, more sociable and better places to live.

3.1.13 Advice on planning and designing Home Zones has been published by the Department (TALs 10/01 and 08/02), the Institution of Highway Incorporated Engineers (IHIE, 2002) and the Joseph Rowntree Foundation (Biddulph, 2001). Further guidance, based on the experience of the Home Zones Challenge, is given in DfT 2005b.

Quiet Lanes

3.1.14 Quiet Lanes is a Countryside Agency initiative that aims to maintain the tranquillity and character of minor rural roads (Fig. 3.2). They should be networks of rural roads which already have low traffic flows and low vehicle speeds and, where possible, should tie in to non-motorised user networks. There are three key elements to a Quiet Lanes project: intensive community involvement to change users' attitudes and behaviour, re-routing of through traffic away from the lanes, and entry signing to inform users they are entering the Quiet Lane network.

3.1.15 Community engagement is used to change the 'hearts and minds' of local residents, rather than focusing on lowering the speed limit or using physical measures for enforcement. However if rat-running or high speeds are a problem on particular parts of a Quiet Lane network, a more interventionist approach will be needed. Schemes in north Norfolk and in West Kent (Greensand Ridge) have been monitored by TRL, in conjunction with the county councils, in terms of traffic flows and speeds, as well as attitudinal surveys (Kennedy *et al.*, 2004a; Kennedy *et al.*, 2004b). Traffic Advisory Leaflet 03/04 summarises the results of these schemes.

3.1.16 The monitoring showed that vehicle flows were reduced slightly compared to control roads in both of the demonstration projects. Vehicle speeds were low both before and after scheme implementation, with negligible changes compared to control roads. Numbers of non-motorised users were very low both before and after scheme implementation and fluctuated throughout the monitoring period. Attitude surveys showed that the two schemes had strong support both before and after scheme implementation (at least three-quarters being in favour). However, there was a significant percentage of respondents who did not feel the schemes were working in practice, because of concerns such as rat-running and inappropriate vehicle speed. Almost 40 per cent of respondents in Kent, and almost half those in Norfolk, reported that they now drive more carefully along the lanes. This was not supported by measured changes in speed, but it could be that the points where care is needed (for example at bends) are not the same as monitoring locations (usually sited away from bends).

3.1.17 Signs to be used at the start and end of a designated Quiet Lane in England were added to TSRGD, as diagrams 884 and 885, through the Traffic Signs (Amendment) Regulations 2006. These are illustrated in Figure 3.3.

3.1.18 Further information on Quiet Lanes is available in the form of the technical advice from the Countryside Agency at:

http://www.countryside.gov.uk/LAR/Recreation/Greenways/quietlanes/index.asp

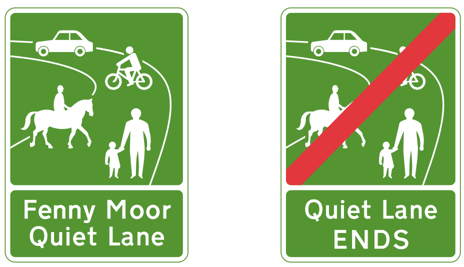


Fig. 3.3 Quiet Lane traffic signs

3.2 Roads with 20 mph speed limits

3.2.1 The first three 20 mph speed limits forming zones were implemented in the UK in 1991 in Sheffield, Kingston upon Thames and Norwich. Since then a considerable number have been installed, about 450 zones, up to June 1999. The DfT no longer keeps a central record of the actual number. Most of the roads within existing 20 mph zones are urban residential roads, but some include district distributor roads and roads in town centres and conservation areas. A small number have been installed in rural areas (e.g. Epping Forest).

3.2.2 A review of the first 230 zones in England, Wales and Scotland (Webster & Mackie, 1996) indicated that average speeds reduced by 9 mph, annual accident frequency fell by 60 per cent, the overall reduction in child accidents was 70 per cent, and there was an overall reduction in accidents involving cyclists of 29 per cent. Traffic flow in the zones was reduced on average by 27 per cent, but flows on the surrounding roads increased by 12 per cent. There was generally little measured accident migration to surrounding roads.

3.2.3 Up to June 1999, specific consent from the Secretary of State was needed to install a 20 mph zone scheme. This regime was changed by The Road Traffic Regulation Act 1984 (Amendment) Act Order 1999 (as explained in DETR Circular 05/99), and local traffic authorities no longer need to obtain the consent of the Secretary of State before implementing 20 mph speed limits (including zones). The changes to the regulations make possible two different means of implementing 20 mph speed limits. Broadly these are:

- the use of speed limits, indicated by terminal and repeater signs alone (to diagram 670, TSRGD, Fig. 3.4);
- a zonal approach using terminal signs (to diagrams 674 and 675, TSRGD, Fig. 3.5) together with suitable traffic calming measures to provide a self-enforcing element.

3.2.4 It is for local authorities to determine whether speed limits or zones should be used. They will need to decide whether the proposed type of speed limit is appropriate to the area, and beneficial in road safety and environmental terms. Equally important is that the form of speed limit chosen does not require unreasonable levels of enforcement by the police.

3.2.5 When the suitability of a 20 mph speed limit is being considered, the area or length of road involved will also have some relevance. It is generally recommended that 20 mph speed limits (including 20 mph zones) should be imposed over an area consisting of several roads and not just an individual road. There may be exceptions to this, but it is doubtful that a 20 mph zone on a single road would have a significant effect on speeds or accidents unless it was at least 500 metres in length with measures spaced at less than 100 metres apart. Accidents in those areas where 20 mph speed limits would be most successful seldom occur in particular locations, but are scattered throughout the area.

Fig. 3.4 20 mph limit and repeater sign. Diagram 670

Fig. 3.5 20 mph zone terminal signs. Diagrams 674 and 675

3.2.6 It is of doubtful benefit to have a short length of either a 20 mph limit or a 20 mph zone outside a school. Apart from the uncertainty of whether drivers will observe the limit, they may subsequently speed up in an area where children, in relatively large numbers, will be approaching or leaving the school. Forming a self-enforcing 20 mph zone in roads surrounding the school would be likely to reduce the frequency of accidents, not only in the immediate vicinity of the school, but more importantly on the routes that children take to that school.

3.2.7 The value of adequate consultation being undertaken cannot be over-emphasised (see Section 2.4). Without such consultation, schemes are more likely to be subject to considerable opposition, both during and after implementation. The police need to be consulted about a scheme; particularly where a 20 mph speed limit is proposed (see paragraph 2.4.1). Residents and businesses within the proposed zone or limit would of course need to be consulted, as well as bus operators and the emergency services. It would also be advisable to consult with school communities within the zone. Additionally, haulage operators may need to be approached, depending on the land use of the area where the zone is to be installed. In more rural areas, the views of users of agricultural equipment will need to be obtained. Local authorities should consult on concept and detailed scheme designs, and be prepared to modify schemes to meet valid concerns.

3.2.8 The success of any 20 mph zone or limit will depend on the local authority being able to demonstrate that the measures introduced have shown significant benefit. In the longer term this will generally be related to the reduction or prevention of accidents, particularly to children. In the shorter term, a good indication of whether a zone is successful is the reduction of vehicle speeds to 20 mph or below. An appropriate method of measurement would be to monitor the mean and 85th percentile speeds on typical roads within the 20 mph zone or limit (see Section 2.9). For zones, this requires measurements both at speed controlling features and at locations between them. If the results were to show that the overall mean speeds (at and between the measures) exceeded 20 mph, then additional speed controlling measures would need to be installed (TAL 09/99). Authorities should ultimately aim to reduce the 85th percentile speed to 20 mph or less if possible.

20 mph speed limits

3.2.9 Research indicates that the speed reduction achieved with the use of 20 mph signs alone is likely to be small, about 1 mph (Mackie, 1998). Therefore, 20 mph speed limits enforced by signs alone would be most appropriate where 85th percentile speeds are already low (24 mph or below) and further traffic calming measures are not needed. 20 mph speed limits without self-enforcing features have the attraction of being relatively inexpensive to implement. However, regard must be given to the 'before' speeds, because the higher they are, the less likely it is that speeds could be reduced to 20 mph.

3.2.10 Attention should be paid to the provisions of the Crime and Disorder Act 1998 which requires local authorities and the police, with other key agencies and the community, to work together in partnership to develop and implement strategies for reducing crime and disorder in their areas. It is essential under the terms of the Act that local authorities and highway authorities liaise with the local police early, to agree in advance an appropriate level of enforcement and how effective that might be in ensuring a significant reduction in speed (DETR Circular Roads 05/99).

3.2.11 20 mph speed limits that are not part of a 20 mph zone require terminal signs and repeater signs to diagram 670 (TSRGD), see Figure 3.4. The terminal signs should be placed on both sides of the carriageway to form a gateway. Terminal signs (to diagram 670) on trunk and principal roads within 50 metres of a street lamp must be directly lit. Elsewhere the terminal signs should be directly lit or reflectorised.

3.2.12 Yellow backing boards can provide additional emphasis for the start of the speed limit. However, these should only be used where necessary to minimise the negative visual impact they cause. Excessive use of backing boards can also mean they become overly familiar to drivers and their speed-reducing impact is diminished. Where a limit starts near to a junction, great care must be taken in siting the signs, so that they are clearly visible to turning traffic and do not obscure other signs. This is particularly important where a junction is controlled by traffic signals. Sign maintenance (both cleaning and removal of obstructions) is also of importance.

3.2.13 Advice on the spacing of repeater signs for 20 mph limits is given in TAL 01/95. The vertical repeater signs (to diagram 670) may be accompanied by 20 mph roundel markings.

3.2.14 Where a 20 mph speed limit is designated by the diagram 670 sign, any road humps installed within the limit will need to be marked separately, and appropriately lit. Road hump warning signs or 'traffic calmed area' signs will need to be erected in advance of the series of humps. Whether other traffic calming measures need to be signed will depend on the circumstances, but diagram 670 cannot be relied upon to warn of their presence.

20 mph zones

3.2.15 20 mph zones should be used where a speed reduction to 20 mph is desirable and where traffic calming measures would be needed to ensure that speeds are at or below 20 mph (e.g. roads where 85th percentile speeds exceed 24 mph before calming). 20 mph zones are particularly appropriate where there is an existing record of accidents to children occurring over an area, or where concentrations of pedestrians and/or cyclists exist or are anticipated. They can help protect children walking and cycling to and from school, and may help to encourage other children to walk or cycle.

3.2.16 A 20 mph zone should have entry treatments with signing at the gateways to the zone and suitable speed reducing measures (Fig. 3.6). Within the zone speed control measures are needed, which are broadly defined in TSRGD 2002 (e.g. road humps, raised junctions, speed cushions, horizontal deflections, mini-roundabouts, bends and reductions in the width of the carriageway; see Sections 4 to 8 of this LTN). The combination and design of measures chosen will depend on the road type, the layout of streets in the area, the level and type of traffic flow and the quality of the streetscape. The speed control capacity of some measures (e.g. narrow speed cushions, thumps and some types of horizontal deflection) can be much less than that of road humps, and the extensive use of these devices within a 20 mph zone may not result in an acceptable reduction in speed levels. Narrowings will normally need to be 3.5 metres or less to be effective at controlling vehicle speeds. However, this can cause problems for cyclists if a cycle lane bypass is not provided.

3.2.17 The speed control measures should be spaced at about 60 to 70 metres apart (TAL 09/99) but must not be more than 50 metres from any given point on the road unless in a cul-de sac less than 80 metres long (TSRGD, 2002). This spacing of traffic calming measures should ensure that the zone is self-enforcing (i.e. vehicle speeds are kept at least at or below an average of 20 mph) and encourage a smooth style of driving. This is beneficial to accident reduction, and also in reducing noise and vehicle exhaust emissions (see Sections 4.4, 4.5, 5.2, 5.3, 6.5, 6.6, 8.3 and 8.4).

3.2.18 Previously, 20 mph zones were not permitted if any part of the zone was more than 1 km from any boundary road. Although this no longer applies, it remains sound general advice. The effects a large zone might have on the public transport system and the commercial viability of the area would also need to be considered carefully. The effects of a 20 mph zone on any additional traffic on peripheral roads

Fig. 3.6 Entry to (left) and exit from a 20 mph zone

should also be taken into account, so that problems of pedestrian access, particularly for older, young and disabled people, do not occur.

3.2.19 Roads serving as cycle routes, away from main distributor roads, may be suitable locations for implementing a 20 mph zone. Speed control devices should be 'cycle friendly' wherever possible (see paragraph 2.7.15). Horizontal deflections and narrowings can be of particular concern to cyclists, and cycle bypasses around these devices are advisable. Sinusoidal humps marginally reduce the discomfort for cyclists compared to flat-top and round-top, but may be more expensive to install.

3.2.20 Motorcyclists also need to be taken into account in the design of the 20 mph zone (see paragraph 2.7.33), though it is inadvisable to permit these vehicles to use cycle facilities. Provided that motorcyclists moderate their speeds, they should have few problems in negotiating speed control devices. However, the layout needs to be clearly visible.

3.2.21 Regard will need to be given to other types of vehicles (e.g. emergency vehicles, buses and goods vehicles) that may operate within the zone, when deciding on the type and design of the speed control measures (see Sections 2.5 and 2.6).

3.2.22 There should normally be appropriate alternative routes available for any through traffic currently using the proposed 20 mph zone. There will be exceptions, for example in rural areas where a village straddles a main road and the character of the village warrants a low speed limit. However, in designing speed reducing and control devices for such roads it should be borne in mind that they are likely to have a higher proportion of large vehicles than other roads, and so problems of noise and ground-borne vibrations could arise (see Section 3.8).

3.2.23 20 mph zones require signs to diagram 674 and 675 (TSRGD, 2002) placed on both sides of the carriageway at the entrances (and hence exits) to the zone. School children have in the past provided designs for the bottom panel of the 20 mph zone signs (see Figure 3.5). It has become recognised that diagram 674 provides a warning to drivers that they are entering an area where they can expect to encounter closely spaced traffic calming measures. For this reason, the road hump and traffic calming regulations do not require additional signs to warn of individual traffic calming measures in the zone. Signs to diagram 674 do not need to be illuminated. Further details are given in TALs 02/93 and 09/99. Road hump markings (to diagram 1062) are also not required within 20 mph zones. However, they may be used if it is considered appropriate, particularly to enhance the conspicuity of the road humps.

3.2.24 The start of a zone is best located on a side road at its junction with the major road. This ensures that traffic speed is naturally reduced by the action of traffic turning into the side road. For a zone to start on one of the arms of a junction, vehicle drivers need to be able to see the zone signs. This is particularly important where a junction is controlled by traffic signals. Siting the zone signs so they do not obscure, or are not obscured by the signals, will need particular attention. If a satisfactory solution cannot be found, then the start of the zone will need to be relocated. Zones can be commenced midway along a street, but care must be taken that the start of the zone can readily be seen. This would normally require speed reducing measures in addition to the zone signs, so that a gateway effect is formed.

3.2.25 Gateways have been shown to be very effective in reducing vehicle speeds (see Chapter 7) but to achieve this they need to be conspicuous. This can present a particular challenge in sensitive conservation areas (see Section 3.7). The use of 20 mph limit repeater signs and roundels is unnecessary within a 20 mph zone as physical speed controlling measures will already be present.

3.2.26 Carriageway texture changes may be used at zone entrances, but care needs to be taken that such surfaces do not create a noise nuisance. Rumble strips (see Chapter 5) are generally not recommended. Whilst they can form a good alerting device, they may not be effective as a speed reducing feature and will often result in a noise nuisance arising. The Department commissioned TRL to develop a new surface profile called rumblewave. This aims to give the same level of noise and vibration within vehicles as rumble strips but negligible increases in external noise (see Chapter 5). Narrowing the carriageway (see Chapter 6) at the entrance to a zone by creating a pinch point can be effective and may be a preferred option where coloured or textured surfacing is considered inappropriate, but should only be used where before traffic speeds are low. Narrowings can be used with a change in road surface to provide further emphasis.

3.3 Roads with 30 mph speed limits

3.3.1 Traffic calming measures have previously been used on 30 mph limit roads, either to ensure that 85th percentile speeds do not exceed 30 mph, or to secure substantial speed reductions to speeds well below this level. Where the installation of traffic calming measures on a 30 mph limit road is likely to reduce or control overall mean speeds (average of 'at' and 'between' the measures) to below 20 mph, it can be simpler and more beneficial for local authorities to implement 20 mph zones.

3.3.2 The self-enforcing measures used to prevent the 85th percentile speed of cars and light vans exceeding 30 mph include 75 mm high flat-top humps with on/off ramp gradients of about 1:15 (but may need to be steeper), round-top humps 50 to 75 mm high, speed cushions, 'thumps', horizontal deflections and mini-roundabout (see Sections 4 to 8). The speed control characteristics of other measures (e.g. narrowings, traffic islands and pedestrian refuges) are not as great and may not be sufficient on their own to keep speeds below 30 mph.

3.3.3 Where no alternative cost-effective solution can be implemented, speed cameras have been used on 30 mph limit roads in isolation or in conjunction with other traffic calming measures, provided that certain procedures have been followed, to deter drivers from exceeding the speed limit at locations where there is a history of road traffic collisions and vehicles exceeding the speed limit. Individual speed cameras, like most individual traffic calming measures, have been shown to have a particular localised effect on vehicle speeds and casualty numbers. Changes in speed vary at individual sites. However, the independent *Three Year Evaluation Report of the National Safety Camera Programme*, published in June 2004, shows average and 85th percentile speeds had fallen by 8 per cent (2.4 mph) and 9 per cent (3.4 mph) respectively at new camera sites on 30 mph limit roads. It also shows a 33 per cent reduction in vehicles exceeding the 30 mph speed limit at the camera sites. Camera systems that calculate average speeds have the potential for reducing speeds over greater distances (see Section 9.3). The Department's 2006–07 research programme includes new research to improve the understanding of the wider effects of cameras.

3.3.4 Vehicle activated speed reminder signs have been used at the entry to 30 mph limit areas to alert drivers who are exceeding the speed limit by a pre-set margin (see Section 9.1). The signs are usually blank until a vehicle approaches at a speed above the pre-set speed. Speed reductions of about 2 to 6 mph have been obtained in 85th percentile speeds at the signs. Mean 'after' speeds were generally at or below the 30 mph limit and 85th percentile speeds still above the limit.

3.3.5 A full range of consultation needs to be carried out during the planning of schemes for traffic calming measures (not including speed cameras) in 30 mph speed limits (see Section 2.4). This should include the police, residents, local traders, the fire and ambulance services, bus operators, vulnerable road user groups, groups representing disabled people and, where appropriate, haulage operators and users of agricultural equipment.

3.3.6 Advice on the use of traffic calming on strategic routes is given in Section 2.6 and TAL 03/94. Although the use of road humps along such routes is not precluded, care will need to be taken in the design of such measures. In some cases, the use of speed cushions no greater than 1.7 metres in width may be acceptable. Similarly, on bus routes, speed cushions will generally cause less discomfort to passengers (see Section 2.5). Where 100 mm high raised junctions are installed on bus routes, it can be an advantage to use shallow on/off ramp gradients of between 1:15 and 1:20 rather than the more common gradients of between 1:10 and 1:15.

3.3.7 The spacing of the traffic calming measures will influence the speed midway between the measures. Spacing in excess of 100 metres may increase speeds significantly (see Section 4.4). Spacing in excess of 150 metres, for any type of measure, is not recommended. For most measures, a spacing of 60 to 90 metres would be appropriate. On strategic routes, a spacing of between 100 and 150 metres may be preferable if humps or raised junctions are used.

3.3.8 Road humps on 30 mph limit roads will need to be marked separately (see Chapter 4) and appropriately lit (see paragraph 2.8.2): signs to diagram 557.1 and 557.2 or 557.3 or 557.4 of TSRGD will need to be erected at the start of the series of humps. Whether other traffic calming measures need to be signed will depend on the circumstances. Pairs of elongated 30 mph roundel markings can be used to accompany vertical 30 mph repeater signs on unlit 30 mph limit roads. Repeater signs of any type cannot be used on lit 30 mph roads.

3.3.9 The current regulations allow the installation of humps (including speed cushions) without special authorisation by the Department, on principal roads having speed limits no greater than 30 mph. Regard will need to be given to the likely approach speeds, the concerns of the emergency services and bus operators (see Sections 2.5 and 2.6) and the relatively high proportion of large vehicles on these roads. Problems of noise and ground-borne vibration can arise when large vehicles travel over some types of vertical deflections (see Section 4.5).

3.3.10 The regulations do not require a speed reducing feature to be located in advance of road humps, whether a single hump or a series of them. However, it is strongly recommended that a speed reducing feature should be used to ensure that, as far as possible, the speed limit is not exceeded when a vehicle meets the first hump. Features could include a junction, a bend of 70 degrees or more, gateways, mini-roundabouts, or 'give way markings' at a pinch point to create priority working. Where a speed reducing feature is used, it should be less than 60 metres from the first hump to obtain the maximum benefit.

3.3.11 Conspicuous gateways with appropriate speed reducing features can achieve, in their immediate location, quite high reductions in speed. Even so, they may not reduce speeds to 30 mph, and this will need to be borne in mind if gateway signing alone is to be used as a speed reducing feature. Where road humps are considered to be appropriate as a speed reducing feature, it may be preferable for the hump to be located a short distance after the gateway, say 10 to 20 metres away. This will ensure that drivers have sufficient opportunity to reduce their speed before encountering the hump, but will deny them the opportunity to accelerate before reaching it.

3.3.12 If a single road hump is used at an entry treatment on a side road, a speed reducing feature on the side road approaching the hump will normally not be necessary. However, local authorities should ensure that, when drivers are approaching the hump along the side road, it is clear to them that there is a junction ahead. Road humps at entry points will need to be signed. Other than when used as an entry treatment on a side road, single road humps are not recommended, unless they can be used in conjunction with other speed reducing features.

3.3.13 Where a side road leads into a road with road humps, it is recommended that a road hump should be met within a distance of 60 metres in order that drivers are not encouraged to increase their speed above 30 mph. Where the side road carries through traffic, it is suggested that the first road hump should be met within 40 metres of the junction.

3.4 Roads with 40 mph speed limits

3.4.1 Legislation does not permit the use of vertical deflections such as road humps, speed cushions and 'thumps' on 40 mph limit roads outside London. These measures are not recommended for use on any 40 mph limit roads and can only be used on 40 mph limit roads in London after consultation with the Secretary of State (see paragraph 2.1.6).

3.4.2 Off-road trials were carried out by Hampshire County Council and by TRL using various hump profiles intended for 40 mph limit roads. It was concluded that the profiles tested were not suitable, because of the heavy pitching or grounding of buses, as well as concerns about high speed loss of control for car drivers and motorcyclists (Hodge, 1993; Webster & Layfield, 1998).

3.4.3 According to the traffic calming regulations, the following self-enforcing measures are allowed on 40 mph limit roads: rumble devices, build-outs, chicanes, pinch points, narrowings, islands, pedestrian refuges, gateways and roundabouts (see Sections 5 to 8). However, for some of these features (such as chicanes) careful planning is required to ensure a safe and effective scheme. The spacing of these measures will influence speeds midway between the measures, and spacing in excess of 100 metres may increase speeds significantly. Pairs of elongated 40 mph roundel markings can be used to accompany vertical 40 mph repeater signs. It has been found that placing speed limit roundels in pairs on a coloured background is more effective as a traffic calming measure than staggered roundels.

3.4.4 The results of a study of traffic calming in villages on major roads (Wheeler & Taylor, 1999) indicate that fairly substantial calming measures are likely to be required to reduce 85th percentile speed to below the 40 mph limit (see Section 3.8).

3.4.5 Whether the traffic calming measures need to be signed will depend on the type of measure and its location within the road network. It is important to ensure that the measures are conspicuous at all times, and that road users are provided with adequate warning (in accordance with Regulation 8 of the Traffic Calming Regulations, see Section 2.1). Signing will need to be carefully considered for significant horizontal deflection such as chicanes, particularly if they are isolated and not used in conjunction with other self-enforcing measures.

3.4.6 As with the use of self-enforcing traffic calming measures in 20 mph zones and on 30 mph roads, a full range of consultation needs to be carried out during the planning of schemes for traffic calming measures in 40 mph speed limits. This should include the police, residents, the fire and ambulance services, bus operators and, where appropriate, haulage operators and users of agricultural equipment (see Section 2.4).

3.4.7 Speed cameras have also been shown to be effective on roads with 40 mph limits, in isolation or in conjunction with other traffic calming measures. Changes in speed vary at individual sites. However, the independent *Three Year Evaluation Report of the National Safety Camera Programme*, published in June 2004, shows average and 85th percentile speeds had both fallen by 7 per cent (2.8 mph and 3.2 mph) respectively at new camera sites on 40 mph limit roads. It also shows a 33 per cent reduction in vehicles exceeding the 30 mph speed limit at the camera sites.

3.4.8 Vehicle activated speed reminder signs have been used on 40 mph limit roads at entrances to villages in Norfolk, to remind drivers that they are travelling above the speed limit (see Chapter 9). Speed reductions of about 3 mph were obtained in mean speeds at the signs. Mean 'after' speeds were generally at or below the 40 mph limit.

3.5 Roads with speed limits greater than 40 mph

3.5.1 Although the same self-enforcing traffic calming measures (described in paragraph 3.4.3) can legally be used on both roads with speed limits of 40 mph and roads with speed limits greater than 40 mph, it is recommended that chicanes or other measures with sudden kerb build-outs are not used on the higher speed limit roads.

3.5.2 Generally, self-enforcing traffic calming measures on these roads have been limited to islands, pedestrian refuges, hatching, coloured surfaces and rumble devices.

3.6 Town centres

3.6.1 The Bypass Demonstration Project was initiated in 1991 by the Department. It was a comprehensive project involving highway planners and town planners in the design of traffic calming and other measures, in six towns where a bypass had been constructed (DoT, 1995c; Social Research Associates, 1999). The purpose was to ensure that speeds on the de-trunked main roads were reduced and that facilities for vulnerable road users on these routes were improved. The main aim of the project report was to provide guidance for other local authorities to follow. The surveys carried out were an essential part of the project, and the need for attention to detail during the design stage and during implementation of the schemes was also highlighted as important.

3.6.2 The results from the Bypass Demonstration Project showed that traffic calming can be a strong stimulus to the economy of town centres, and that people react favourably to quieter environments, wider footways, lower traffic speeds and easier crossings. Walking about in the towns is also encouraged when car access is given less priority and traffic speeds are perceived as slower. Overall accidents during the project were reduced. In addition there was evidence that pedestrian areas were popular and good for trade. In such environments people not only feel more relaxed but they also walk about more and visit more shops. This view was recognised by the majority of traders in the towns, many of whom had initially been against, or at least wary of, the schemes.

3.6.3 One of the key elements in the success of town centre pedestrianisation schemes is careful consultation, and ensuring that appropriate provision is made for, amongst others, disabled people (who often rely on cars as well as taxis and buses), cyclists, buses and deliveries. Targeted restrictions on vehicles ('vehicle restricted areas') can be a better solution

Fig. 3.7 Rising bollards raised and lowered

than a simple ban. LTN 01/87 *Getting the right balance* is the primary guidance on this issue. Access by motor vehicles relies on drivers being conscientious, and it is important that drivers give priority to pedestrians. Bus operators should agree safe speeds with the local authority and instruct their drivers accordingly (LTN 01/97). Rising bollards (Fig. 3.7), described in TAL 04/97, can be used to limit access to allow permitted vehicles only. However, the potential for these devices to be damaged will have maintenance implications. Special warning signs, which would require authorisation, may be necessary.

3.6.4 A study of cycle pedestrian interactions in pedestrian areas (Trevelyan & Morgan, 1993) concluded that cyclists could be permitted into pedestrian areas without detriment to pedestrians. More recent work (Davies *et al*., 2003) concluded that sharing of vehicle restricted areas is not an ideal solution, either for pedestrians or cyclists, but that it may be an appropriate compromise in terms of trying to meet sustainable transport objectives. In each situation, the relative risks and benefits to both user groups should be assessed, as these may vary with local circumstances.

3.7 Historic areas

3.7.1 In England and Wales there are almost 8,500 designated conservation areas. Local authorities have a statutory duty to preserve or enhance the character or appearance of these areas. There are also many thousands of listed buildings: local authorities must have special regard for the desirability of preserving the listed building or its setting.

3.7.2 In England, detailed policies on historic buildings and conservation areas are set out in Planning Policy Guidance Note 15 (PPG15) (DOE, 1994), which offers specific advice on reconciling transport and townscape issues. It recommends that highway authorities should reflect the need to protect the historic environment through the more detailed aspects of road building and road maintenance, such as the quality of the street furniture and road surfaces.

3.7.3 Traffic calming techniques aimed at reducing accident problems can have a dramatic impact on the visual appearance of historic areas. In order to meet safety, planning and environmental objectives, such works are most appropriately carried out as part of an integrated approach to the management of the townscape, within the context of a traffic management strategy for the wider area.

3.7.4 The English Heritage *Streets for All* manuals (English Heritage, 2005) and TAL 01/96 *Traffic Management in Historic Areas* give general advice on the introduction of traffic engineering measures in historic areas. A prime consideration will be whether the physical measures preserve or enhance the character or appearance of the historic area, while meeting operational and safety requirements. Simplicity of design is advocated, and the use of materials that match, rather than contrast with, their surroundings. The cost of high quality materials may often seem prohibitive. However, an assessment should consider the durability of many natural materials and the benefit to the local economy of quality schemes in town centres.

3.7.5 Care will need to be taken in historic areas to ensure that the design of traffic calming measures does not diminish the visual amenity or character of the area. Some historic areas already include townscape features that have a natural traffic calming effect. These include tight kerb radii, narrow carriageways, cobbled and setted streets, and traditional gateways or pinch points. New entry treatments and gateways could be based on appropriate local townscape features, producing a wide variety of designs.

3.7.6 If proposed traffic calming measures or their associated signs and markings do not conform with the current regulations in historic (or any other) areas, special authorisation must be sought from the Department.

3.7.7 The Historic Core Zones project was initiated by The English Historic Towns Forum in 1994 with the support of DfT, English Heritage, CSS and others. This project investigated how traffic management or calming schemes could be designed to suit areas of special historic character. Four schemes were selected for study: Halifax, Lincoln, Bury St Edmunds and Shrewsbury. These are described in a report by The English Historic Towns Forum (EHTF, 1999), and an update on their progress has also been published (EHTF, 2003). Results of traffic and interview surveys are summarised in TALs 10/97, 02/98, 08/98 and 13/99.

3.7.8 There are no standard solutions for historic areas, but local authorities might consider whether some of the elements of these schemes would be appropriate in their areas. Generally, the schemes reduced the traffic flows on the affected roads by up to a third, and mean speeds by up to 7 mph. Illegal parking activity was reduced in some areas, and many pedestrians used the informal crossing places, but only 17 per cent of those drivers who could give way did so. Over two-thirds of the public interviewed felt that the schemes had improved the appearance of the areas and the ease of walking on the footway, but fewer thought that the safety and convenience of crossing the road had improved. There were mixed views about the effects of some of the schemes on conditions for cyclists. The results reinforce the point that is important that cyclists are taken into account at the design stage, because features that might enhance the appearance of the area, such as granite setts, may be unsuitable for cyclists. Depending on their design and location, narrow carriageways or the use of narrowings can also cause problems for cyclists.

3.8 Villages and rural areas

3.8.1 Vehicle speeds through villages are often the cause of public anxiety. The Government's road safety strategy states that a standard speed limit of 30 mph should be the norm in villages. Further information about the definition of a village is provided in TAL 01/04. Where villages do not meet the criteria set out in TAL 01/04, there may still be a need to reduce the speed limit below the national speed limit.

3.8.2 Signs alone may not be sufficient to reduce speeds to the desired level. In such instances, some form of physical engineering measures may be required to ensure that the speeds are reduced sufficiently and then controlled throughout the village. However, many rural main roads carry relatively high volumes of traffic, including commercial vehicles, and the use of vertical deflections may result in environmental problems of noise and ground-borne vibration, particularly if full-width road humps are used to control vehicle speeds. In order to be effective, signing and marking measures need to be conspicuous. This can conflict with wider environmental objectives in designing schemes that are sympathetic to the local landscape.

3.8.3 Some roads in the UK are designated as abnormal load routes, which are able to accommodate exceptionally wide, high and long vehicles. On such routes, the traffic calming measures that are used must be able to cater for these loads, and it is important that adequate consultation is undertaken prior to the scheme design stage. In rural areas the design of any horizontal measures should allow combine harvesters or similar agricultural machinery to pass through without causing problems (for example chicanes on the A47 at Thorney; Wheeler *et al.*, 1997).

3.8.4 Some speed reduction can be achieved by introducing local 30 mph speed limits on higher speed limit roads. In 1994, Suffolk County Council initiated a policy of introducing new speed limits at 450 villages, using standard 30 mph signing and entry roundels. These new limits were set up alongside a continuous policy of introducing physical traffic calming measures where there was an evident accident problem, mobile speed enforcement cameras, and a high profile antispeeding campaign. Where the limit was previously 40 mph, 85th percentile speeds were reduced by 3.5 mph. Where the limit was 60 mph, the results showed a reduction of about 6 mph (Jeanes, 1996). A follow up study of the impact of the change in speed limits on accidents indicated that the number of injury accidents had been reduced by 20 per cent (Watson & Allsop, 1999).

3.8.5 Further speed reduction can be achieved with the use of gateway treatments and traffic calming measures within the village. The first major study of traffic calming on rural roads was the **Vi**llage **Sp**eed control (VISP) study (Wheeler *et al*., 1994). This was a joint study between the then County Surveyors' Society, DTLR, the Scottish and Welsh Offices, and TRL. A sample of 24 village traffic calming schemes was selected for study, most with existing 30 mph or 40 mph limits, which remained unchanged. The gateway treatments encompassed such measures as signing, pinch points, carriageway narrowings, surface treatments, 30 mph roundels, dragon's teeth markings, and transverse bar markings. The measures within the villages included speed cameras, mini-roundabouts, roundels, central hatching and islands, footway extensions, pinch points, carriageway narrowings, and pedestrian crossing facilities. The main points to emerge from the study were that:

- comprehensive measures are required throughout the village if significant speed reductions are to be obtained;
- gateways can reduce speeds in their vicinity by up to about 10 mph, but for reductions to be maintained in the village, additional measures need to be used;
- the amount of speed reduction broadly mirrors the type of scheme: simple gateway signing and marking provides small reductions, while gateways comprising very striking visual measures or physical measures produce greater benefits;
- speed reductions are maximised when visually striking or physical gateways are accompanied by repeated physical measures in the village.

3.8.6 The VISP work was followed up by a DfT study of the application of speed reducing and speed controlling measures to nine villages on major roads, particularly trunk roads. More extensive measures were used in these situations (TAL 02/97, 06/97,14/99 and 01/00). The speed reducing measures at, or on the approach to the gateways included countdown signs, bar markings, dragon's teeth markings, speed limit changes, narrowings, coloured surfacing, speed limit roundels, surface treatments, a vehicle actuated 30 mph sign and speed camera signing. Within the villages, the speed control measures included coloured patches with speed limit roundels, islands, refuges, centre hatching, speed cushions, mini-roundabouts, chicanes, speed cameras, a pedestrian crossing, and variable 20 mph limit signing. The results from this study (Wheeler & Taylor, 1999) complemented the previous work with the following main findings:

- the level of speed reduction, following the installation of a traffic calming scheme on a main road, is likely to be affected by the pre-existing speed limit, the magnitude of the 'before' speeds, the new speed limit and the traffic calming measures used;
- conspicuous traffic signing and road marking measures can bring about large speed reductions (up to 15 mph) at entries to villages on trunk roads, when used together for high visual impact. Repeated use through the village can also reduce speeds, but is unlikely to achieve 85th percentile speeds below the posted speed limit;
- speed cushions (1.5 metres wide), mini-roundabouts and chicanes can be used in trunk road villages to bring about greater speed control than signing and marking measures alone. Care is needed with the design and siting of vertical deflections where there are high flows of heavy vehicles or emergency service vehicles, or where the soil type is especially prone to transmit vibration;
- if the spacing of measures is too great, any speed reduction is localised;
- residents are unlikely to be satisfied with schemes that do not achieve their expectations of reducing speeds below the new/retained speed limit, and it is important not to raise their hopes unrealistically.

3.8.7 The study highlighted the importance of involving residents in the development of schemes and providing them with an understanding of what can be achieved. There is often a trade-off between scheme effectiveness in terms of vehicle speed and accident reduction, and potential unwanted side effects such as visual intrusion. The optimum solution will vary widely according to the situation.

3.8.8 The impact of village traffic schemes on accident frequencies, which included schemes in the VISP study, those in the major roads study and an additional sample of villages not previously studied, has also been examined. The accidents were classified by severity and type, and the villages (56 in total) were grouped by the type of measures installed, by traffic flow and by the speed reduction achieved. However the schemes were grouped, reductions were found in the frequency of all injury accidents (i.e. all severities) and accidents involving fatal or serious injuries (KSI), the majority of the reductions being statistically significant. Across all villages, all accidents and KSI accidents were reduced by about one quarter and one half respectively. These changes substantially improve on national trends for accidents on all roads (excluding motorways), which show a 7 per cent reduction in all accidents and a 27 per cent reduction in KSI accidents. Child pedestrian accidents involving fatal/serious injury were reduced by three-quarters and child cyclist accidents were halved regardless of severity. The higher the speed reductions in the village – generally commensurate with the use of more extensive measures – the greater the reduction in accidents (Wheeler & Taylor, 2000). It should be noted that the speed limit in the majority of these villages remained unchanged at 30 mph or 40 mph.

3.8.9 The schemes described above have used a combination of signs, markings and physical measures to achieve their speed reductions and consequent reductions in accident frequencies. However, the signs, markings and measures used can change the visual appearance of a village in a manner that may detract from, rather than add to, the character of the village. An alternative approach is to consider how natural traffic calming features work to slow people down, and how the principles found might be applied to future schemes.

3.8.10 In order to further this approach, the Scottish Executive commissioned a study of ten locations in Scotland where traffic appeared to be 'naturally calmed'. The results (Scottish Executive, 1999a) highlighted the importance of transition in helping drivers adjust their perceptions and their speed to the environment they are entering and also the importance of street activity in influencing vehicle speed. The study found that the examples of natural traffic calming rarely relied on a small number of key factors, and it appeared that drivers were more influenced by the combined impact of a large number of factors and features.

3.8.11 Generally, opportunities to reorganise the layout of roads and buildings will seldom present themselves. However, by working within the environmental context of the location it may be possible to use existing features or replicate these features for traffic calming purposes. The environmental impact of rural traffic calming measures was considered as part of a review of 20 traffic calming schemes on the trunk and principal road network in Wales (National Assembly for Wales, 1999). This provides general design guidance for fitting traffic calming measures into the local environment and concludes that, in the main, a specific set of measures will be required at each site.

3.8.12 The Department commissioned research to identify potential 'psychological' calming measures and test their effectiveness. The aim was to increase the psychological load on drivers and thereby encourage them to reduce their speed. It is also intended to examine opportunities for developing the sense of place of an area and consider how changes to all aspects of the streetscape may suggest a lower 'appropriate' speed than was thought previously.

3.8.13 These techniques were tested is in the village of Latton, Wiltshire. The road through this village had been de-trunked, but there had been no changes in the streetscape to reflect this change in road function. Changes to the village included creation of a gateway feature to emphasise the start and end of the village (Fig. 3.8), reduction in the size of signs and lamp columns, addition of sheltered parking bays to create gentle chicanes and break up sightlines, removal of centre line markings, increased emphasis of a village triangle and memorial, and a reduction in the speed limit from 40 mph to 30 mph (the start of the new limit was also moved to connect visually to the start of the village). Mean speeds within the village have been reduced by 7–8 mph, with 85th percentile reductions of 8–10 mph (Kennedy *et al.*, 2005). See paragraph 6.3.4 for further details.

3.8.14 The Countryside Traffic Measures Group (CTMG) was set up in 1997 by the Countryside Commission (now the Countryside Agency) and DTLR, to support the planning and implementation by local authorities of innovative rural traffic management

Fig. 3.8 Gateway feature, Latton

schemes. Under this initiative, local authorities were invited to propose schemes that formed part of their traffic and transport strategies, and were designed to integrate sensitively into the local environment. The chosen schemes were located in Norfolk (Stiffkey, Blakeney and Wiveton), Suffolk (Occold), Surrey (Charlwood, Fig. 3.9), Hampshire, Devon and Cumbria. For various reasons, those in Hampshire, Devon and Cumbria were not pursued.

3.8.15 The five schemes that were monitored were all in villages and were aimed at reducing vehicle speeds (Kennedy & Wheeler, 2001a; Wheeler, Kennedy *et al.*, 2001a; Wheeler, Kennedy *et al.*, 2001b). The measures found to have most effect on speed were:

- vehicle-actuated fibre optic speed limit reminder sign (Blakeney);

Fig. 3.9 Charlwood after treatment

- kerbed build-outs (one-way working) with light coloured surfacing at entries to 20 mph zone (Occold);
- grey imprinted surfacing with footway widening or carriageway narrowing (Charlwood);
- village gateways, with imitation gates, 30 mph roundels and either rumble strips or a simulated narrowing (Charlwood).

3.8.16 Other measures included:

- sandy coloured surfacing, with no road markings and a 20 mph speed limit, to impart a ‘country lane’ feel (Stiffkey);
- footway incorporating overrun areas composed of grey imprinted surfacing (Stiffkey);
- changes to signing to preserve village character (Norfolk villages);
- re-alignment of Y-junction to a T-junction using light coloured surfacing (Occold).

3.8.17 The size of the reduction in mean speed depended on both the ‘before’ speed, and the speed limit before and after scheme implementation. The sandy coloured surfacing in Stiffkey had only a small effect on mean speed, which was already constrained to just above 20 mph. Speed reductions were not maintained unless measures were continuous or repeated throughout the length of the village.

3.8.18 The level of satisfaction with the appearance of the schemes was fairly high, but there were mixed views over their effectiveness. The imprinted surfacing in Charlwood was considered noisy, with noise surveys showing a change in character of noise on this surface. The patches of light coloured surfacing in Occold were seen as untidy.

3.8.19 Quiet Lanes are an initiative of the Countryside Agency, supported by DfT (see paragraph 3.1.12). They are intended to form a network of country lanes, suitable for use by walkers, cyclists and equestrians as well as by motorists. They may also help to link off-road routes for non-motorised users and so provide continuity of the off-road network. Their aim is to help preserve the character and tranquillity of rural areas and to encourage an increase in non-motorised users, whilst maintaining vehicular access. The intention is to make motorists more aware of non-motorised users and maintain low motor vehicle numbers and speeds against a background of increasing rural traffic.

3.8.20 The streetscape manual *Streets for All* (English Heritage, 2005) provides information on designing measures for rural roads. The rural White Paper *Our Countryside: the future – A fair deal for rural England* (DETR & MAFF, 2000a) may also be relevant.

3.8.21 Traffic calming may be appropriate in rural areas when planning road crossing points connecting footpaths, bridleways etc. Such measures will need to be cycle-, equestrian- and pedestrian-friendly.

4. Road humps

4.1 Background

4.1.1 Road humps are the most widely used form of traffic calming device because they have proved to be effective at controlling speeds and are generally applicable to most road layouts. The advantages and disadvantages of using road humps and speed cushions are given in Appendices E and F respectively. Road hump geometry can affect the degree of discomfort experienced by road users and the subsequent speed controlling effect.

4.1.2 Some traffic calming schemes consist purely of road humps, with spacings determined by the road layout and the desired speed reduction at a given location. This can be a satisfactory solution for many roads, but area-wide schemes can often be enhanced by having a variety of measures that blend in with the surrounding area and are appropriate for the desired speed required. Planting of trees may be used to enhance an area and may also help in reducing pollution levels in the area.

4.1.3 The original work on the development of a suitable profile for road humps was carried out by TRL in the early 1970s (Watts, 1973), and resulted in the circular profile (round-top) hump 3.7 metres long and 100 mm high. The trials found that humps less than 3.7 metres long became less effective as speed rose. It is strongly recommended, though not obligatory, that a speed-reducing feature is provided before an isolated hump or the first in a series, so that drivers approach the first hump at an appropriate speed. Care must be taken in locating road humps adjacent to junctions with traffic signals, as drivers may accelerate through the junction (to avoid having to stop if the lights change) and then approach the hump at too high a speed. Adequate warning (e.g. traffic signing) should be provided before drivers encounter road humps.

4.1.4 75 mm high humps are generally recommended by DfT (TAL 02/96; Webster & Layfield, 1996), along with lower height speed cushions (TAL 01/98; Layfield & Parry, 1998), and these are now widely used. However, the Highways (Road Hump) Regulations 1999 still allow a maximum height of 100 mm. Lower height features generally cause less discomfort at a given speed or less delay for bus operators (LTN 01/97; TfL, 2005) and the emergency services, and have been shown to give speed reductions comparable to those from 100 mm high humps.

4.1.5 Smoothing the initial rise of humps and smoothing the return to the road level exit (see paragraph 4.2.7) can reduce the dynamic impact on vehicles by up to 20 per cent (Kassem & Al-Nassar, 1982), though these profiles will generally be better for cyclists. Hidas (1993) proposed continuous waves, but these were found to be unsuitable for use on the highway (Alexander, 1990; Webster & Layfield, 1998).

Grounding of vehicles

4.1.6 UK legislation for vehicle construction does not require a minimum clearance to be provided between the underside of a vehicle and the carriageway surface. Vehicle manufacturers, including those adapting vehicles for particular purposes, e.g. for disabled people, are expected to take into account the need to negotiate a variety of features likely to be encountered on the highway, including road humps. However, a few sports cars have unladen ground clearances as little as 100 to 120 mm (Webster, 1993b) and, when such cars are fully laden, ground clearances can be approximately 30 mm lower. Some limousines of the type used for weddings and funerals can have an unladen ground clearance of around 100 mm and, when they are fully laden, the clearance can be 75 mm. As they have a long wheelbase, they can straddle the shortest flat-top humps. The likelihood of grounding can be minimised by suitable hump design (Section 4.2) and is one reason why a maximum height of 75 mm is recommended for individual road humps that are not raised junctions. Similarly, the length and breadth of the speed cushions will affect the likelihood of low vehicles grounding on them. If a low vehicle can have all wheels on the ground while traversing the cushion, grounding problems are likely.

Fig. 4.1 Track trials to examine grounding of vehicles

With short (less than 3 metres) or narrow (around 1.6 metres wide or less) cushions, a lower height such as 65 mm may be appropriate, but this will probably lead to increased vehicle speeds.

4.1.7 It should be stressed that vehicles travelling over road humps at appropriate speeds (Fig. 4.1) should not suffer damage, provided the humps conform to the hump regulations. The consultation period should be used to determine if any residents or local bus operators have vehicles that demand careful treatment of the road hump design (see Section 2.5). The effect on articulated buses may differ from conventional buses, and this should be taken into account.

4.1.8 Some local authorities have reported grounding problems with caravans (Webster, 1993b) and have overcome this by ensuring that in specific instances there are lower humps between particular houses and the entry to the scheme. However, ensuring that a caravan is loaded properly and that the jockey wheel is raised sufficiently can reduce the probability of grounding occurring. Other types of trailers, low loaders and some farm machinery could also have grounding problems, but in specific instances of difficulty appropriate lower height humps of 50–75 mm can be used to minimise the problem.

Signing and marking of road humps

4.1.9 The signs and road markings for road humps are prescribed in TSRGD. The required signs to diagram 557.1 must be illuminated during the hours of darkness, and each hump should be signed if the humps are spaced at more than 150 metre intervals. Diagram 557.1 must be used in conjunction with an appropriate distance plate (557.2, 557.3, or 557.4). In the case of humped crossings, the 'Humped crossing' plate (diagram 547.8) should be used in conjunction with the zebra (diagram 544) or signal-controlled crossing (diagram 543) sign. White arrowhead markings to diagram 1062 of the TSRGD are used to indicate the ramps. Signs and markings are not required if the humps are within a 20 mph zone. Figures 4.2–4.4 show appropriate sign assemblies and road markings.

Structures

4.1.10 Other than in 20 mph zones, road humps must not be constructed on any bridge, subway, culvert, inside a tunnel or within 25 metres of any of these structures on the same carriageway or within 20 metres of a railway crossing. This requirement is to ensure that structural damage does not arise from vehicle impact or increased impact loading.

4.2 Types of road hump

4.2.1 The longitudinal profile of a road hump can be based on a segment of a circle, a sine wave or have a flat top with straight ramps up to the plateau. The Seminole County Profile (Nicodemus, 1991) used in the USA is a flat-top hump with rounded ramps. The height of a road hump must not exceed 100 mm, and it is generally recommended that it does not exceed 75 mm regardless of the profile.

Note

A - Signs on both sides of the carriageway may be appropriate where it is considered that emphasis needs to be given to the prescience of road humps ahead.

B - Signing of humped Zebra and Pelican Crossing signs will generally only be necessary if the spacing between the adjacent humps is greater than 100m.

C - Distance plates should indicate the distance that the series of road humps extends along the road to which the sign immediately applies.

D - Side roads with road humps do not need to be separately signed, provided the first hump in the side road is within 40m of the junction. Similarly, these same side roads do not have to warn of road humps on the main road if the humps on the main road are within 40m.

E - Cul-de sac leading to a road having road humps do not need signs to warn of humps if the cul-de sac only serves around 100 dwellings.

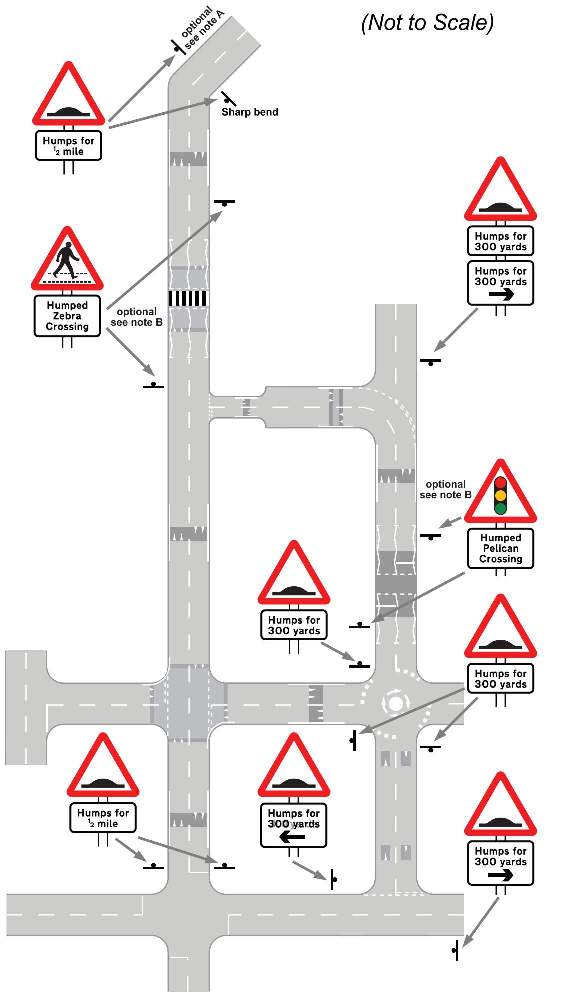
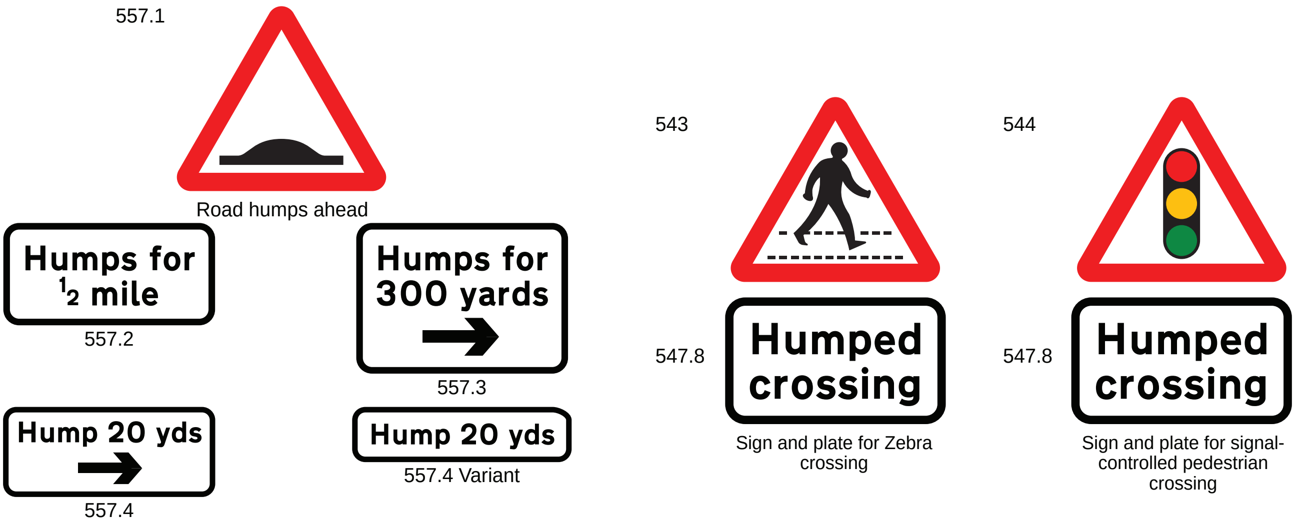


Fig. 4.2 Road markings and sign assemblies for humps



Refer to the Traffic Signs Regulations and General Directions 2002 for appropriate dimensions.

Fig. 4.3 Signs for road humps

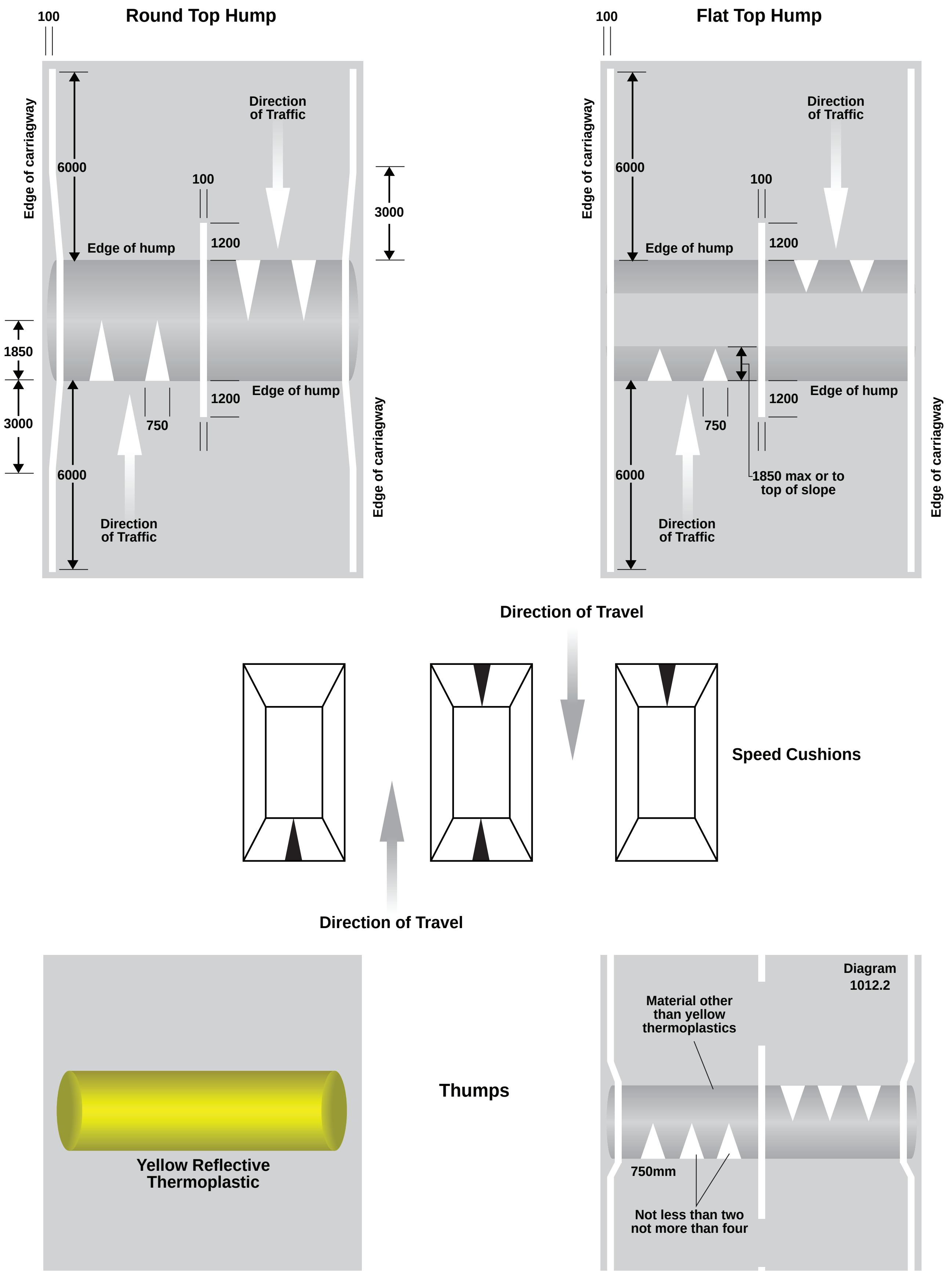


Fig. 4.4 Marking of road humps

4.2.2 The transverse profile of road humps is not prescribed, but it is generally recommended that designers follow well-proven designs. Tapered humps (humps that are not completely kerb-to-kerb) should not generally have a channel greater than 200 mm, and the width of the side ramps should be between 150 and 300 mm. An edge line marking should be provided to indicate the top of the taper. However, when a larger gap between the hump and kerb is to be provided for cyclists, designers should aim for a width of 1000 mm (with 750 mm as the minimum width required). Further details are given under each type of hump if they vary from the above dimensions.

4.2.3 Ramp gradients can be varied to lessen the impact of a hump, and it is suggested that a maximum of 1 in 10 combined with a height of 75 mm should avoid grounding of almost all vehicles (Webster, 1993b). It should be noted that gradients of 1:15 have been found to be the best compromise between speed reduction and discomfort for bus passengers (TAL 02/96). For speed cushions, the side ramps should not exceed 1:4 to avoid safety problems for two-wheeled road users (see paragraphs 2.7.22 and 2.7.37) and the on/off ramps should not be steeper than 1:8.

4.2.4 There have been reports of problems from road humps on inclines where vehicles travelling uphill encounter an increased 'actual gradient' of 1 in 5 or greater. In these situations grounding of vehicles can also be a problem. Local authorities found that uphill gradients of 1:15 were appropriate on hills of about 1:10, with shallower gradients for ramps on steeper inclines (see TAL 02/96 and paragraph 2.5.7).

Round-top and flat-top humps

4.2.5 Round-top humps (3.7 metres long) were the first humps to be used in Great Britain, and these were then followed by raised junctions and flat-top humps that had a minimum plateau length of 2.5 metres, giving a minimum hump length of 3.7 metres (see Figure 4.5). The main advantage of the flat-top hump is that it can also be used as a pedestrian crossing (see paragraph 2.7.8) when constructed from kerb to kerb (see DoT, 1995a and 1995b). Kerb-to-kerb round or flat-top humps will require additional drainage, normally in the form of gullies, on both sides of the carriageway on the uphill side.

4.2.6 A maximum spacing of 150 metres is normally recommended for round-top and flat-top road humps and raised junctions (when used in a series), but at this spacing (closer for 50 mm high humps) there may be more braking and acceleration than if the spacing is below 100 metres. Hump spacing of 150 metres is not suitable for 20 mph zones where a spacing of 60–70 metres will be required.

Sinusoidal profile road humps

4.2.7 Sinusoidal profile humps (Figs 4.6 and 4.7) have not been used to any great extent in the UK. Examples, however, can be seen in Edinburgh. The main difference between the round-top and sinusoidal profile is that the initial rise is much less on the sinusoidal hump. It has been reported from the Netherlands (De Wit & Slop, 1984; De Wit, 1993) that this profile is more cycle friendly. However, track trials at TRL have shown that the levels of discomfort

Fig. 4.5 Round-top (left) and flat-top humps

Fig 4.6 Sinusoidal road hump

Fig. 4.8 'H' road humps

are only slightly less than for round-top humps and that cyclists were more concerned with the effect of vertical faces or discontinuities at the edge of the hump where it meets the road. Care should be taken by local highway authorities to ensure humps are built to the correct specification, with a good hump to road transition.

4.2.8 Research commissioned by the Department has shown that the maximum vertical acceleration from a sinusoidal hump is slightly greater than that from a round-topped hump of the same length, which may cause slightly increased discomfort to vehicle occupants (Kennedy et al., 2004). Flat-top humps with 1 metre length sinusoidal ramps gave lower levels of noise and vibration compared to flat-top humps with straight ramps. Discomfort, noise and vibration are discussed in greater detail in Section 4.5. Local authorities will also need to consider any additional cost in achieving a true sinusoidal profile, possibly including the need for additional construction site monitoring.

'H' road humps

4.2.9 The 'H' hump (Fig. 4.8) was designed (Kjemtrup, 1990) as a combination hump (sometimes called a combi-hump) so that buses and cars could travel over the hump at similar speeds. Cars, which have a narrower track, have to use the steeper part of the hump, whereas buses, which have a wider track, are able to use the less severe outer ramps. This affects large buses and fire appliances, but may not be as effective for small ambulances or minibuses with narrower tracks. Off-road trials were carried out in Scotland (Strathclyde, 1993). The 'H' hump has been used in the UK by Fife Council (1996); the dimensions used are given in Figure 4.9. This shows that the outer ramps are 1 in 24 and the inner ramps 1 in 12, with an overall height of 75 mm and a plateau length of 7 metres.

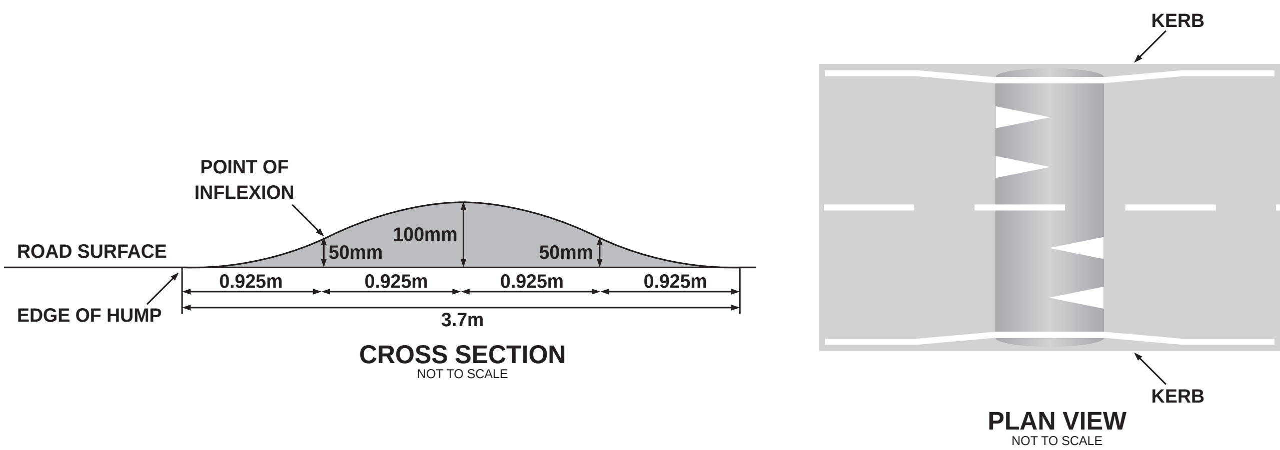


Fig 4.7 Cross-section and plan view of a sinusoidal hump

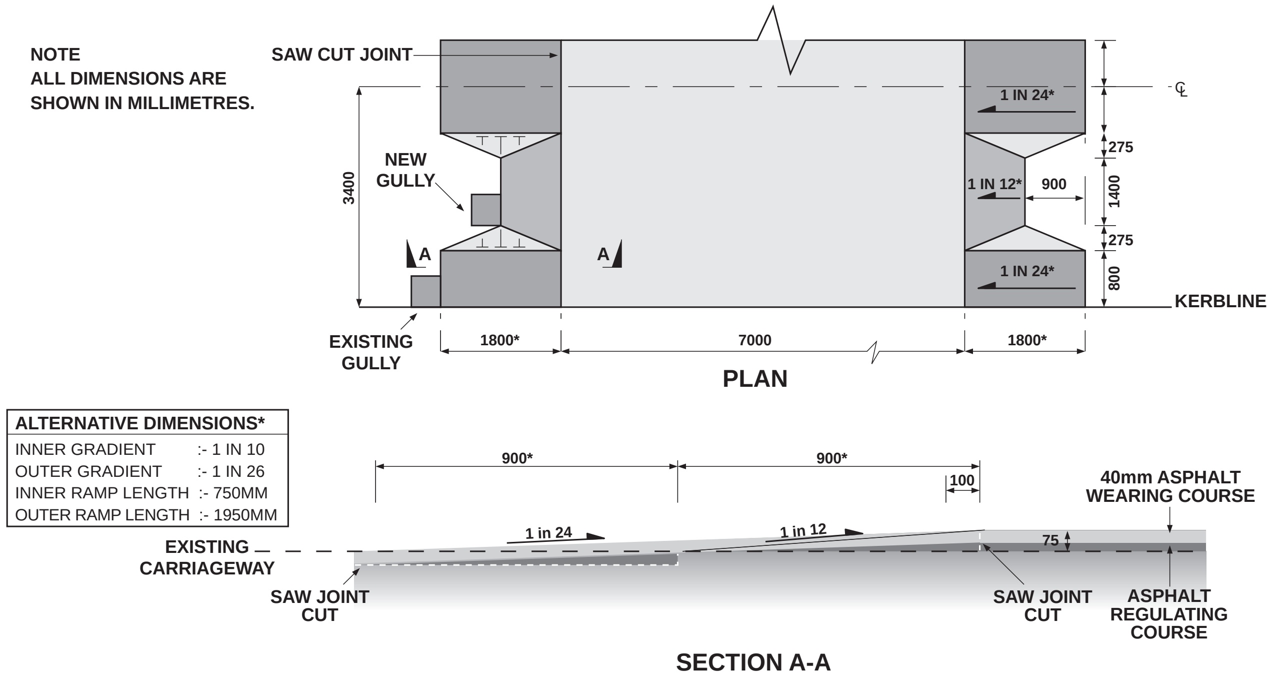


Fig. 4.9 Plan view and cross-section of an 'H' road hump

4.2.10 A spacing of 100 metres was found to be acceptable for the 'H' road humps in Fife (TAL 09/98; Webster & Layfield, 1998) but the spacing and ramp gradients might need to be varied for specific situations. A practical constraint is that additional drainage gullies are needed to prevent water ponding in the indentation formed by the 'H'. The 'H' hump could be used in a speed cushion scheme if pedestrian crossings were required, as was done for the Gloucester Safe City project. The ramps on the stems of the 'H' need careful construction to ensure that any side slopes do not cause difficulties to pedal cyclists or motorcyclists (see Section 2.7). The speed differential between cars and buses was about 6 mph, which is similar to those for round-top and flat-top humps, but the speeds were higher at the 'H' humps (see paragraph 4.4.9).

'S' road humps

4.2.11 The 'S' hump (Fig. 4.10) was designed by Fife Council (1996) in Scotland, using a similar principle to the 'H' hump described above. The 'S' hump dimensions used by Fife are given in Figure 4.11. This shows that the minimum gradient for the outer ramps are 1 in 33 and the maximum inner ramp gradients are 1 in 8, with an overall height of 75 mm and a plateau length of 7 metres. Vehicles with a narrow track have to use the steeper part of the hump, whereas those with a wider track are able to use the less severe outer ramps. This benefits large buses and fire appliances but may not be as effective for small ambulances or minibuses with narrower tracks. The 'S' hump could be used in a speed cushion scheme, where raised junctions or pedestrian crossings are required. A spacing of 100 metres was found to be acceptable for the 'S' road humps in Fife (TAL 09/98, Webster & Layfield, 1998). The speed differential between buses and cars was similar to the 'H' hump.

Fig. 4.10 'S' road humps

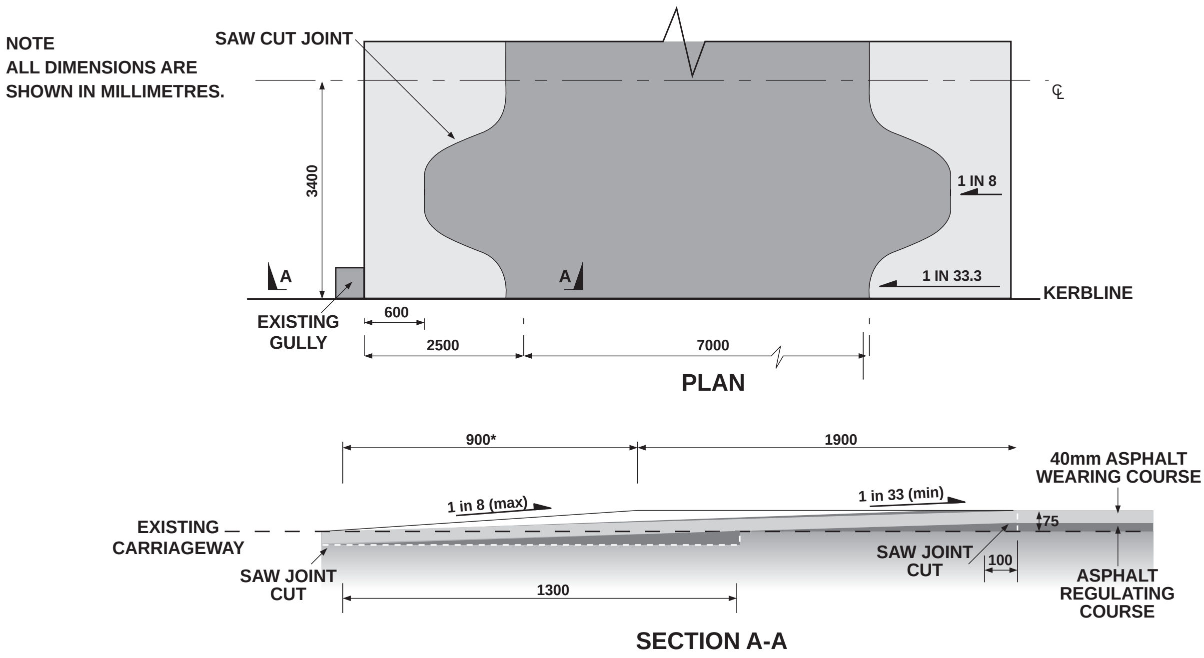


Fig. 4.11 Plan view and cross-section of an 'S' road hump

Thermoplastic humps or 'thumps'

4.2.12 Thermoplastic humps (thumps) are generally 900 mm long and about 40 mm high with a round-top profile – see Figure 4.12. They were first used in the UK in Wakefield as a low-cost option to standard 3.7 metre long round-top road humps. Thumps in excess of 50 mm may cause considerable discomfort to vehicle occupants and are therefore not recommended. An assessment of thumps schemes was carried out (Webster, 1994a) to determine their effectiveness (see paragraph 4.4.10). A maximum spacing of 70 metres is normally appropriate. Thumps may not be suitable for some roads because short humps do not give an increased discomfort at higher speeds.

4.2.13 As with all road humps, thumps require warning signs (as prescribed in TSRGD 2002, see paragraph 4.1.9). However, upright signs for road humps (diagram 557.1) or for humped crossings (diagrams 543 or 544 with the 'Humped crossing' plate diagram 547.8) are not authorised without the white triangle road markings (diagram 1062) on the hump itself. A special direction from the Department is required to disallow these road markings for thumps. However, if the thump is made of yellow thermoplastic, it may be appropriate to use the 'Traffic calmed area' upright sign (diagram 883); there is no requirement for the white triangle road markings (diagram 1062) to be used with this sign.

Speed cushions

4.2.14 Advantages and disadvantages of speed cushions are summarised in Appendix F. Speed cushions were originally used in Germany and have been called 'Berlin plates' or 'Berlin pillows'. However, the term 'speed cushion' appears to have been generally adopted in the UK. Speed cushions (see Figures 4.13 to 4.15) are narrow rectangular humps which allow wide tracked vehicles, such as buses

Fig. 4.12 Thermoplastic hump (thump)

and large emergency vehicles, to straddle or partially straddle the speed cushion. They thus minimise the discomfort for passengers, though in some cases while the front set of wheels straddles the cushion, rear inner wheels may not depending on the type of vehicle. For fire appliances it means that their speed can be less compromised compared to traversing a conventional round or flat-top hump.

4.2.15 Off-road trials (Hodge, 1993) and open-road trials (Layfield and Parry, 1998) have been carried out. The dimensions in Table 4.1 have been found to be acceptable.

4.2.16 Short-length cushions of under 2000 mm may enable cars to straddle the cushions lengthways and ground on them. For this reason, heights of short-length cushions should not be greater than 75 mm and preferably about 65 mm. Similarly, where narrow speed cushions (1600 mm or less) are implemented, it may be advisable to reduce the height of the cushion to 65 mm to prevent grounding. One case was noted in TAL 01/98 where a very narrow cushion had to be reduced to 55 mm.

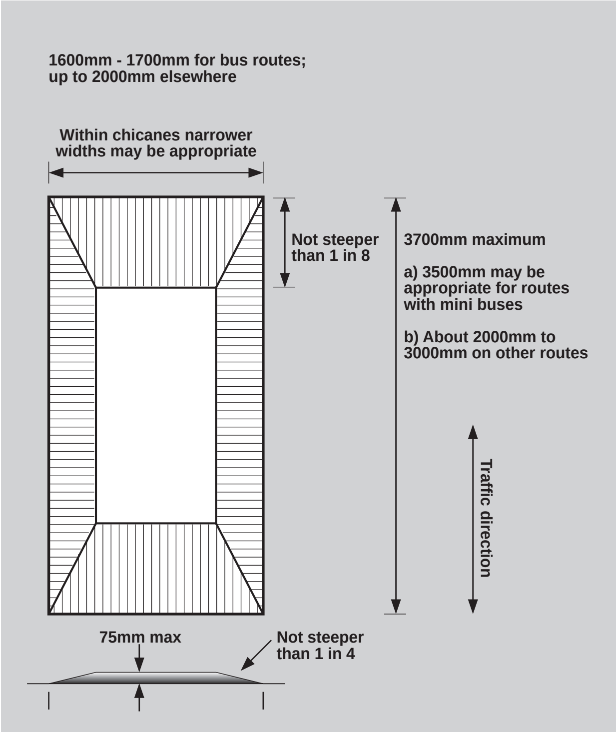


Fig. 4.13 Recommended dimensions for speed cushions

Fig. 4.14 Cushion and associated build-out (left) and cushion in narrowing

Table 4.1 Dimensions of speed cushions found acceptable in trials

Height	75 mm maximum (65 mm if very narrow or short)
Length	1900–3700 mm (3000–3700 mm should deter lengthways straddling by cars)
Width	2000 mm maximum (non bus routes)
Width	1600–1700 mm (bus routes)
Width	1600 mm (fire/ambulance/minibus)
Width	1500 mm (high percentage of HGVs in traffic flow)
Ramps (on/off)	Not steeper than 1 in 8 Not steeper than average of 1 in 5 (curved ramps)
Ramps (side)	Not steeper than 1 in 4

Fig 4.15 Speed cushions (left to right: two abreast, three abreast and double pair)

4.2.17 Two-wheeled vehicles are unlikely to be affected by speed cushions, which is an advantage for cyclists (paragraph 2.7.22) but also means that motorcyclists may not reduce their speeds. Motorcycle and sidecar combinations should be able to negotiate speed cushions, but at relatively slow speeds, i.e. below 20 mph.

4.2.18 It is important that the gaps between speed cushions, and between the kerb and cushion, are at least 750 mm. Smaller gaps should not generally be used unless the cushions are continually parked over, where 500 mm may be regarded as a minimum. Gaps should be measured to the edge of the side ramp, not to the start of the plateau. The positioning of the cushions should not encourage drivers to 'cut in' as they approach the cushion, because this can endanger cyclists. Distances between cushions, or cushions and the kerb, should not generally exceed 1200 mm, with 1000 mm as an ideal maximum. These dimensions are designed to deter drivers of small vehicles from attempting to drive in the gap. Central islands (see paragraph 6.3.5) can prevent such manoeuvres, but the extra expense may not be justified. A maximum spacing of 70 metres is normally appropriate for speed cushions. In 20 mph zones a closer spacing may well be required, but even then average speeds of 20 mph or less may not be achieved (see Figure 4.17).

4.2.19 Speed cushions cannot be used in the zig-zag areas of pedestrian crossings. They should also be located away from where pedestrians are likely to cross the road, so that the chances of pedestrians tripping over them are minimised.

4.2.20 Along bus routes, care should be taken that parked vehicles in the vicinity do not prevent buses straddling cushions. Waiting restrictions may be required to achieve this aim. Where cushions are used near junctions, sufficient space should be allowed for a large vehicle to complete its turn and straighten up before crossing a cushion. Groups of three cushions spaced across the road ensure at least one cushion is available to be straddled, limiting the impact of parking directly over the cushions. Ensuring larger vehicles are able to straddle speed cushions will also reduce the noise and vibrations generated by these vehicles (see Section 4.5).

Mechanical humps

4.2.21 A mechanical hump may be regarded as one where the height can be varied. Special authorisation is necessary for any mechanical humps, unless the dimensions conform to the Highways (Road Hump) Regulations 1999. Since a road hump must be between 25 and 100 mm high, a hump that lowered to be flush with the surface is unlikely to be regarded as meeting this requirement. A local authority considering the use of mechanical humps should in the first instance consult with DfT. For authorisation to be considered, the most important criteria are that the hump should be safe for all road users, particularly users of two-wheeled and three-wheeled vehicles, under all weather conditions and that any failure of the device would not cause any risk to the general public. This would usually require the device to return flush with the road surface so as not to cause an obstruction. Any fluids or mechanisms used to operate the hump would need to be non-toxic and able to withstand foreseeable vandalism problems that might occur in some areas. In London the situation is different (see paragraph 2.1.5), but the criteria are still valid.

4.3 Cost and maintenance

Cost

4.3.1 The cost of road humps can vary considerably, depending on the materials used. However, the indicative costs shown in Table 4.2 have been identified (Webster, 1993a; Webster, 1994a; Webster & Layfield, 1998):

4.3.2 The costs given for round-top and flat-top humps are based on those with tapered edges, so that additional drainage is not required. A kerb-to-kerb flat-top hump suitable for a pedestrian crossing would cost more because drainage is required. Traditional blockwork materials suitable for conservation areas can cost more, and any narrowing of the road would add further to the cost. Gully costs can be significant, in the order £1000.

Maintenance

4.3.3 Winter maintenance (Silke, 1996) can cause problems because features that are not individually signed can be damaged by snow ploughs when obscured by snow. It is essential that those responsible for winter maintenance are kept informed of traffic calming measures installed, particularly along gritting routes, in areas where high snow falls occur.

4.3.4 Thumps may require maintenance, as they can gradually become flattened in hot weather or crack under very cold conditions. However, this should not be a common problem because the mixture of the thermoplastic can be varied at construction to suit the expected road temperature range and site conditions.

4.3.5 Maintenance of pre-formed humps has been reported as an issue by some, with bolts becoming loose and sections of the hump rising up. A regular inspection programme is recommended to ensure such instances are rectified quickly. It should be remembered that, if a poorly maintained hump has a vertical upstand of over 6 mm, it will no longer be in accordance with the road hump regulations.

4.3.6 Cycle bypasses will require manual road sweeping to remove debris if vehicle sweepers are too wide to negotiate the bypass. Unremoved debris can have safety implications and can deter cyclists from using the bypass.

4.4 Effectiveness

4.4.1 The effectiveness of road hump schemes can be determined by:

- the impact on traffic speeds and flows;

Table 4.2 Indicative cost of road humps (Prices given are approximate and for guidance only and do not include an allowance for inflation since the reports were published.)

Hump type	Cost (£)
Round-top hump	400–1000
Flat-top hump	500+
Raised junction	10,000 approx.
‘S’ hump	2000
‘H’ hump	2500
Thermoplastic hump (thump)	300–500
Speed cushion	240–700
Pair of speed cushions	500–2000

- the impact on accident frequency and severity (and perceptions of road safety);
- the impact on the local street environment including noise, vibration, visual impact, community severance and emissions (see Section 4.5).

The perceived changes in these parameters will affect public attitudes to the traffic calming scheme.

4.4.2 The impact on pedestrians, cyclists and motorcyclists is discussed in Section 2.7.

4.4.3 The regulations permit isolated road humps, but it is recommended that a speed reducing feature is used in advance of a road hump to avoid high speeds that could have safety implications. The feature should be less than 60 metres in advance of the first hump to be most effective. Appropriate features include junctions, bends of 70 degrees or more, mini-roundabouts, and ‘give way’ markings at pinch points to create priority working. Conspicuous gateways (Chapter 7) can achieve quite high reductions in speed at the gateway, but they may not reduce speeds to 30 mph at the first hump. This should be borne in mind if gateways are used as speed reducing features. If vehicle speeds are already low, around 20 mph or less, an additional speed reducing feature may not be required, for example where a flat-topped hump is used as a raised crossing.

Vehicle speeds

4.4.4 Round-top and flat-top humps. Vehicle speeds at road hump schemes are determined generally by the height and spacing of the road humps, and sometimes by the vehicle speeds before implementation of the scheme. The height of the hump does not appear to be critical in the range 75 to 100 mm (Webster & Layfield, 1996). Results from schemes on public roads showed the mean crossing speeds of vehicles to be 14.7 mph and 13.8 mph for 75 mm and 100 mm high round-top humps, and 12.8 mph and 13.6 mph for 75 mm and 100 mm high flat-top humps (with gradients of 1:10 to 1:15) respectively. The speeds of buses at 75 mm high humps were generally 5 mph lower than those obtained for cars at the same humps. The hump spacing required to obtain a target mean speed is given in Table 4.3.

4.4.5. Shallower ramp gradients of 1:15 to 1:20 gave little further gain in reduced discomfort compared with 1:10 to 1:15 gradients, and therefore 1:15 gradients appear to be a suitable compromise to obtain reasonable speed reduction without excessive discomfort to passengers.

4.4.6 If the hump height is lower than 75 mm, then vehicle speeds may be higher. A study (Webster, 1994a) of seven sites with 50 mm high round-top humps gave 85th percentile speeds of 31 mph, suggesting that they are suitable for 30 mph roads where injury accidents are not a critical problem.

4.4.7 The Seminole County Profile (see paragraph 4.2.1) appears to give 85th percentile speeds that are 2–3 mph higher than equivalent straight-ramped humps (Ewing, 1999).

4.4.8 Sinusoidal humps. Sinusoidal humps (100 mm high) installed in Edinburgh reduced mean vehicle speeds from 33 to 16 mph at the hump and to 21–25 mph between the humps for spacings of 70 to 132 metres (TAL 09/98; Webster & Layfield, 1998). These vehicle speeds are similar to those for round-top humps. This result has been confirmed by a track trial (Sayer et al., 1999), which showed that sinusoidal

Table 4.3 Estimated hump[1] spacing required to achieve a mean ‘after’ speed between humps

Mean ‘before’ speed (mph)	Spacing between humps (metres)						
	20	40	60	80	100	120	140
	‘After’ speed between humps (mph)[2]						
20	13	14	15	16	18	19	20
25	15	16	17	18	20	21	22
30	17	18	19	20	22	23	24
35	19	20	21	22	24	25	26

Note[1]. For round-top humps 75 or 100 mm high, flat-top humps 75 mm high (ramp gradient 1:10 to 1:15) and flat-top humps 100 mm high (ramp gradient 1:8 to 1:10).

Note[2]. The corresponding 85th percentile speeds would be 4 to 5 mph higher than the means.

humps (75 mm high) gave similar discomfort levels to round-top humps for all users except car passengers and cyclists, who showed a slightly reduced discomfort level.

4.4.9 'H' and 'S' humps. Mean vehicle speeds at the 'H' and 'S' humps in Fife were about 22 mph and 16 mph for cars and buses respectively (TAL 09/98; Webster & Layfield, 1998). The mean speeds between the humps (spaced at 100 metres apart) were about 26 mph and 22 mph for cars and buses respectively. The 85th percentile speeds between both types of hump were reduced by 7 mph from about 36.5 mph to 29.5 mph. These results indicate that the 'H' and 'S' humps used in Fife are most suitable for 30 mph roads that have a bus route. It should be possible to adjust the ramp gradients and spacing used so that the humps would be suitable for use in 20 mph areas.

4.4.10 Thermoplastic humps 'thumps'. The 85th percentile vehicle speeds between thumps, spaced from 40 to 75 metres, were 28 mph. Mean speeds were about 5 mph lower (Webster, 1994a). The speeds at the thumps were within 1 mph of the speeds between the thumps, indicating that drivers were adopting a smooth driving style. An overall speed reduction of 9 mph was achieved at the sites in the study. Thumps were not generally popular with bus passengers because of discomfort, particularly to passengers of mini or midi buses. At one site the thumps were increased in width from 900 to 1500 mm to reduce discomfort, which resulted in an increase of vehicle speeds of between 1 and 5 mph.

4.4.11 Speed cushions. The speed of vehicles on roads with speed cushions (Figs 4.16 and 4.17) depends on the width, length, height and spacing of the speed cushions. The speed before installation was also found to be a factor in the speed of vehicles at the speed cushions.

4.4.12 The overall mean speeds at 1600 mm and 1900 mm wide speed cushions were about 19.5 mph and 15.5 mph, based on before mean speeds of 30 mph. A separate study at Craven Arms on the A49 (TAL 02/97) found that mean speeds for light vehicles at 1500 mm wide cushions were 26 mph for before speeds of 34 mph.

4.4.13 Analysis of a number of speed cushion installations (Layfield & Parry, 1998) revealed, for an average cushion spacing of 70 metres and cushion width of 1700 mm, average speeds were reduced by about 10 mph to an overall average of 22 mph and an 85th percentile of 26 mph. This indicates that cushion widths of 1700 mm and spacings of 60 and 100 metres would give mean speeds of 20.5 and 24.5 mph respectively. Thus using narrow cushions (1500–1700 mm) may not be suitable for achieving speeds of 20 mph or less.

4.4.14 The effectiveness of cushions for controlling vehicle speeds can be improved (TAL 01/98) if the cushions appear more formidable than they actually are on the road. Coloured cushions, which contrast with the adjacent carriageway, can help to give the desired effect. However, this additional speed reduction should be balanced against the visual intrusion of brightly coloured measures. Research into the visual intrusiveness of road humps is reported in paragraph 4.5.21.

4.4.15 The mean speed of buses over cushions was generally similar to or slightly greater than cars, whereas before installation of the cushions the car speeds were 2 to 8 mph faster than the bus speeds (TAL 04/94).

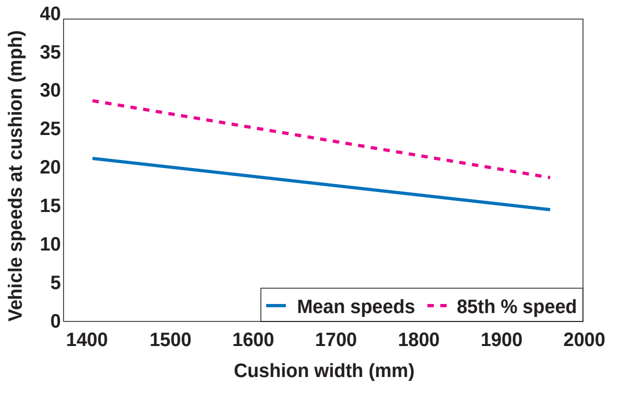


Fig. 4.16 Vehicle speeds at cushions

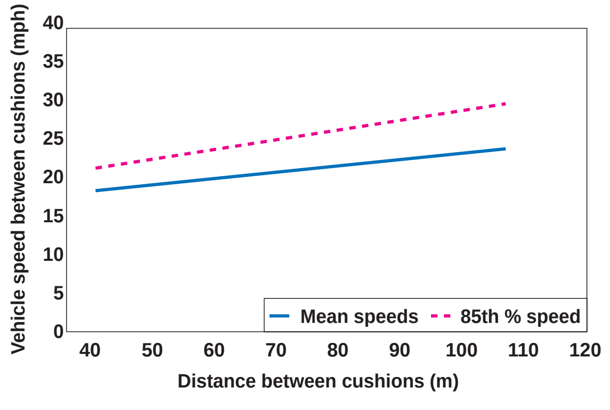


Fig. 4.17 Vehicle speeds between cushions

4.4.16 Fire appliances on ‘urgent’ responses can cross speed cushions at speeds 10 to 20 mph higher than 75 mm high full-width humps. Ambulances on ‘urgent’ responses can cross wide (1.9 metres) speed cushions at similar speeds to 75 mm high humps, and cross at slightly higher speeds for narrower (1.5 to 1.7 metres) cushions.

Vehicle flows

4.4.17 Round or flat-topped humps. Changes in vehicle flows are very difficult to predict, because traffic flow patterns continually change. Results from 48 sites show average reductions of –18 per cent (range +13 per cent to –59 per cent) from an average flow of 3,415 (range 200 to 13,000) before, to 2,800 (range 120 to 10,000) vehicles per day after (Webster, 1993a). Flow measurements at 75 mm high humps showed that the overall flow reductions were similar –26 per cent (+18 per cent to –54 per cent), but it appeared that the before flows for flat-top humps were generally higher (7,040 vehicles/day) than for the round-top humps (3,285 vehicles/day) (Webster & Layfield, 1996). Average flow reductions of about 20 per cent can be expected after road humps have been installed.

4.4.18 Sinusoidal humps. Sinusoidal humps (100 mm high) installed in Edinburgh, (see TAL 09/98 and Webster & Layfield, 1998), reduced peak vehicle flows of 400 per hour by an average of 23 per cent (range 17 per cent to 33 per cent).

4.4.19 ‘H’ and ‘S’ humps. The vehicle flows in Fife, reported in TAL 09/98 and Webster & Layfield, (1998) were reduced from 9,000/day to 6,000/day, giving a reduction of 33 per cent.

4.4.20 Thermoplastic humps ‘thumps’. A limited amount of data (Webster, 1994a) showed that vehicle flows were reduced from 2,716 to 2,096 (–23 per cent) at one site, and unaffected at the other sites.

4.4.21 Speed cushions. Flows of 3,000–7,000 vehicles per day were reduced by an average of 24 per cent with a range from +2 per cent to –48 per cent at 11 sites measured (Layfield & Parry, 1998). It was noted that at one site flows on the adjacent roads, which had no traffic calming, increased by an average of 19 per cent.

Accidents

4.4.22 General traffic calming. It has been shown that on average each 1 mph reduction in mean vehicle speed results in an average accident reduction of 5 per cent (Taylor *et al*., 2000), though this will vary according to the type and location of the traffic calming. Hence a 10 mph speed reduction may give a 50 per cent accident saving. This result has been confirmed by two further studies (Stark, 1995; Webster & Mackie, 1996). These both gave similar results for traffic calming schemes where speeds were recorded both before and after the measures were installed. It is important to note that these accident savings were average values, and therefore schemes may achieve better or worse results than the projected figures.

4.4.23 Traffic calming measures have been shown to reduce the frequency of accidents involving pedestrians, cyclists and motorcyclists (Section 2.7).

4.4.24 An accident analysis involving a number of schemes in Cambridgeshire (Amis, 1995) showed that traffic calming schemes reduced accidents by 64 per cent and there was no migration of accidents onto the surrounding roads. By contrast, the number of accidents increased by almost 100 per cent on the main road surrounding a large traffic calming scheme in Maidstone (Kent County Council, 1996). It was concluded by Kent County Council that small schemes were unlikely to result in increases in accidents on adjacent roads, but that large schemes and area-wide traffic calming need to be assessed to ensure that the junctions on the main roads can safely cope with the traffic that is transferred to them.

4.4.25 Road humps: Accidents were reduced by 71 per cent at 34 sites (Webster, 1993a) and by 60 per cent in 20 mph zones, which comprised mainly humps (Webster & Mackie, 1996). Both reports concluded that there was no overall increase of accidents on the surrounding roads, but it was shown that the areas gave quite variable results. It has been reported (Hampshire County Council, 1996) that before and after accident results for 10 hump sites showed a reduction of 89 per cent for an average speed reduction of 13 mph.

4.4.26 Sinusoidal humps: Sinusoidal humps (100 mm high) installed in Edinburgh (Webster & Layfield, 1998) have reduced accidents slightly. However, the numbers are small and further sites would be needed to confirm whether the expected effect could be similar to other humps for a given speed reduction.

4.4.27 'H' and 'S' humps: Accident data supplied by Fife (Fife Council, 2004) for their 'H' and 'S' hump scheme on South Parks Road, Glenrothes, shows that injury accidents have been reduced from 10 in 5 years (2 per year) to only one in the five years (0.2 per year) after the scheme was installed. Damage-only accidents were also monitored, and these have shown a slight reduction from 39 in 5 years (7.8 per year) to 11 in 5 years (2.2 per year) after installation. It should be noted that this scheme also involved implementation of mini-roundabouts and Zebra, Pelican and Toucan crossings.

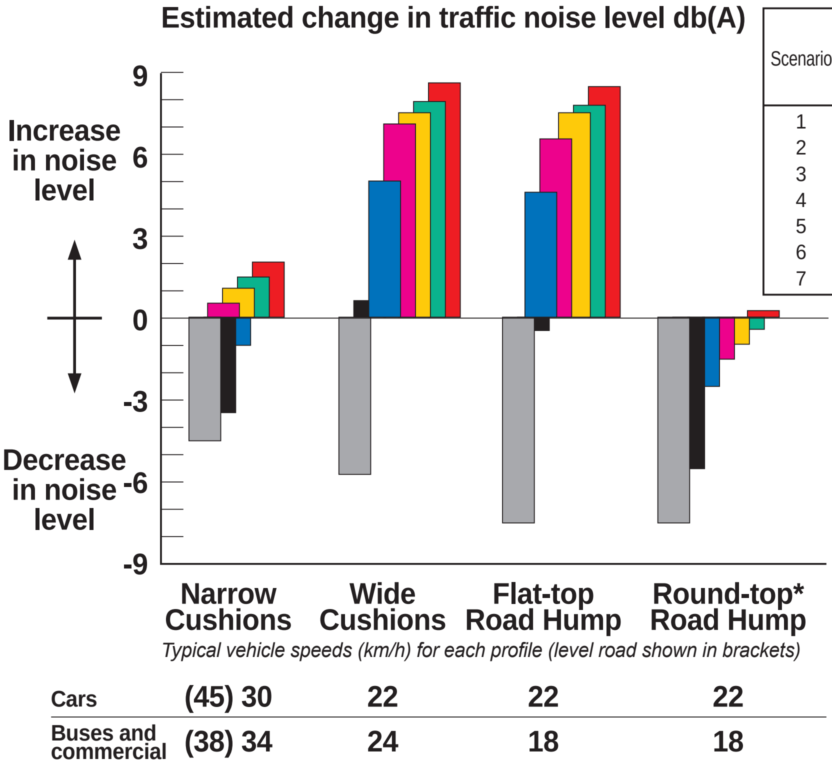
4.4.28 Speed cushions: Accident reductions of 86 per cent have been reported in Victoria Road, Huddersfield (CSS *et al.*, 1994), which included cushions in a pinch point. An accident reduction of 86 per cent was also reported for Billing Brook Road, Northampton (Northamptonshire CC, 1998). Speed reductions of approximately 15 mph and 11 mph were reported respectively, and the accident results for both schemes were based on 3-year before and after accident data.

4.4.29 Thermoplastic humps ('thumps'): Accidents were reduced by 97 per cent at the three sites examined by TRL (Webster, 1994a). It has been reported (Bradford MDC, 1998) that three schemes installed in Bradford during 1996, containing 219 thumps (and three sets of cushions) reduced the number of casualties from 16 per year to 9.64 per year giving an overall reduction of 40 per cent for all of the sites combined. Further schemes would be required for a fuller accident analysis.

4.5 Environmental impact

Noise

4.5.1 The introduction of a speed-controlling measure such as a road hump or cushion can influence traffic noise levels in a number of ways (Figs 4.18 a and b). For example, lowering the speed of vehicles may mean that vehicle noise emission levels are reduced. In addition, after the measures are installed, traffic flows may be reduced, leading to further reductions in noise levels. However, vehicle noise emissions may also depend upon the way vehicles are driven:



Scenario	Percentage of vehicle type in traffic system			
	Cars	Buses	Commercial Vehicles	Key
1	100	0	0	grey
2	98	1	1	black
3	94	1	5	blue
4	89	1	10	magenta
5	84	1	15	yellow
6	79	1	20	green
7	74	1	25	red

** (Changes in traffic noise levels are highly sensitive to changes in vehicle speed)*

Fig. 4.18 (a) Noise from humps

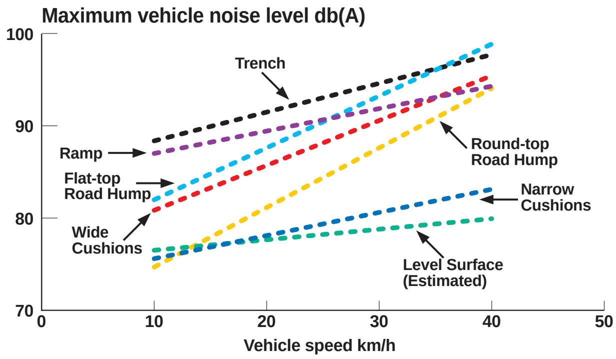


Fig. 4.18 (b) Noise from humps

- a passive style of driving, at a lower but constant speed, contributes to lower noise levels;
- an aggressive style, with excessive braking and acceleration between speed control devices, gives rise to a highly fluctuating noise level, which can in turn contribute to noise disturbance to residents.

4.5.2 The use of road humps and cushions to reduce traffic speed may give rise to vehicle body noise (e.g. body rattles, suspension noise etc.), which may be a cause of noise disturbance (Abbott *et al*., 1997).

4.5.3 Studies of vehicle and traffic noise levels were made alongside road humps in Slough and speed control cushions in York (Abbott *et al*., 1995a and 1997). The general finding of these studies was that, for light vehicles, noise levels were reduced substantially, these reductions being attributable to the change in vehicle speeds. The reductions in traffic noise at these sites (with low flows of heavy commercial vehicles) were such that they would be expected to produce a reduction in disturbance to residents.

4.5.4 For light vehicles, the within-scheme variation in noise levels was highly correlated with the variation in vehicle speed, and this was related to the spacing between the measures. To minimise fluctuations in vehicle noise emissions it is important, therefore, that the design and spacing of cushions is optimised, so that average speed is reduced whilst maintaining a fairly constant speed profile along the road section treated.

4.5.5 Following the noise measurements in Slough and York, research was undertaken on a test track to measure maximum noise levels from a range of heavy vehicles passing over a selection of road humps and cushions (Abbott *et al*., 1995c). The results showed that, at sites located alongside the measure with typical vehicle speeds, installing speed cushions or humps would lead to: substantial reductions in light vehicle noise levels, smaller changes in noise levels for buses, and generally an increase in maximum noise levels for unladen commercial vehicles with steel leaf suspensions, despite reductions in vehicle speeds.

4.5.6 Based on an assumed reduction in vehicle speed, estimates of the change in traffic noise levels following the installation of cushions or humps showed that, where the traffic flow consists of all cars, substantial reductions would be expected. As the percentage of commercial vehicles increases to 10 per cent, together with an increase in the percentage of buses to 1 per cent, these reductions deteriorate dramatically. That factor is particularly true for wide cushions and flat-top humps, for which traffic noise would increase substantially.

4.5.7 Additional track trials have confirmed that noise levels generated by heavy commercial vehicles crossing road humps or cushions are dependent on vehicle loading, the type of suspension system, the hump or cushion profile and whether the vehicles straddle any speed cushions (Harris *et al*., 1999). When assessing the potential noise impacts of traffic calming schemes involving road humps or cushions, consideration needs to be given to the number of commercial vehicles, particularly those in the heavier category that are fitted with steel leaf suspensions and are unladen. It is also important to ensure that the incidence of commercial vehicles not straddling cushions is minimised (TAL 06/96), for example by the introduction of waiting restrictions to maintain clear space around the cushions.

4.5.8 While there is a reasonable understanding of the relationship between noise and the overall perception of nuisance experienced by people in the vicinity of roads, the established relationship appears to break down for situations where a recent change has occurred. Conventional methods of measuring traffic noise do not readily expose annoyance factors associated with changes in the variability of noise. Consequently, it is difficult to predict accurately the perceived noise impact of traffic calming schemes

(Abbot *et al.*, 1995b). In some schemes, at locations where traffic noise levels have decreased, residents have perceived little overall impact, possibly because changes in the characteristics of the noise have nullified the reductions in the overall noise levels (Cloke *et al.*, 1999; Wheeler & Taylor, 1999).

Vibration

4.5.9 Traffic-generated, ground-borne vibrations are produced mainly from the interaction between the rolling wheels of vehicles and the road surface. The magnitude of the vibrations is affected by discontinuity in the road profile, the vehicle loading, the vehicle speed, the vehicle suspension, the distance from the vibration source and the soil type. Ground-borne vibration diminishes as it radiates from the source. The firmer the soil in the vicinity, the more localised will be the vibration effects. Traffic vibrations are generally experienced by fewer people than traffic noise. However, once vibration is experienced, it is more likely to cause a high degree of disturbance or annoyance. Extensive research by Watts (1990) failed to find any conclusive evidence that traffic-induced vibrations can cause significant building damage.

4.5.10 Track trials have been carried out to assess the effect which road humps and speed cushions might have in generating ground-borne vibrations when commercial vehicles are driven over them (Watts & Harris, 1996; Harris *et al.*, 1999). Measurements of vibrations were made for a wide range of vehicle types crossing a selection of road humps and speed cushions at a range of speeds. The results of these studies show that speed cushions and road humps can produce perceptible levels of ground-borne vibration, and that vehicles with a gross vehicle weight over 7.5 tonnes generate the highest levels. Under the most severe conditions this can lead to complaints and anxieties concerning building damage. However, even under these worst case conditions, it is very unlikely that the introduction of the road humps and speed cushions pose a significant risk of even minor damage to property.

4.5.11 For a given speed, the narrowest cushions (1500 mm) produced the least vibration. This was expected, as commercial vehicles can straddle the cushion and the wheels do not rise to the full height of the cushion, limiting the peak vibration levels generated. On the road, different hump and cushion profiles influence speed to a different extent, and the lower vibration levels of the narrow cushions are offset by higher crossing speeds. Based on typical crossing speeds, wide (1900 mm) cushions generally gave higher maximum and mean vibration levels for commercial vehicles than did the 75 mm high road

Table 4.4 Predicted minimum distance (m) between road humps and dwellings to avoid vibration exposure (for speed cushions see TAL 08/96). All humps are 75 mm high.

	Level of perception					Complaint					Superficial cracks from sustained exposure					Minor damage (BS7385)				
Hump type	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**	**a**	**b**	**c**	**d**	**e**
Alluvium	31	32	34	46	53	7	7	7	10	12	2	2	2	2	3	<1	<1	<1	<1	<1
Peat	12	12	13	16	17	4	4	5	6	6	2	2	2	2	2	<1	<1	<1	<1	<1
London clay	10	10	11	14	15	3	3	4	4	5	1	1	1	2	2	<1	<1	<1	<1	<1
Sand/gravel	2	2	2	3	4	<1	<1	<1	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boulder clay	1	1	1	2	2	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chalk rock	<1	<1	<1	1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

a = sinusoidal 3.7 metres long hump
b = round-top 3.7 metres long hump
c = round-top 5 metres long hump
d = flat-top (sinusoidal ramps) 8 metres long hump
e = flat-top (straight ramps) 8 metres long hump
Minor damage (BS7385) relates to minor cosmetic damage such as the formation of hairline cracks on plaster finishes or in mortar joints and the spreading of existing cracks.

humps and narrower (1500–1600 mm) cushions. 75 mm high round-top and sinusoidal hump profiles gave lower vibration levels than a 75 mm high flat-top hump. Vibration levels increased when vehicles did not straddle the narrow cushions, and care should be taken that cushions are placed so that they are likely to be straddled by commercial vehicles.

4.5.12 The results from these studies have been included in Traffic Advisory Leaflets 08/96 and 10/00, and used to provide initial guides to the predicted minimum distances from dwellings to avoid vibration exposure (see Table 4.4). This is of particular relevance in trying to avoid locating road humps and cushions near dwellings where, because of the soil type, complaints might arise.

Vehicle emissions and air quality

4.5.13 The Environment Act 1995 requires local authorities to review air quality in their area against targets set by the Government. Where air quality standards do not meet those targets, authorities are required to establish local air quality management plans. Even where action plans are not required, regard needs to be given to the effect that traffic management schemes might have on vehicle exhaust emissions (TAL 04/96).

4.5.14 Low speeds are generally associated with high rates of exhaust emission because they usually involve a high proportion of acceleration and deceleration. However, smooth, low speed driving, in as high a gear as possible, will result in relatively low emissions. The effect on emissions, therefore, of any traffic calming scheme will depend on how the scheme influences both the average speed of traffic and the amount of speed variation (Abbot *et al*., 1995b).

4.5.15 A number of theoretical and experimental studies have examined these effects. These were reviewed by Boulter & Webster (1997) and their results displayed wide variation, and sometimes conflicted. More recent studies using a variety of measurement techniques (instantaneous emission model, remote sensing and chassis dynamometer) have shown generally good agreement, and clearly indicate that traffic calming measures increase the emissions of some pollutants from passenger cars (Cloke *et al*., 1999; Boulter, 1999; Boulter *et al*., 2001).

4.5.16 The study by Boulter *et al.* (2001) investigated the impact of various traffic calming measures, comparing the difference in emissions recorded from 15 types of passenger cars before and after the measures were introduced. The results showed that, for the petrol non-catalyst, petrol catalyst and diesel cars tested, the mean emissions of carbon monoxide (CO), hydrocarbons (HC) and carbon dioxide (CO_2) increased by between 20 per cent and 60 per cent. For oxides of nitrogen (NOx) emissions, only the diesel cars showed a substantial increase (about 30 per cent). The increases in NOX emissions for petrol non-catalyst and petrol catalyst cars were much smaller and not statistically significant. Emissions of total particulate matter from the diesel cars increased by 30 per cent.

4.5.17 A more recent study has been undertaken as part of the Department's **Tra**ffic **M**anagement and **A**ir **Q**uality (TRAMAQ) research programme. This study specifically examined the impact of various traffic management measures on pollutant emissions and compared these with normal driving cycles. A predictive model for emissions was also developed as part of this project. Emissions from vehicles operating in traffic management schemes were higher than those operating at constant speed but not when compared with those from a congested urban cycle. The study found that, although there were differences between the emissions from vehicles operating in different types of traffic management schemes, these differences were generally small compared with the likely errors in the measurements.

4.5.18 Although some traffic management measures can result in increased emissions per vehicle, they also generally result in a reduction in the volume of traffic. Thus, even though emissions per vehicle may increase, this can be offset by the reduction in traffic. The amount of traffic in residential areas is relatively small, and traffic diverted to other roads is unlikely to have a significant effect on emissions.

4.5.19 In the study by Boulter *et al*. (2001), the atmospheric pollution concentrations associated with the types of scheme and levels of traffic were calculated, using a dispersion model, and were found to be well below the 2000 Air Quality Strategy standards. Furthermore, the improving performance of emission control technology over time means that, in the future, breaches of the standards would be even less likely to occur as a result of traffic calming. However, in Air Quality Management Areas where air pollution standards are frequently breached, particular attention would need to be given to the balance between reductions in injury accidents and increases in vehicle emissions.

Visual impact

4.5.20 Concerns have been expressed about the visual intrusion of road humps and how they fit with local surroundings, for example whether road humps make rural villages more 'urban'. As with any traffic calming scheme, all potential impacts should be considered at the scheme design stage. Alternative methods of achieving the scheme objectives should also be considered. However, road humps remain one of the most effective methods of speed control and are therefore likely to continue to be used for some time.

4.5.21 A similar concern is the visual impact of road humps on historic streetscapes. The use of high-quality materials and minimal road markings can reduce this impact (see Section 3.7).

4.5.22 Different authorities have tried different road hump designs in an effort to make them more aesthetically pleasing, including humps in block paving or different colours. The success of such schemes has been mixed. A study by Kennedy *et al.* (2004c) showed that the same type of hump in different locations could provoke very different reactions, confirming hump design should be linked to local context. However, a few general conclusions could be drawn:

- Aesthetics were generally a minor issue compared with the speed-reducing qualities and concerns over possible damage to vehicles.
- Conspicuity of the hump through the use of freshly painted white arrowhead markings (diagram 1062, TSRGD) and contrasting colour was considered a high priority by respondents. However, coloured surfacing that extended beyond the humps was disliked.
- Respondents had mixed views as to whether road humps looked better than speed cushions, although about half preferred full-width humps
- Views on a scheme's success did not appear to correlate with views on its appearance

Discomfort to vehicle occupants

4.5.23 Road humps are effective because they cause discomfort to the driver when they are crossed at high speeds. Unfortunately for some vehicle occupants, for example those with back injuries, road humps cause discomfort even at low speeds. It is important that humps are carefully designed and built to minimise discomfort for those travelling at appropriate speeds. The first consideration must be to ensure the hump dimensions are within those specified in the road hump regulations. A hump specification should not be for the maximum (100 mm) height, as this would not allow for any construction tolerance. Generally humps of 75 mm in height are recommended, as these minimise discomfort whilst maintaining effectiveness (see paragraph 4.4.4).

4.5.24 Small changes in hump construction can have significant effects on discomfort levels, and it is therefore important that humps are built to the local authority design specifications. This is especially true for certain types of hump, such as sinusoidal humps.

4.5.25 Some professional drivers have expressed concerns about the potential for them to receive injuries from repeatedly crossing road humps. A research project was therefore commissioned to examine the discomfort experienced by vehicle occupants and the possibility of injury to the lower spine arising from repeated traversing of road humps. It was concluded (Kennedy *et al.*, 2004e) that the levels of discomfort were generally acceptable if (75 mm) humps were traversed at appropriate speeds, i.e. not exceeding 15–20 mph. However, some occupants, for example those in the rear of taxis and ambulances, experienced considerably more discomfort than others, due to the specific design of the vehicles involved. Of the hump profiles tested, the sinusoidal profile gave the highest peak vertical acceleration.

4.5.26 Biomechanical modelling of the lower part of a human spine was used to determine forces generated when traversing road humps. The study showed that ligament forces were almost an order of magnitude lower than the damage threshold. In addition, forces transmitted through the spine were at least a factor of 4 smaller than those generated in discs by heavy lifting. Medical opinion was that the low ligament forces could be taken to imply that the muscles would also be very unlikely to be damaged under the loads predicted by the model. It was thought that repeated traversing, rather than causing injury, would build up the muscle and make it more resistant to injury.

4.5.27 Therefore, although it is not possible to predict the effect of such forces on people with pre-existing spinal conditions, it was considered that vehicle occupants with healthy spines are very unlikely to be injured as a result of single or repeated traversing of road humps constructed to recommended dimensions.

Damage to vehicles

4.5.28 Vehicles travelling over road humps at appropriate speeds should not suffer damage, provided the humps conform to the Highways (Road Hump) Regulations. However, concerns about accelerated wear to vehicles have been raised by some groups, especially where they are required to traverse road humps repeatedly.

4.5.29 The study mentioned above also investigated the effect of repeatedly traversing road humps on vehicles (Kennedy *et al.*, 2004e). No damage to any of the vehicles was seen, despite repeated passes at speeds up to 40 mph. However, suspension geometry checks revealed some minor changes in the suspension systems of the taxi, minibus and ambulance tested. Further testing showed there was no continuing trend for the suspension to move further out of specification; instead, it drifted in and out of the manufacturer’s tolerance. This indicates a looseness in the suspension system rather than an indication of accelerated wear. It was seen that the forces generated when traversing road humps were comparable to those likely to be sometimes experienced during normal driving activities, such as driving over a very irregular surface or pothole, or mounting a kerb.

5. Rumble devices and overrun areas

5.1 Types of rumble device

5.1.1 Rumble devices are small raised areas across the carriageway with a vibratory, audible and visual effect. They are used, usually in rural areas, to alert drivers to take greater care in advance of a hazard such as a bend or junction. In combination with a gateway they can indicate the entry to a village or the start of a series of traffic calming measures. They have also been used to designate the start of shared use roads in new developments (TAL 11/93).

5.1.2 Although in some locations rumble devices have been used with the aim of reducing speeds, the evidence so far indicates that any speed reduction is likely to be minimal and will be eroded with the passage of time. It is also known that at some sites drivers have learned to accelerate over the devices to lessen the vibratory effect. Reliance should, therefore, not be placed on using rumble devices alone to reduce speed.

5.1.3 The Highways (Traffic Calming) Regulations 1999 permit rumble devices up to 15 mm in height, provided no vertical face exceeds 6 mm in height. Special authorisation can be sought where a device is required to exceed these dimensions, though any applications would need a strong justification. The requirement not to exceed 6 mm for the vertical face is important. Heights greater than that could create difficulties for riders of two-wheeled vehicles, particularly cyclists.

5.1.4 Rumble devices come in a variety of forms, which have been described as rumble strips, riblines, jiggle bars, rumble areas, Rippleprint™ and rumblewave surfacing. Rumble strips, riblines and jiggle bars are all similar in concept and design, comprising narrow strips of material laid transversely across the carriageway. Rumble strips (Fig. 5.1) are commonly formed from thermoplastic type material and are laid down as a single group of strips, or as a series of groups. For normal use a height of 13 mm is adequate for providing both audible and vibratory warning, whilst achieving any speed reduction that might be obtainable. When used in combination with other features, such as gateways, lower heights may yield acceptable results. Rumble areas (Fig. 5.2) are large areas or bands of coarse material (e.g. block paving or 14 mm chippings) laid across the carriageway to give a contrasting ride compared to the rest of the road (Sumner & Shippey, 1977). Rumblewave surfacing (Fig. 5.3 a and b), also known as corrugated surfacing or Rippleprint™, is a recent development. It consists of a bitumen-based surfacing shaped to conform to a sinusoidal profile with a maximum wave height of 6–7 mm and a wavelength of 0.35 metres (see TAL 01/05).

Fig 5.1 Rumble strips

Fig. 5.2 Rumble areas

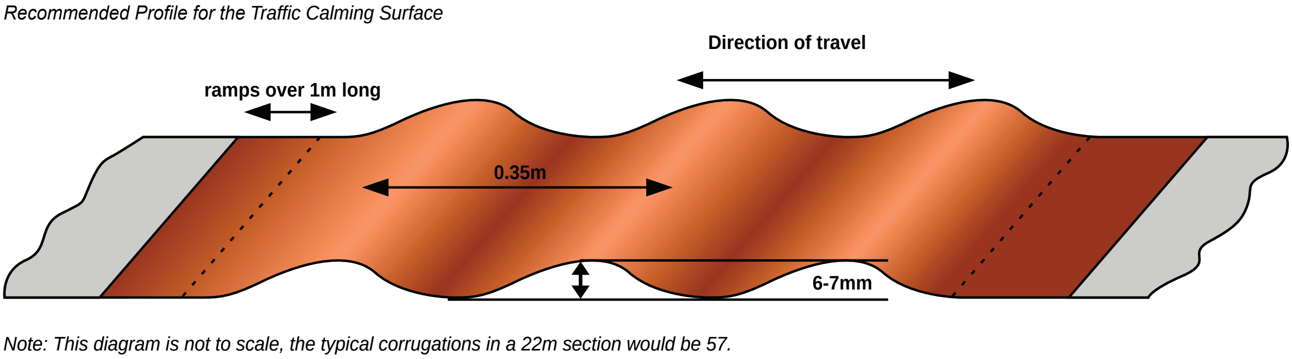


Fig 5.3 (a) Rumblewave

Fig 5.3 (b) Rumblewave

5.1.5 Rumble devices in the UK have been described in detail by Webster & Layfield (1993) and those from the US have been described by Harwood (1993). Various patterns have been used, with decreasing spacing between devices designed to have an alerting effect by making drivers feel that they are going faster than their actual speed.

5.1.6 Rumble devices should be made from materials with a suitable skid resistance. There may be an advantage to making rumble strips visible at night to avoid startling motorists, and the use of reflective material may be feasible. However as rumble devices are a method of alerting drivers to a hazard ahead, rather than being a hazard themselves, pre-warning of the device is not essential and careful consideration should be given to the potential negative visual impact of the scheme. To avoid confusion with road markings, white must not be used. The devices can be half or full carriageway width. The full width version is the preferred option, because that deters drivers from crossing the centre line of the road to avoid the devices, though it will generate additional noise.

5.1.7 Where rumble strips are used at the approach to a hazard, such as a bend or junction, they should be sited in obvious relationship to signing that warns of the hazard. Where this cannot be achieved, specific signing for the rumble strips should be considered. It should be noted that such signing may need special authorisation, for example a 'rumble strip' supplementary plate is not prescribed (see also paragraph 5.4.9).

Pattern

5.1.8 The pattern to be adopted will depend on physical characteristics of the road and driver behaviour at the particular location. To avoid unnecessary noise generation, the number of groups or areas of rumble devices should be kept to a minimum. Irregular spacing between groups or areas will help to break up the noise patterns generated, which may make them more acceptable to nearby residents. Progressive reduction in spacing between groups or areas is generally the most effective means of creating an alerting effect. The pattern of rumble devices should finish within 50 metres of any hazard it is associated with.

5.1.9 A rumble area may be solitary or installed as a series. Unless accompanied by other measures, single areas are likely to have a very limited effect, not only in terms of speed reduction but also as an alerting device. If narrow bands are used, then the number of bands may need to be increased. (Figures 5.1 and 5.2 give examples of narrow and broad area patterns.)

5.1.10 Rumblewave surfacing may also be installed as a solitary pad or in a series. If a single pad is installed as an alerting device, it should be placed in clear conjunction with the warning signs for that hazard.

5.1.11 Where rumble strips are used, about 50 rumble strips divided into two to four groups will normally be sufficient. Various patterns have been tried with strip widths about 100 mm wide and strip spacing 300 to 500 mm (from midpoint to midpoint). Spacings below 400 mm are more suitable for roads having speed limits of less than 40 mph. On roads with higher speed limits, the closer spacing tends to allow vehicles to 'float' over the strips.

5.1.12 It is important for motorcyclists that rumble strips have adequate skid resistance and, where possible, are located away from the final braking area on the approach to a hazard. There is some evidence to suggest that rumble strips should not be used on bends with a radius of less than 1000 metres because of possible danger to motorcyclists. It is advisable to provide a gap, preferably 1000 mm (minimum 750 mm where roads are narrow), between the edge of carriageway and the device to allow for drainage and help cyclists to avoid rumble devices.

5.2 Cost and maintenance

5.2.1 The cost of schemes can vary with the type of device and the number of strips or bands used. From the schemes studied it would appear that the typical range for a thermoplastic installation was £500–1500, at 1993 prices. Coarse aggregate rumble areas cost £2500–10,000 at 1992 prices and had an estimated life of about three years. Rumblewave surfacing costs c. £50 per square metre or c. £5000 for a 20 metres strip on a single carriageway road.

Maintenance

5.2.2 The amount of maintenance required on thermoplastic strips will depend on how well they were constructed and the suitability of the mix used. Manufacturers of the strips should be consulted so that suitable mixes can be used depending on the road temperature and site conditions. The thermoplastic strips at one site lasted four years before they were renewed, whereas at another site they lasted 17 months because they were installed at 24 degrees centigrade. The long-term durability of rumblewave surfacing is not yet known

5.3 Effectiveness

Vehicle speeds

5.3.1 A study of available information (Webster & Layfield, 1993), found that the overall effect of rumble strips and areas on 85th percentile vehicle speeds was a reduction of 3 mph (about 6 per cent). The average 85th percentile speed differences showed a reduction of 1 mph for 5–6 mm high strips; 2.5 mph for 10 mm high strips; and 2.3 mph for 13+ mm high strips (excluding rumble devices removed within three months of installation). There was evidence from some sites that 'after' speeds increased slightly with time but were still below the 'before' installation speeds. Further rumble area and ribline sites have been reported (Barker, 1997) with mean speed reductions of up to 6 mph, but again there was evidence from one site that the 'after' speeds increased over time.

5.3.2 Changes in vehicle speed as a result of rumblewave surfacing are reported in TRL Report 545 (Watts *et al*., 2002). The average mean speed reductions were just over 1 mph, and reduction in 85th percentile speeds were similar.

Vehicle flows

5.3.3 There was *no* evidence from sites where measurements have been made that rumble devices have had any effect on vehicle flows.

Accidents

5.3.4 Early work by Sumner & Shippey (1977) and the study by Webster & Layfield (1993) found reductions in injury accident frequency of 35 per cent and 28 per cent respectively. Due to the relatively small number of accidents involved, neither of these results was individually statistically significant. Injury accident frequency at a ribline site reported by Barker (1997) was reduced by 60 per cent, but again the result was not statistically significant. However, these results are encouraging since, if the accident reductions are representative, the measures are highly cost effective.

5.3.5 Rumblewave surfacing has not been in place long enough to have three years of 'after' accident data. However, at the time of publication early results are encouraging.

5.4 Environmental impact

Noise

5.4.1 Traditional rumble devices may generate considerable noise, or result in a change in noise characteristics. Depending on the topography and ambient noise levels, this may be annoying to residents over a large area. In consequence, the scope for using rumble strips or areas in urban areas will generally be limited. The noise generated will vary from location to location and depend on the speed of the traffic, the pattern and the type of device used. To avoid complaints, and the subsequent necessity to remove a device, the possible noise nuisance should be assessed at the outset.

5.4.2 In general, siting rumble strips close to residential properties should be avoided. Some authorities do not use rumble devices within 200 metres of residential properties. In open country, the distance may need to be increased to avoid complaints from residents. Noise generation can be minimised by using lower-height strips, though this may compromise overall effectiveness. Rumble areas tend to be less noisy than rumble strips, but are a more expensive form of construction.

5.4.3 It is often the change in characteristic of the noise that is noticed by the residents. At Hayton, reduced speeds at the village gateway had resulted in reduced noise levels, but a nearby resident complained of a 'pulsing' sound as vehicles crossed the 5 mm high textured patches. Measurement of vehicle noise profiles showed that this phenomenon was indeed measurable, but only for a minority of light vehicles. The effect is possibly linked to tyre type. At Thorney, residents close to a village gateway had complained of the noise as vehicles traversed the imprinted surfacing. Again, the overall noise levels had reduced, but subsequent detailed measurement of noise characteristics showed distinct peaks at certain frequencies that were related to the vehicle speed and the regular pattern of the imprinted surfacing (Wheeler & Taylor, 1999).

5.4.4 Rumblewave surfacing was developed to create the same noise and vibration within the vehicle as rumble strips but reduce the external noise. Car and van drivers in tests rated the recommended surface profile 'noticeable' to 'very noticeable'. At the pilot sites, recorded external noise levels did not change greatly after scheme implementation, indicating that rumblewave could be suitable for locations closer to residential properties (Watts *et al*., 2002).

Vibration

5.4.5 Ground-borne vibration has not generally been a problem at traditional rumble device sites. At Thorney, it was reported that increased vibration at the raised imprinted surface gateways had caused some concern for residents (Wheeler *et al*., 1997). However, the soft peaty soil conditions at the site were a major contributory factor in the level of vibration experienced. (Vibration and soil types are covered in detail in relation to road humps and speed cushions in Section 4.5.)

5.4.6 Problems of ground-borne vibration have been reported at some rumblewave sites. Additional measurements were carried out at four of these sites (Watts & King, 2004). This led to the development of an equation that provides guide values for the minimum distance allowed between the nearest house façade and the rumblewave pad (see Table 5.1).

5.4.7 Although recorded maximum vibration levels at the four rumblewave installations examined were well below that known to cause even minor building damage, the vibrations were within perception levels at three of these locations. In some of these cases annoyance to local residents has led to the surfacing being removed. At the fourth location studied, the levels of vibration were below generally accepted perception levels and it was thought possible that the resident was sensitive to low-frequency noise, causing him to complain (Watts & King, 2004).

5.4.8 In addition to the vibrations excited by the sinusoidal profile, it was found that the on/off ramps could excite 'wheel-hop' frequencies. To avoid this problem, ramps of less than 1 metre should be avoided, especially on softer soils. In general, longer ramps reduced this vibration effect.

Table 5.1 Guide values for minimum distances to avoid perceptible vibrations

Ground	Minimum distance (m)
Alluvium	105.8
Peat	30.8
London clay	19.9
Sand/gravel	18.1
Boulder clay	7.8
Chalk	4.7

Note: the minimum guide distances are based on the distance from the nearest section of rumblewave pad to the house foundations.

Air quality

5.4.9 The effect of rumble devices on vehicle exhaust emissions and air quality is likely to be minimal, as the speed reductions possible are relatively small and the devices are unlikely to cause a great deal of acceleration and deceleration.

Visual impact

5.4.10 When considering the use of brightly coloured and/or reflective material for rumble devices, the visual impact of the scheme on the local environment should also be taken into account. Rumble devices are a warning, rather than a hazard, therefore mechanisms to alert drivers to the presence of the warning are not essential.

5.5 Overrun areas

5.5.1 Overrun areas are designed to visually narrow the roadway while maintaining the effective width for larger vehicles. The most common applications of overrun areas are at roundabouts, narrowings and chicanes. They have also been used on bends on narrow residential roads which require access for large vehicles such as refuse vehicles or removal lorries. Overrun areas are described in TALs 12/93 and 07/95.

5.5.2 The maximum dimensions prescribed in Regulation 5 of The Traffic Calming Regulations are as follows (as shown in Figure 5.4):

- No vertical face of any material forming part of the area shall exceed 6 mm measured vertically from top to bottom of that face.
- The overall slope of the area shall not exceed 15 degrees measured between an imaginary line extending the general line of the slope of that area to the surface of the carriageway and the surface of the carriageway where it is intersected by the imaginary line
- The overrun area shall not be so constructed or maintained that an imaginary vertical line measured from the base of any upstanding face intersects an imaginary line extending the general line of the slope of the area more than 15 mm above the base of that upstanding face.

Cyclists

5.5.3 Because of the locations where overrun areas are likely to be used, cyclists might find they are forced onto the features by passing vehicles. The design of the overrun area should not prevent cyclists crossing it safely. For example, a bullnose kerb having a 16–19 mm nose radius, provided that only this nosing is exposed above the carriageway, will conform with the requirements of the regulations. Cyclists should be able to negotiate such a feature safely, even on

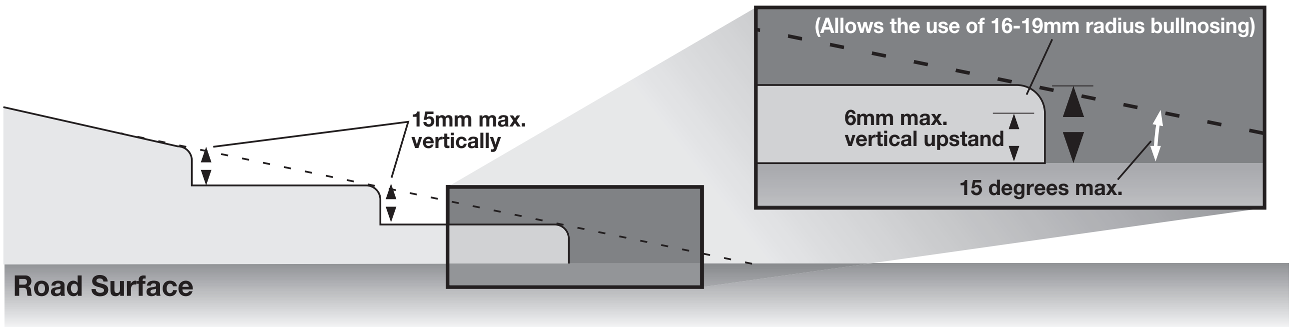


Fig. 5.4 Detail of an overrun area

an angled approach. However, if any vertical face is present, the feature will be more difficult and possibly dangerous to negotiate. The regulations do not dictate the use of any particular materials, but their wet-weather performance should be considered to ensure that they are safe for cyclists.

Pedestrians

5.5.4 If not located appropriately, overrun areas can cause difficulties and possible danger for pedestrians. Therefore it is important to avoid positioning these areas in places where pedestrians often cross the road. In some cases pedestrians may need to be directed to safer crossing places. Where the overrun area is in the highway, it must conform with the Traffic Calming Regulations.

6. Narrowings and chicanes

6.1 Background

6.1.1 Attitude surveys conducted into traffic calming schemes suggest that the public dislike horizontal deflections, such as chicanes, more than they dislike road humps (not including speed cushions) (see paragraph 2.10.3). Care needs to be taken in designing these devices, to ensure maximum acceptability.

6.1.2 Horizontal carriageway deflections, such as localised narrowings and chicanes, have been installed to influence vehicle speeds, though not always successfully. In the case of kerb build-outs and pinch points, the narrowed carriageway, even if reduced to a single lane, still allows most vehicles to be driven relatively quickly through the available gap, unless there is opposing traffic to prevent this occurring.

6.1.3 A study of traffic calming schemes using horizontal deflections by Hass-Klau & Nold (1994) indicated that balanced vehicle flow is one of the most important aspects when opting for localised road narrowings. Unfortunately, in many residential streets traffic is either tidal or such low-flow that it is unlikely that vehicles from opposite directions will meet at the narrowing. This is also something to consider when designing a rural narrowing scheme such as a single track road with passing places. There is also some evidence that, even where there is opposing traffic, one stream does not willingly give way to the other (TALs 09/94 and 02/04).

6.1.4 Where kerb build-outs are used to form narrowings or chicanes, care should be taken that access to frontage properties is not prevented.

6.1.5 Where traffic calming takes the form of a localised narrowing of the carriageway, such as occurs where central traffic islands are installed, cyclists can feel threatened by the proximity of motor vehicles. A cycle bypass should therefore be given serious consideration (see TAL 01/97 for further details). If one is provided, there is no need to allow sufficient width through the narrowing for motor vehicles to pass cyclists safely. The carriageway can therefore be further reduced to maximise the traffic calming effect. If there is not enough room for a cycle bypass, one option is to run a cycle lane through the narrowing. The presence of a cycle lane is unlikely to discourage overtaking but it can serve to increase the separation distance between cyclists and other vehicles. Cycle lanes should normally be 1.5 metres wide, but short lengths at a slightly reduced width may be acceptable. An advisory cycle lane of adequate width is usually preferable to narrower mandatory one.

6.1.6 Total widths through narrowings of between 2.75 and 3.25 metres should be avoided if no cycle bypass is provided. Within this range some motorists will attempt to overtake cyclists, even though there is insufficient room to do so safely. See TAL 15/99 and paragraph 2.7.20.

6.1.7 The advantages and disadvantages of using chicanes are summarised in Appendix G.

6.1.8 More recent developments in traffic calming advocate the use of narrowings along an entire route or in a residential area (see paragraphs 6.3.3 and 6.5.4.). This type of narrowing can be used to reduce the dominance of motorised vehicles and increase the sense of places for people, especially in residential areas. Narrowing of this type will often require complete redesign of the road to physically reduce space for motorised vehicles. This ‘extra’ space can then be reallocated to increase the size of footways, create segregated cycle lanes, recreational areas (e.g. for play equipment in Home Zones), for planting or to increase parking capacity (for example using echelon parking bays).

6.1.9 In the case of schemes that involve narrowings or chicanes, it is important to ensure that larger vehicles likely to use the route, i.e. farm vehicles, gritters etc., can negotiate the layouts.

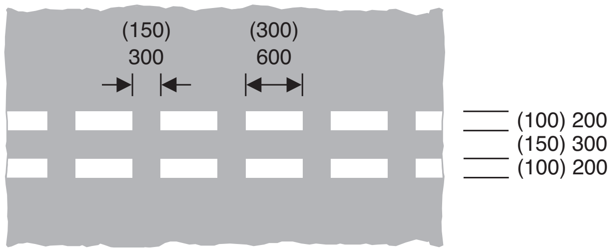


Fig. 6.1 'Give way' markings. Diagram 1003

6.2 Signing

6.2.1 To assist in giving drivers information as to which direction of traffic has priority in single-lane-working chicanes and other road narrowings, TSRGD allows the use of 'give way' markings (to diagram 1003, either on their own or in conjunction with priority sign diagram 615). If used, diagram 615 must be accompanied by the supplementary plate 'Give way to oncoming vehicles', and a sign to diagram 811 with supplementary plate 'Priority over oncoming vehicles' erected to face traffic in the opposite direction. The Give Way sign to diagram 602 is not permitted at these locations.

6.2.2 In most traffic calming schemes it will be sufficient to use markings to diagram 1003 alone (Fig. 6.1). Diagram 1023 (triangular marking) may be used with diagram 1003 to provide additional emphasis. Diagram 1003 markings should not be used on both approaches, as this can lead to confusion and TSRGD does not permit such use.

6.3 Narrowings

6.3.1 Carriageway narrowing may be limited to a particular location or take place along a whole length of road. Carriageway narrowing can be achieved by the use of physical measures (e.g. kerb build-outs and/or central islands), by road markings and coloured surfacing (e.g. central hatching – see paragraph 10.2.9, or cycle lanes), by reallocation of roadspace (see paragraph 6.1.8) or by a combination of all methods. Cycle lanes should not be implemented solely for speed-reducing purposes, as this could create unnecessary conflict between cyclists and motorists.

6.3.2 Narrowings must not be used to prevent physical access by any particular vehicle type unless there is a Traffic Regulation Order prohibiting such traffic. Narrowings will need to be clearly visible at all times, and where bus routes serve the area narrowings should not impede the movement of buses. In rural areas the effects on access requirements for agricultural vehicles should be considered.

Narrowing of distributor roads

6.3.3 To date in the UK narrowing of through routes has largely been achieved by the creation of bus or cycle lanes. However, narrowing is now starting to be used on roads where other traffic calming measures such as road humps are inappropriate and there is a need to enhance the environment for non-motorised users. Several recent projects have considered this approach including the DfT's Mixed Priority Route Road Safety Demonstration Project, and the Revitalising Communities on Main Roads projects being co-ordinated by Transport 2000. Both these projects involve main roads where there is a mix of uses including retail, through transport and residential. The aim is to transform the character of the road to improve road safety and amenities for all uses.

6.3.4 Some schemes involve reduction of the road space available and reallocation of that space to other uses. If narrowing of this kind is being considered, traffic modelling is essential. The Department has commissioned research to examine the effectiveness of such techniques in a more rural setting. In Latton, Wiltshire, roadspace reallocation and measures to enhance the village character of the road in question have been implemented with the aim of reducing vehicle speeds (see paragraph 3.8.13 for measures implemented). Sheltered parking with end planters or build-outs was used to create a gentle chicane effect. However, the road remained at least 5.5 metres wide at all points, as it is used by heavy-duty vehicles servicing a nearby quarry.

Traffic islands and pedestrian refuges

6.3.5 Traffic islands and pedestrian refuges (collectively referred to as islands) may be similarly constructed, except that traffic islands are not intended for use by pedestrians and therefore will not have dropped kerbs or tactile surfacing. Islands (Fig. 6.2) can be introduced in the highway for a

Fig. 6.2 Pedestrian refuges

variety of purposes such as: separating traffic moving in opposite directions, facilitating movement by pedestrians, controlling vehicle speeds (TAL 07/95) and ensuring that drivers straddle speed cushions.

6.3.6 Islands have been used as part of a gateway to indicate the start of a traffic calming scheme, and as measures to maintain low speeds within a traffic calming scheme. However, care needs to be taken that islands, which substantially narrow the carriageway, are not encountered at high speeds, especially where they are combined with kerb build-outs.

6.3.7 Islands are required to be clearly visible to approaching vehicles at all times. It is recommended that islands used for traffic calming purposes are indicated by internally illuminated bollards, incorporating ‘keep left’ signs (diagram 610) where appropriate. Any street furniture placed on an island should be set back at least 0.5 metres from the kerb edge. Central hazard markings on the approaches should be of an appropriate taper length, and off-set, in accordance with the DfT’s *Traffic Signs Manual*, Chapter 5.

6.3.8 In siting islands, consideration should be given to existing and likely pedestrian flows and movements, remembering that pedestrians will cross the road where it is most convenient for them to do so. Where an island is likely to be used as a pedestrian crossing facility, a pedestrian refuge with dropped kerbs and tactile surfacing may be more appropriate. The placing of the refuges should be carefully considered in relation to the spacing and the actual location, so that maximum benefit is gained. Guidance on the location of pedestrian refuges is given in LTN 02/95. Advice on installing tactile slabs at various sizes of refuge is given in *Guidance on the Use of Tactile Paving Surfaces* (DETR, 1998b).

6.3.9 Islands do not have to be centrally positioned relative to the carriageway. An offset island may be used, for example, to provide protection for a cycle lane or introduce a cycle bypass, in addition to its speed control purpose.

Build-outs and pinch points

6.3.10 A build-out is a section of kerb built out into the carriageway on one side only to narrow the road. These features can be constructed in many different ways (e.g. as footway extensions and planted areas). The build-outs can either be connected with the footway, or a drainage channel may be left between the build-out and the footway. If the space is available, the drainage gap can be widened to form a cycle bypass. To narrow the existing carriageway on a junction, it is possible to construct build-outs on the corners (Hass-Klau & Nold, 1994).

6.3.11 A pinch point (Fig. 6.3) is where the road is narrowed from both sides at the same position along the road for a distance of 5 to 10 metres. It may sometimes be described as a throttle, and it has been called necking, particularly in the USA. (See Appendix H for a glossary of traffic calming terms.) By implementing this measure, the carriageway width can be restricted so that only one vehicle at a time may pass, or so that two cars can pass slowly. Roads with a high frequency of buses and/or heavy goods vehicles need a wider carriageway width between the pinch points.

Fig. 6.3 Pinch point

6.3.12 All sections of kerb that are built out into the carriageway will need to be clearly visible to approaching vehicles at all times.

6.3.13 Some pinch points may have central islands on the approaches to encourage drivers to reduce their speed further. The resulting layout requires drivers to deviate in a similar manner to a chicane (see Section 6.4).

Sheltered parking

6.3.14 Sheltered parking (Fig. 6.4) can be created by build-outs, pinch points or hatching with occasional promontories to aid visibility of pedestrians, so that they can see and be seen beyond the parked vehicles. In narrow streets where drivers are known to park partly on the footway along both sides, it may be better to provide properly marked out spaces on just one side of the carriageway. If the marked out spaces are provided in short lengths along alternate sides of the road, they can form a chicane and may have the effect of reducing vehicle speeds. This is described in TAL 04/93.

6.3.15 Parking is an important consideration and can be used to create chicanes in shared streets such as Home Zones. It is important to consider that some designs may fail during public consultation if the number of parking spaces is insufficient (Polus & Craus, 1996). It is also important to remember that parked vehicles may only be present at certain times of day, limiting their speed-controlling effectiveness.

Fig. 6.4 Sheltered parking

6.4 Chicanes

6.4.1 Chicane designs vary considerably but most fall into two broad categories:

- single-lane working, consisting of staggered build-outs, narrowing the road so that traffic from one direction has to give way to opposing traffic
- two-way working, using build-outs to provide deflection, but with lanes separated by road markings or a central island.

6.4.2 A single-lane working chicane allows traffic in both directions, but there is only room for one vehicle to pass through at a time. Generally a priority is given to one direction, so that the possibility of vehicle conflicts is minimised. Priority should be given to vehicles leaving a traffic-calmed area, so that the speed of vehicles entering is reduced.

6.4.3 Two-way working chicanes take up more carriageway space than other chicanes, as they allow two vehicles to pass in opposite directions at the same time. Where chicanes do not have a central divider, vehicles can encroach into the opposing traffic lane, and this may result in less speed reduction being achieved, and/or safety being compromised.

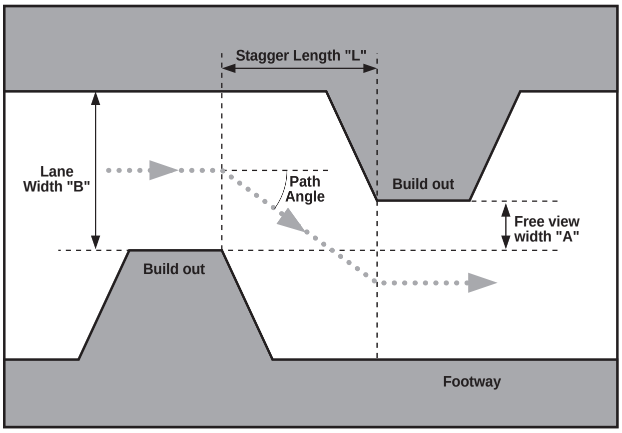
6.4.4 Chicanes have been used successfully in traffic calming schemes. However, in some instances the features have been removed because of complaints from residents, emergency services, or bus operators. Consultation prior to installation of horizontal deflections is a necessary part of the design process (see Section 2.4). Besides the groups mentioned, consultation should include haulage associations, particularly if an abnormal load route is involved, and farmers in rural areas.

Design considerations: dimensions

6.4.5 Information on the design of horizontal deflection features, including chicanes, is available from experience in mainland Europe (e.g. Danish Road Directorate, 1991; Herrstedt *et al.*, 1993; CROW, 1998). However, to ensure compatibility with conditions in the UK, the DfT commissioned track trials to ascertain suitable design criteria for horizontal deflections, and in particular chicanes. The main parameters affecting the mean speed of cars through the chicane were stagger length, free view width, lane width and path angle (TAL 09/94; Sayer & Parry, 1994). See Figure 6.5.

6.4.6 The results of the study are summarised in Tables 6.1, 6.2 and 6.3. Chicane dimensions that were suitable for reducing the mean speed of cars to around 20 mph reduced the speed of buses and coaches to about 10 mph, but were too tight to allow an articulated lorry to pass.

6.4.7 Installing speed cushions on the approach to a chicane would partially compensate for the longer stagger lengths required to accommodate large vehicles, while keeping the speed of cars to around 20 mph. An alternative approach is to use overrun areas to give car drivers the impression of a restricted-width carriageway, but allowing additional manoeuvring room for large vehicles (see Section 5.5).



Free view width (A) – the width of the central gap between build-outs on opposite sides.

Lane width (B) – the average width between the build-out and the opposite kerb.

Stagger length (L) – the length between the start of the stagger on the offside and the end of the stagger on the nearside.

Path angle – the angle through which the traffic lane is displaced.

Fig. 6.5 Chicane terminology

Table 6.1 Stagger length and car speeds

Lane width 'B' (metres)	Free view width 'A' (metres)	Stagger length 'L' to achieve required vehicle speed in chicane (metres)		
		15 mph	20 mph	25 mph
3.0	+1.0	6	9	14
	0.0	9	13	18
	–1.0	12	16	-
3.5	+1.0	-	-	11
	0.0	9	12	15
	–1.0	11	15	19
4.0	+1.0	-	7	9
	0.0	-	9	12
	–1.0	-	11	15

Table 6.2 Minimum dimensions of stagger length for larger vehicles at very low speeds

Lane width 'B' (metres)	Stagger length 'L' needed for a free view width of 0.0 metre (metres)		
	Articulated lorry	Rigid lorry	Single deck bus
3.0	20	12	13
3.5	15	9	11
4.0	11	7	9

Table 6.3 Dimensions of large vehicles used in track trial

Vehicle type	Vehicle dimensions (metres)		
	Width	Length	Wheelbase
Articulated lorry	2.5	16.1	-
Rigid lorry	2.5	9.2	5.8
Single-deck bus	2.5	11.8	5.5

Design considerations: signing and marking

6.4.8 There is no specific warning sign for chicanes. However, chicanes should be made conspicuous both in the day and at night, particularly the kerb build-outs. In single-lane working chicanes, 'give way' markings and priority signs can be used to indicate which direction has priority. The 'Traffic calmed area' sign (diagram 883 in the TSRGD 2002) could also be used if necessary to provide additional warning.

6.4.9 Although chicanes have shown an overall reduction in injury accident frequency (see paragraph 6.6.20), vehicles are known to have collided with the kerb build-outs at some chicanes, resulting in damage only and injury accidents. The signing, illumination and location of the chicane may be relevant in minimising such accidents. The following points should be considered, especially where the approach speeds may be high:

- A speed reducing feature such as a roundabout or T-junction should ideally be provided prior to the location of the first chicane.
- Reliance on signing alone to reduce speeds may not be sufficient, unless it can be incorporated into a conspicuous gateway feature, with both vertical and horizontal elements.
- For a combination of a roundabout or gateway and chicane to be both safe and effective, they must be within a relatively short distance of each other (see TAL 12/97).
- Illumination and signing of chicanes needs to be checked regularly, as poorly illuminated or poorly signed chicanes can become hazards during bad weather (including snow) or the hours of darkness.
- At single-lane working chicanes, opposing drivers should have sufficient visibility to enable either of them to give way to the other without sudden braking.

Design considerations: pedestrians

6.4.10 Chicanes are not generally appropriate at locations where crossing activities take place, as drivers may be concentrating more on how to manoeuvre through the feature than on the movements of pedestrians. If a traffic island is used to form a chicane, it may be necessary to introduce additional features to discourage the use of the island for pedestrian crossing purposes or, if possible, to ensure the island is sited away from pedestrian desire lines.

Design considerations: cyclists

6.4.11 Investigations have shown that cyclists can be concerned when cycling through narrowings such as chicanes. Where possible, a cycle bypass around the chicane should be strongly considered (see paragraph 6.1.5).

Design considerations: motorcyclists

6.4.12 It is inappropriate for motorcyclists to use any cycle bypass facilities. Whilst the chicane needs to exert an effect on the speed of motorcyclists, care needs to be taken that the layout does not place them at risk. The chicane and the route through it should be clearly delineated, particularly any overrun areas incorporated into the design, both for day and night-time conditions.

Design considerations: horse riders

6.4.13 Reports from equestrian groups suggest people riding horses can feel threatened when travelling through road narrowings or chicanes. This is likely to be especially true where there are high volumes of traffic competing for space at the narrowing. If possible a grass verge alongside the narrowing would allow horse riders to avoid this conflict area.

6.5 Cost and maintenance

6.5.1 The cost of chicanes and narrowings can vary depending on their size, whether any road realignment is required, and the signing and lighting needed to improve conspicuity at night. An approximate average cost for a single-lane working chicane was found to be £3,000, including signing and lighting (Sayer *et al.*, 1998; TAL 12/97).

6.5.2 Cycle lanes that bypass chicanes or narrowings will require manual road sweeping to remove leaves and debris if vehicle sweepers are too wide to negotiate the bypass (TAL 01/97). They also require to be kept as free of ice and snow as the main carriageway: any snow should not just be pushed from the path of motor vehicles into the cycle lane or cycle bypass. Cycle bypasses may therefore not be the best option if the traffic flows are low and cyclists are able to integrate safely with other traffic, for example on minor rural roads.

6.6 Effectiveness

6.6.1 A study of traffic calming schemes using a variety of horizontal deflections (Hass-Klau & Nold, 1994) found an overall reduction of about 7 mph in 85th percentile speed. The speed reductions varied considerably among schemes (1 to 19 mph). The overall 'after' 85th percentile speed was about 34 mph, indicating that, in order to achieve sufficient speed reduction with 20 mph zones, horizontal traffic calming features need to be combined with vertical measures (e.g. road humps, raised junctions or speed cushions).

Vehicle speeds: roadspace reallocation

6.6.2 Roadspace reallocation in Latton, Wiltshire, resulted in mean speed reductions of 7–8 mph and 85th percentile reductions of 8–10 mph (Kennedy *et al.*, 2005). This was despite the fact that the sheltered parking bays were not fully used and the planting was immature, reducing both the impact on sightlines and the actual narrowing of the road. However, the scheme was not sufficient to bring mean speeds below the 30 mph limit (mean speed after implementation was 31 mph).

Vehicle speeds: traffic islands and pedestrian refuges

6.6.3 Where an island or pedestrian refuge has been used to narrow the carriageway, and the remaining carriageway is greater than 3.5 metres, the speed control effect may be predominantly psychological.

6.6.4 Studies of specific sites (Thompson *et al.*, 1990; Cloke *et al.*, 1999; Boulter, 2000) indicate that the speed-reducing effect of carriageway narrowings achieved by a series of central islands is likely to be modest (between 1 and 5 mph).

Vehicle speeds: chicanes

6.6.5 A study for the Department for Transport of 49 schemes on the public roads has provided information on speeds through chicanes (Sayer *et al.*, 1998). The data collected showed that an increased path angle leads to a reduction in speed. In general, path angles greater than 15 degrees reduce mean speeds at the chicane to less than 20 mph, while path angles of less than 10 degrees allow speeds of 25 mph or more. For 85th percentile speeds, path angles of about 10 degrees would allow speeds of over 30 mph, whereas path angles of 15 to 20 degrees would result in speeds of 20 to 25 mph. By necessity, path angles at two-way working chicanes are less than at single-lane working chicanes; as a result the speed reduction will be less.

6.6.6 The chicanes in the study tended to be installed on roads with higher 'before' speeds than those where road humps or speed cushions have been installed. While average speed reductions of 12 mph were obtained for the mean speeds at the chicanes in the study, the overall 'after' mean and 85th percentile speeds at the chicanes (23 mph and 28 mph) were higher than those for road humps or speed cushions.

6.6.7 At the single-lane working chicanes, the average 'after' mean and 85th percentile speeds were 21 mph and 26 mph respectively. At the two-way working chicanes, the average 'after' speeds were 27 mph and 31 mph respectively (Sayer *et al.*, 1998). The speed data at locations between chicanes was less complete, so reliable speed-to-chicane spacing relationships could not be compiled. The information available indicated a reduction in overall 'after' mean speed between chicanes to 29 mph, and 85th percentile speed to 31 mph.

6.6.8 Track trials (TAL 09/94) showed that a visual restriction (obscuring forward visibility across the build-outs) had a positive effect in reducing speeds by 2 mph to 4 mph. As discussed earlier, the height of any visual restriction should not be greater than 600 mm where children are likely to be crossing. Although in the trials the restriction was built up to the carriageway edge, it would normally be preferable to provide a clearance between the barrier and the carriageway edge, to avoid the barrier being struck. Reductions in speed may then be smaller, because of the increased forward visibility.

Vehicle flows

6.6.9 Danish advice (Danish Road Directorate, 1991; Herrstedt *et al.*, 1993) for single-lane working is that there should not be more than 3,000 vehicles per day. Balanced vehicle flow is important, and some local authorities only implement road narrowings where there is a traffic flow of about 400 vehicles per hour in each direction (Hass-Klau & Nold, 1994).

6.6.10 Traffic flows in Latton increased by approximately 16 per cent following the implementation of the 'psychological' traffic calming scheme. The project team postulated that this was due to a combination of effects: new housing within the village, national trends over the 22-month period and the differences in flow between the months of January and November (Kennedy *et al.*, 2005).

6.6.11 Pedestrian refuges and traffic islands can create problems for cyclists, but their impact on cycle flows is not known.

6.6.12 At chicane schemes studied by Sayer *et al.*, 1998, the average daily flow for the single-lane working chicanes was about 3,900 (affected by two of the 49 sites where flows exceeded 7,000 vehicles). For two-way working, the average daily flow was about 7,300 (though two schemes had flows in excess of 10,000 vehicles).

6.6.13 There was an average reduction of about 15 per cent in traffic flow at the single-lane working chicane schemes, and 7 per cent at the two-way working schemes. However, there were large variations in the changes at individual sites, ranging from a reduction of 55 per cent to an increase of 12 per cent. Of the 13 schemes with 'before' and 'after' data, flows decreased at eight schemes, increased at three schemes and did not change at the other two.

Accidents: narrowings

6.6.14 A study of area-wide traffic calming measures in Germany, (Brilon & Blanke, 1994), showed that traffic calmed zones reduced overall injury accidents by 50 per cent, but where constricted lane widths were used there was an increase in accidents. These were largely damage-only accidents, which mainly involved wide vehicles such as buses and trucks.

Accidents: pedestrian refuges

6.6.15 An analysis of pedestrian refuge schemes where a series of refuges was installed for channelisation of two-way traffic (Lalani, 1977), gave an overall small non-statistically significant increase in accidents.

6.6.16 In the Urban Safety Project, (Mackie *et al.*, 1990) a series of central refuges was used on some wider arterial and local distributor roads. Injury accidents appeared to be reduced at these locations, mainly to pedestrians and users of two-wheeled vehicles. However, the results are only indicative, as the accident numbers involved were relatively small.

6.6.17 An analysis of pedestrian refuge schemes in Nottingham (Thompson *et al.*, 1990) considered 23 refuge schemes. It showed that overall accidents were reduced by 24 per cent, but pedestrian accidents increased slightly by 13 per cent. However, the results were not statistically significant when compared with the appropriate control data. The majority of residents interviewed felt that the pedestrian refuges in their area had increased pedestrian safety and were helpful to children and senior citizens. However, they did not feel that similar advantages were conveyed to other road users, particularly cyclists and drivers of large vehicles. Dissatisfaction with the refuge schemes was greatest at schemes that had produced the greatest narrowing of the carriageway.

6.6.18 In Adelaide, Australia, the replacement of painted median strips with wide raised median islands was investigated (Claessen & Jones, 1994). The results showed that overall casualty accidents were reduced by 32 per cent and pedestrian accidents by 23 per cent.

Accidents: sheltered parking

6.6.19 In the Urban Safety Project, (Mackie *et al.*, 1990), the overall accident reduction attributed to sheltered parking was 17 per cent, with pedestrians the main group to benefit. However, the results are only indicative, as the accident numbers involved were relatively small. An Australian study (Hawley *et al.*, 1993) showed that injury accidents were 60 per cent lower on a 2-lane road with sheltered parking, compared with an untreated 4-lane section. 'Tow away' accidents (equivalent to damage only) were also lowered.

Accidents: chicanes

6.6.20 The chicane sites investigated by Sayer *et al.* (1998), gave a reduction of 54 per cent in injury accident frequency. Of the 17 schemes with accident data, accident frequencies were reduced at 10 schemes, unchanged at 4 schemes and increased at 3 schemes. Accident severity was also reduced, from 18 per cent of accidents involving fatal or serious injury before scheme installation, to 12 per cent after.

6.6.21 Accident data from MOLASSES (see paragraph 2.2.5) showed that injury accidents at chicanes or narrowings in urban areas had been reduced, on average by 47 per cent (DETR, 2001b).

6.6.22 Although chicane schemes give an overall reduction in the frequency of injury accidents, vehicles are known to have collided with the kerb build-outs at some chicanes, resulting in both damage-only and injury accidents. Care should be given to the design, signing, illumination and location of chicanes in order to minimise these accidents (see Section 6.4).

6.7 Environmental impact

Distributor road narrowings

6.7.1 Route-long narrowings should result in reduced speeds without the stop-start flow that can be associated with intermittent traffic calming measures, vehicle noise is therefore likely to decrease. In addition, if the road space is reallocated, improvements could be made to the streetscape and sense of place by using planting, improved provision for non-motorised users, street art, etc. In the longer term, this change in the character of the street could promote economic vitality in shopping areas as numbers of pedestrians increase.

6.7.2 Careful design at the early stages of scheme development is required to ensure that maximum benefits are achieved. As mentioned previously, traffic modelling will be essential, especially if the number of lanes is to be reduced. This is in order to avoid congestion problems, which could cause public resentment towards a scheme. On the other hand, use of high-quality materials, seating and street trees may improve civic pride and sense of community, helping to gain community approval for a scheme. It is suggested that communities should be involved from an early stage, so that particular needs and place-making desires are picked up.

6.7.3 The 'psychological' calming scheme in Latton involved reallocation of road space for sheltered parking, planting and bus bays, along with environmental improvements and new gateways. There was close liaison between the local highway authority, the local parish council and the design consultants. The resulting scheme had high levels of support in the local community, with three-quarters of respondents supporting the scheme as a whole and liking its visual appearance.

Pedestrian refuges

6.7.4 Daytime traffic noise measurements at a pedestrian refuge site in Havant (TAL 02/99) showed that the daytime noise levels reduced by 1.9 dB(A) after installation (attributed to lower traffic speeds). The night-time noise was influenced by high wind conditions, so it was difficult to draw any firm conclusions about changes in night-time noise levels.

Chicanes

6.7.5 Chicanes will generally generate less vehicle body rattle than road humps, unless a speed cushion or road hump is incorporated. However, drivers may show increased stop-start acceleration and braking behaviour through chicane schemes, which can create a noise nuisance (TAL 12/97).

6.7.6 Chicanes are not likely to cause any vibration problems unless a speed cushion is included in the design (see paragraph 4.5.8).

6.7.7 Stop-start movements at single-lane working chicanes may increase vehicle exhaust emissions, though they would have to be in very large numbers to have any real effect. A study (Boulter *et al.*, 2001) investigating emissions at a range of traffic calming measures (including a pinch point and a single-lane working chicane) found increases in some pollutants of up to 60 per cent (see paragraph 4.5.13). The variability of the emission data precluded a definitive ordering of the different measures tested, but the more severe traffic calming measures in the study tended to result in the largest increases in emissions. It was estimated that, although these measures generally increase the emissions per vehicle, they would be unlikely to result in poor local air quality in the areas concerned. Furthermore, traffic calming generally results in a reduction in traffic flow in the calmed area, which should reduce overall emissions.

6.7.8 Planters can be used to enhance chicane schemes, but it is important that these are not more than 600 mm high where children may be crossing and that they are maintained adequately. Alternatively, trees could be used, as long as these are located so as not to obscure pedestrians waiting to cross. Where a single-lane priority system is used at narrowings, the planting or other features should not prevent drivers approaching in opposite directions from being able to see each other.

6.7.9 The potential for reduced sightlines to bring about naturally a reduction in vehicle speed, and hence improved road safety, as a result of increased driver uncertainty is being investigated as part of the Department's *Manual for Streets* project. This will be reported in later publications.

6.7.10 It is important that the visual appearance of a whole chicane scheme is considered and that advice from conservation officers, landscape architects and others is obtained. The initial use of temporary materials to construct chicanes can prejudice acceptance of the proposals where the finish is unattractive, unless residents are fully informed about the nature of the permanent scheme. Chicanes will reduce on-street parking availability, and care is needed to avoid obstructing entrances.

6.7.11 Drainage issues will need to be considered during scheme design, as build-outs may block existing channels. Additional gullies or bypass systems through the chicane may be required.

7. Gateways and entry treatments

7.1 Background

7.1.1 Gateways (TAL 13/93) are used to signify the approach into a village, or into a traffic-calmed area such as a 20 mph zone. Gateways are sometimes called 'entry treatments' (Section 7.3) or 'thresholds'. They can have many different forms, but those implemented to date have most commonly incorporated a distinctive change in road surface colour or material, a prominent sign to alert drivers to the calmed area and perhaps other measures such as 'dragon's teeth'. In some areas the conspicuity of the signs and markings can raise objections, but trials have shown that conspicuity of the gateway is a requirement for them to be effective. Some local authorities have overcome this problem by using existing features such as historic arches, or features using local materials such as fences or brickwork coming near to the edge of the carriageway to emphasise the gateway in a manner more in keeping with the surroundings. It is advisable that gateway features are set at least 450 mm from the edge of the carriageway (increasing to 600 mm where there is a severe camber or crossfall), to avoid the risk of vehicles clipping them. Linking gateway features to the visual start of a village may also help to reduce vehicle speeds.

7.1.2 A report entitled *Natural Traffic Calming: guidance and research report* (Scottish Executive, 1999a) concluded that the calming of roads as they enter settlements requires a process of adjustment and transition involving a range of different physical and perceptual factors.

7.2 Gateways to villages

Visibility

7.2.1 A gateway (Fig. 7.1) should be sited so that drivers do not encounter it suddenly. It should be visible over at least the stopping distance for the 85th percentile of the approach speed of vehicles.

Fig. 7.1 Village gateway at Charlwood

Basing the distance on the speed limit will often not be sufficient, and speed measurements should be taken to identify the 85th percentile speed. Site inspection will determine if the stopping distance is sufficient or if it needs to be increased. Care should be taken when considering placing gateways on long curves where they may not be initially in the driver's line of vision. Gateways should be linked to the visual start of the villages. TAL 01/04 (*Village Speed Limits*) defines a village as having at least 20 houses and a minimum length of 600 metres, with a recommended average density of at least 3 houses per 100 metres.

Conspicuity

7.2.2 Gateways should be as conspicuous as possible, whilst remaining in keeping with the surroundings. The effectiveness of various individual gateways is described in Wheeler *et al.*, 1993 and Wheeler *et al.*, 1994. The conspicuity of a gateway may be marginally enhanced by the use of dragon's teeth (TAL 01/00), which are not road markings and therefore do not require special authorisation. However, it should be noted that, as the markings are not visible from a distance or in wet weather, their impact is likely to be minimal and the use of such markings alone would not be advisable. If dragon's teeth markings are being considered, the negative

Fig. 7.2 Entry treatment at the start of a 20 mph zone

visual impact on the local environment should be weighed up against the slight potential for additional speed reduction.

Horizontal elements

7.2.3 These can have the form of a contrasting coloured surface, which may also be textured or form a rumble device (see Chapter 5). The area should be at least 5 metres long. Longer lengths up to 10 metres can improve conspicuity, but beyond this length they may detract from the effect of the gateway. Edgeline hatched markings with a dashed border (diagram 1040.4 of TSRGD) can make the carriageway appear narrower, whilst still allowing larger vehicles to overrun the areas if necessary. Islands or build-outs can be used to narrow the carriageway at the gateway, but care should be taken to maintain adequate road width for the vehicles that use the road. Ghost islands or overrun areas can be used where farm machinery or specialist vehicles are likely to need to negotiate the narrowing. Islands can be placed towards one side of a gateway to give protection to cycle lanes or cycle bypasses.

Vertical elements (including road signs)

7.2.4 Speed limit and village nameplate signs are prescribed in TSRGD. Road furniture positioned at the gateway should be set sufficiently far back so that vehicles do not come into contact with the furniture. Location on the footway or cycle track should be avoided, unless there is sufficient space remaining to allow safe passage of pedestrians and cyclists. If signs span the footway or cycle track, there should be adequate headroom for users. For any structure erected as part of the gateway, careful consideration needs to be given to the effect if impacted by a vehicle.

7.3 Entry treatments

7.3.1 An entry treatment is a form of gateway, usually used in urban areas (Fig. 7.2). Entry treatments have been developed for use at side roads to let drivers know that they are leaving a major road and entering an area of different character, which may be a residential road. They may indicate the start of a series of traffic calming measures, or they may identify the gateway at the boundary of a 20 mph zone or Home Zone.

7.3.2 Gateways to 20 mph areas can incorporate coloured surfaces, with or without a 20 mph elongated roundel marking. Where a 20 mph roundel marking is used, a coloured background can give it added prominence. Under TSRGD, such roundels do not require authorisation by the Department.

7.3.3 Entry treatments in urban areas can include features such as raised crossings. These give drivers further encouragement to decrease their speed. If used, these must be appropriately signed and marked (see paragraph 4.1.9).

7.3.4 Entry treatments must not interfere with access to the frontage of properties.

7.4 Effectiveness

Gateways

7.4.1 The effect on speeds at gateways can sometimes be difficult to quantify, since the design of a scheme may include measures on the approach to the gateway that can contribute to the overall effectiveness, such as rumble strips (see Chapter 5). Results from the VISP village speed project (TAL 01/94) showed that minor gateway treatments achieved 85th percentile speed reductions of generally below 3 mph at the gateways. With more significant treatments at gateways, speed reductions of 6–7 mph were attained. Where major gateways relying on more physically restrictive treatments were installed, reductions in 85th percentile speeds were up to 10 mph in some cases. Further information can be found in TRL reports (Wheeler *et al.*, 1993; Wheeler *et al.*, 1994; Wheeler & Taylor, 1999).

7.4.2 Where speed reductions have been achieved, these have not been sustained over any distance, and speeds within villages have at most been reduced by 1 or 2 mph if there are no additional measures in place. For maximum benefit, gateways need to be used in conjunction with other measures within the village, so that drivers are made aware that lower speeds are required throughout.

7.4.3 An analysis of accidents at village traffic calming schemes (Wheeler & Taylor, 2000) has shown that traffic calming measures can yield reductions in speed that are associated with substantial reductions in injury accidents (a 1 mph reduction in mean speed gave a 4.3 per cent reduction in accidents), particularly accidents involving fatal or serious injury (see TAL 11/00).

Entry treatments

7.4.4 Entry treatments are designed to be used at points where speeds should be low because they are a visual message to drivers, and therefore their individual effectiveness is difficult to assess.

7.5 Environmental Impact

Visual intrusion

7.5.1 It is important to balance the speed- and accident-reducing impact of a gateway against the potential visual intrusion it will cause in the local landscape. By their nature, gateways are designed to be conspicuous, but careful design can minimise the negative impacts on the village character and reduce urbanisation of the rural environment. Signs can be mounted on structures built with local materials such as stone walls or fences. Similarly, build-outs at gateways can be made into features or be designed to complement local buildings. The use of coloured surfacing and/or dragon's teeth markings should be avoided in sensitive areas.

Other impacts

7.5.2 Where gateways are combined with additional traffic calming within villages, speed reductions caused by the gateway may be maintained throughout the village. For village residents, this can lead to improvements in quality of life arising from reductions in noise, vibrations, community severance and vehicle emissions.

8. Roundabouts

8.1 Background

8.1.1 Roundabouts, particularly mini-roundabouts, are a useful speed-reducing measure. They have been incorporated into many traffic calming schemes, often as the first measure encountered. Information on the design of roundabouts is contained in the *Design Manual for Roads and Bridges* (Highways Agency, 1993) and in *A TRL State of the Art Review* (Brown, 1995). On mini-roundabouts, the County Surveyors' Society and the Department published a joint document entitled *Mini-roundabouts – Good Practice Guidance* in November 2006. Another useful reference that illustrates good and bad examples of mini-roundabout design is *Mini-roundabouts – Getting them right* (Sawers, 1997).

8.1.2 Where roundabouts are used in a traffic calming context, designs must ensure that vehicle speeds through the roundabout are reduced, and attention is paid to how pedestrians and cyclists can safely negotiate the junctions. When they are used as a traffic calming measure, it is better to have single lanes on approaches and exits, and the designs should not incorporate 'easy' exits from the roundabout. The danger of drivers ignoring the priority at a mini-roundabout should be taken into account during the design stage.

Fig. 8.1 Mini-roundabout

8.1.3 Aligning each approach arm at a right angle to the circulatory carriageway, and keeping entry radii relatively small, can be an effective means of improving the driver view of cyclists (TAL 07/95). However, this reduces the capacity of the roundabout and is therefore unsuitable where there are low vehicle flows (see paragraph 8.4.5).

8.2 Types of roundabouts

Mini-roundabouts

8.2.1 Mini-roundabouts (Fig. 8.1) are recommended for use on urban single-carriageway roads where the speed limit is 30 mph or less. They have central islands with a diameter up to 4 metres that are capable of being driven over by large vehicles. The islands should be smooth and white, and may be flush or domed.

Roundabouts

8.2.2 Roundabouts have central islands with a diameter greater than 4 metres and between 3 and 7 arms. They may be used in both rural and urban areas, on single and dual carriageways, and may be signalised.

8.2.3 Overrun areas can be used in combination with small central islands to encourage greater deflection in the driving line for light motor vehicles. This can give greater reductions in speed whilst allowing adequate space for large vehicles to manoeuvre around the island. (TAL 07/95; see also Section 5.5).

8.2.4 Large island roundabouts would not normally be included as a traffic calming measure, but may be an effective way of managing traffic, depending on the location. There are several types of roundabouts used in the rest of Europe (particularly in Denmark, the Netherlands and Germany), which have been designed with cycle facilities or 'cycle-thinking' (Morgan 1998). Figure 8.2 illustrates a roundabout with cycle facilities implemented in York.

Fig. 8.2 ‘Magic’ roundabout, York

8.2.5 Roundabouts can be particularly hazardous for cyclists, but there are two main issues here. Motorists anticipate the movement of other vehicles, partly through looking at their position on the road. For reasons of self-preservation, cyclists tend to stay to the left on roundabouts. When a motorist encounters a cyclist at an exit arm, this can give the motorist the impression that the cyclist is going to leave at that exit, because that is where they would position themselves for this manoeuvre. A motorist wishing to leave a roundabout might feel it is safe to overtake a cyclist they believe is going the same way, and this can result in a collision.

8.2.6 The second hazard is when the cyclist on the roundabout is about to pass an entry arm. On entering a roundabout, motorists sometimes seem only to concentrate on large vehicles coming from their right. They may altogether forget to look out for cyclists or motorcyclists. In addition, because of cyclists’ size and shape of their cross-sectional area when viewed head-on (i.e. small, tall and thin), they are easier to overlook, so cycling past an entry arm is another relatively high-risk manoeuvre.

False roundabouts

8.2.7 A central island can be used to create a roundabout with no side road connections (i.e. with only two arms). This can be used, where space is available, to give good deflection of motor vehicles (TAL 07/95). It could be used as part of a gateway feature, or to break up long straight sections within a traffic calming scheme. Close attention to the design of a ‘false’ roundabout will be required, to ensure that the deflection provided is sufficient to appropriately influence the speeds of vehicles passing through it. It should be noted that diagram 611.1 of TSRGD is not authorised for use with ‘false’ mini-roundabouts, as the signs refer to vehicular requirements when ‘entering the junction’. In this instance the ‘keep left’ sign to diagram 610 should be used.

8.3 Cost and maintenance

8.3.1 The cost of roundabouts can vary enormously, but a mini-roundabout may cost about £5,000–15,000 or more, depending on the location and any site conditions (IHT, 1990). Full-size roundabouts may cost about £100,000 or more, depending on the size, location and land purchase requirements.

8.4 Effectiveness

Vehicle speeds

8.4.1 It was shown in Växjö (Hyden *et al.*, 1995) that there was a clear relationship between speed on the approach to a roundabout and the degree of deflection required to negotiate the roundabout: the bigger the deflection, the lower the speed. When roundabouts were installed at junctions, speeds on the links between junctions were also reduced, becoming lower as the distance between the roundabouts became shorter. When the distance between the roundabouts exceeded 300 metres, there was no speed reduction.

8.4.2 In a study of roundabouts on continental Europe (Morgan, 1998), it was found that the designs in Germany and the Netherlands with tighter geometry and narrow circulation seemed to have reduced vehicle speeds.

Vehicle flows

8.4.3 It is unlikely that the inclusion of a roundabout within a traffic calming scheme will greatly affect vehicle flows. However, an imbalance in vehicle flow can make it difficult for vehicles to enter from some arms. This can occur where minor side roads form one or more arms of the roundabout.

8.4.4 Changes in roundabout geometry will affect roundabout capacity, which can be predicted using the program ARCADY (Binning, 2000).

8.4.5 The principles for roundabout design developed in continental Europe (Fig. 8.3) focus on reducing speed of motor vehicles on entering and negotiating the roundabout, and improving visibility for cyclists. They are also designed with adverse camber on the circulatory carriageway, contrary to current UK design standards. The capacity of such a roundabout is less than that of one based on UK geometric design parameters, but may still be adequate for entry flows of up to 2,500 vehicles per hour (TAL 09/97).

Accidents

8.4.6 The MOLASSES database indicates that new roundabouts and mini-roundabouts in urban areas have reduced injury accidents, on average, by 40 per cent, and in rural areas by 54 per cent (MOLASSES database, 2004).

8.4.7 The safety of a proposed roundabout design can be predicted using the program ARCADY (Binning, 2000). Also, the effect of modified designs can be calculated so that the optimum design can be established.

8.4.8 Measures found to be useful in reducing accidents at roundabouts with poor safety records are given in the *Road Safety Engineering – Good Practice Guide* (DETR, 2001a).

8.4.9 A study has shown (Kennedy *et al.*, 1998) that the mean severity of accidents at mini-roundabouts was much lower than at priority junctions or at signalised junctions. Accident involvement rates were much higher for pedal cycles and motor cycles than for cars and light goods vehicles. The relative accident rates for pedal cycles were higher at mini-roundabouts than at priority junctions, whilst those for motor cycles were similar at both types of junctions. Visibility was a key variable, with accidents increasing with increasing sight distances.

8.5 Environmental impact

Noise

8.5.1 The level of vehicle-generated noise may be affected by the introduction of a roundabout, but the overall impact will depend on the composition of the traffic flow.

8.5.2 In Växjö (Hyden *et al.*, 1995), a noise reduction of between 1.9 dB(A) and 4.6 dB(A) was recorded at roundabouts after they had been installed.

8.5.3 In a study of a traffic calming scheme in Havant, Cloke *et al.* (1999) found that the noise from light vehicles travelling through the mini-roundabout was reduced. However, the decrease was less than that projected from the before survey noise-to-speed relationship, given the reduction in mean speed achieved. This was attributed to the fact that, prior to installation of the mini-roundabout, vehicles travelled smoothly, whilst afterwards vehicles decelerated on the approach and accelerated away at the exit. The selection of low gears on the approach was thought

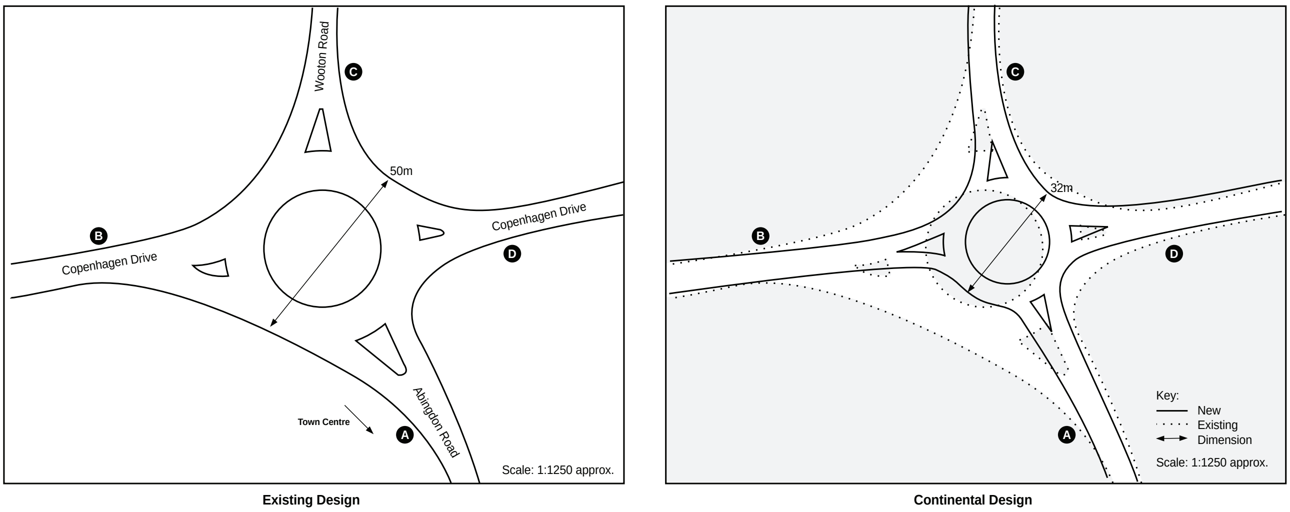


Fig. 8.3 Modifications to roundabout geometry according to parameters used in continental Europe

to have resulted in higher engine speed, and therefore relatively higher noise levels. Similar changes in driving styles caused levels from heavy vehicles to increase by 5 to 6 dB(A). However, the proportion of heavy vehicles in the traffic stream was low, so the influence on overall traffic noise was small (TAL 02/99).

8.5.4 The noise generated at a domed mini-roundabout can be nuisance. In Thorney, it resulted in the roundabout being removed because of complaints from nearby residents. The main problem was caused by heavy goods vehicles overrunning the domed island (TAL 06/97).

Exhaust emissions

8.5.5 The introduction of a roundabout or a mini-roundabout may increase vehicle exhaust emissions.

8.5.6 In Växjö, exhaust emissions were increased for cars travelling through the roundabouts on the main roads, while they decreased for cars travelling through the roundabouts from the side roads. On average, emissions of carbon monoxide (CO) and nitrous oxides (NOx) increased by about 5 per cent at roundabouts compared with priority junctions. The reduction in emissions per vehicle at the side roads was about 1.4 times higher than the increase on the main roads. Thus the change at individual intersections depends on the total share of traffic that enters from a side road (Hyden *et al.*, 1995).

8.5.7 A study by Boulter *et al.* (2001) investigating emissions at a range of traffic calming measures (including a mini-roundabout) found increases in some pollutants of up to 60 per cent (see paragraph 4.5.15). The variability of the emission data precluded a definitive ordering of the different measures tested, but the more ‘severe’ traffic calming measures in the study tended to result in the largest increases in emissions. However, it was estimated that, although these measures generally increase the emissions per vehicle, they would be unlikely to result in poor local air quality in the areas concerned.

Visual impact

8.5.8 Roundabouts can have either negative or positive effects on the surrounding landscape. Mini-roundabouts are likely to have a negative visual impact, as there will be little or no scope to make the roundabout itself into an attractive feature. With larger roundabouts, the central island could be planted; alternatively, the island could be used as a platform for public art or some other feature to reflect local distinctiveness.

5.5.9 Both mini and standard roundabouts could increase the road footprint, as they require more than the standard carriageway width.

Non-motorised users

8.5.10 Traditionally, roundabouts have been designed with motor vehicles in mind rather than the needs of all users. Roundabouts oblige non-motorised users to divert from the most direct route, especially if the arms of the roundabout are splayed. The tendency for drivers to concentrate solely on circulating motor traffic can give rise to safety concerns with regard to non-motorised users. Pedestrian refuges and narrow approach lanes with high deflection on entry combined with a single lane circulating carriageway can help mitigate against these effects.

8.5.11 Lawton *et al.* (2004) found that the following features appeared to have a positive effect on the safety of cyclists at roundabouts:

- a tighter geometry on approaches;
- a reduction in the number of entry and exit lanes;
- an enlarged central island;
- the introduction of toucan crossings on the arms of roundabouts; and
- the addition of cycle strips at ‘give way’ lines.

9. Vehicle activated devices

9.1 Vehicle activated signs

9.1.1 Vehicle activated signs (VAS) are LED or fibre optic signs that have been used to address the problem of inappropriate speed where conventional signing has not been effective. They are usually blank until triggered by an approaching vehicle travelling at a speed above a pre-set speed. The vehicle then activates a hazard warning or speed limit sign. Certain signs may be accompanied by a 'SLOW DOWN' message or flashing lights in the corners of the sign (known as 'wig-wags'). More information may be found in regulation 58 of TSRGD and in TAL 01/03.

9.1.2 The signs have the advantage of being blank when not activated, limiting their visual intrusion, which is particularly relevant in rural areas. A variety of methods (e.g. battery, solar panel and wind generator) have been used to power these signs in rural locations away from a mains electricity supply (DTLR, 2001a).

9.1.3 Costs will vary depending upon local factors, such as the cost of connection to an electricity supply. The cost of purchase and installation of vehicle activated signs can range between £2000 and £8000.

9.1.4 Following trials of individual sign installations, with promising results, a full-scale study of the effectiveness of over 60 installations was carried out on rural single carriageway roads in Norfolk, Kent, West Sussex and Wiltshire (Winnett & Wheeler, 2003). The main aims of the trial were to assess the effect of the signs on speed and injury accidents, and to assess drivers' understanding of the signs (see paragraph 9.3.1).

9.2 Speed cameras

9.2.1 Speed cameras are now used throughout the UK to combat the effects of excessive speed at sites where there is a history of road traffic collisions.

9.2.2 Speed cameras can be fixed, with the unmanned camera installed in camera housings, or mobile. Mobile cameras are manned and set up at the roadside. The cameras use either wet film, digital or video technology. Unmanned film-based cameras need regular site visits, as they can only record a limited number of detections per film. Digital and video-based systems can allow rapid transmission of data via a telemetry link and should allow a greater percentage of speeding drivers to be prosecuted (DTLR, 2001a).

9.2.3 The trigger speeds for cameras are set by individual police forces and vary from force to force.

9.2.4 Speed-over-distance cameras, which monitor average speeds between two cameras, are used at some locations. Using two (or more) digital cameras linked to automatic number plate reading technology, speed-over-distance cameras normally enforce roads where there has been a higher density of collisions spread over a distance (Mackie *et al.*, 2003).

9.3 Effectiveness

Vehicle activated signs

9.3.1 Earlier limited studies had indicated small reductions in vehicle speeds at the signs (Webster, 1995a). The more recent full-scale evaluation by Winnett and Wheeler (2003) found that the speed limit repeater signs reduced mean speeds of traffic as a whole by an average of between 3 and 9 mph, the higher reductions being where the speed limit had also been reduced by 10 mph. The vehicle activated junction and bend warning signs reduced mean speeds by up to 7 mph. Speeds exceeding the limit were also reduced, with the reductions tending to be greater at the speed limit repeater signs. Most drivers made the connection between their own speed and the signs being triggered. There was a statistically significant one-third reduction in accidents across all of the trial sites in Norfolk when compared with the number of accidents that would have been expected without the signs.

Speed cameras

9.3.2 The Department has regularly monitored the effectiveness of cameras. The independent report of the first three years of the safety camera programme, published in June 2004, covers 24 safety camera partnerships in England, Scotland and Wales operating between April 2000 and March 2003. The report confirms the effectiveness of cameras in reducing casualties and speeds, with the report showing:

- a 40 per cent reduction in the number of people killed or seriously injured at camera sites over and above the UK's general downward trend in killed or seriously injured casualties;
- within this overall reduction, there was a 35 per cent reduction in pedestrians being killed or seriously injured;
- a 33 per cent reduction in overall collisions involving personal injury at camera sites;
- a 32 per cent reduction in the number of vehicles breaking the speed limit at camera sites;
- average vehicle speed across all new sites fell by 7 per cent overall; and
- a larger, 43 per cent reduction in excessive speeding (vehicles exceeding the speed limit by 15 mph or more).

10. Additional traffic calming elements

10.1 Background

10.1.1 Road markings, traffic signs and street furniture are an important adjunct to traffic calming. They may be used to warn drivers of changes ahead and support the traffic calming measures. The markings are therefore designed to assist drivers, rather than 'waking them up', as do the rumble devices described in Section 5. It has been shown that signing and lining at 303 sites throughout the UK gave an average accident reduction of 38 per cent (Lee, 1998). It has also been reported (Mayhew & Smith, 1998) that signs and road markings were removed in a village to give it the 'feel' of a village (see paragraph 10.4.7). The signs and markings were returned after the trial period. A report has been published which described schemes that had no physical measures (Mackie, 1998). The results covered speed sign experiments particularly on 20 mph and 30 mph roads, and are detailed in the appropriate sections below.

10.2 Additional traffic calming elements

Speed limit roundel markings

10.2.1 Speed roundel markings are white thermoplastic elongated circles with the speed limit in the centre (Fig. 10.1), which are laid on the road carriageway surface. Since they were prescribed in TSRGD (diagram 1065), speed roundels have not required special authorisation, but they must be placed in conjunction with upright speed limit signs or upright speed limit repeater signs. They cannot therefore be used along lit 30 mph roads, because such roads are not permitted to have 30 mph repeater signs. No useful purpose would be served by using repeater signs and roundels within 20 mph zones, as there would already be physical measures present.

10.2.2 A considerable number of speed limit roundel markings do not conform to the proportions prescribed in the regulations. Local authorities should ensure that their contractors adhere to the specification. Detailed working drawings are available on the Department's website at: **www.dft.gov.uk/pgr/roads/tss**

10.2.3 Speed roundel road markings may be difficult to see in wet weather, particularly at night, when the wet surface makes retroreflection less effective. They need to be maintained regularly so that they remain conspicuous.

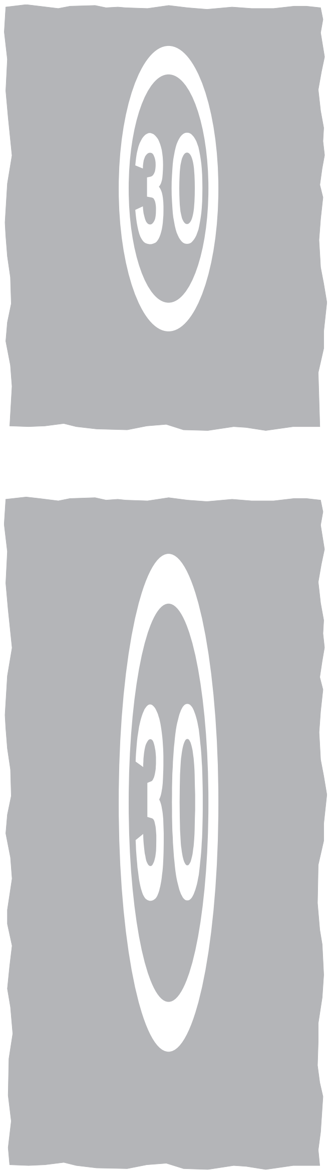


Fig. 10.1 Diagram 1065 TSRGD 2002: speed limit roundels

Coloured surfaces

10.2.4 Coloured surfaces have been used for traffic calming purposes at many urban and village sites, notably in Craven Arms (Wheeler et al., 1996; TAL 02/97) and Thorney (Wheeler et al., 1997; TAL 06/97). Surfaces with high skid resistance are often used at the approaches to pedestrian crossings or roundabouts to assist drivers when braking for pedestrians or other vehicles. These are usually in a contrasting colour, which may have the added effect of alerting the drivers.

Surface texture

10.2.5 Changes in surface texture can encourage lower speeds, but it is important that the skid resistance for any material used for traffic calming is adequate for the type and speed of traffic carried.

10.2.6 Rough surfacings can be difficult for elderly people and mobility-impaired people to cross (Steen & Hageback, 1999) and can also be uncomfortable for cyclists. Noise from vehicles crossing the textured surface may be a nuisance to those working or living near the road.

10.2.7 Block paving has been used in historic areas such as Bury St Edmunds (Wheeler, 1999b; TAL 13/99) and in Shrewsbury (Wheeler 1999a; TAL 08/98). An imprinted surface has been used in a village traffic calming scheme in Charlwood (Kennedy & Wheeler, 2001).

10.2.8 Improving the skid resistance of a road by resurfacing does not increase traffic speeds, as reported by Cooper *et al.* (1980), provided the profile had not deteriorated to a variance of less than 3 mm^2 about a 5 metre moving-average datum before resurfacing. Slightly increased speeds of about 1.6 mph (mean speed 45 mph) were noted if the variance was greater than 8 mm^2 before resurfacing.

Hatched road markings

10.2.9 Central hatched road markings (Fig. 10.2) can be used to discourage drivers from overtaking and can also give the impression that the road is narrower (optical width) than it is in reality. Placing them on a coloured background can give additional emphasis.

Fig. 10.2 Hatched road markings

Hatched road markings have been used at a number of villages (Wheeler *et al.*, 1996; Wheeler *et al.*, 1994) and have also been used extensively by the Highways Agency on trunk roads (Highways Agency, 2003).

10.2.10 Central hatching can squeeze cyclists, because of the reduced width, and thereby increase the perceived danger and unpleasantness for them. Where there is sufficient carriageway width, central hatching can be combined with cycle lanes to create reduced motor vehicle lanes, as used in the Safer City project in Gloucester (Bellotti, 1998). However, cycle lanes should not be implemented solely for traffic calming purposes.

Countdown signs

10.2.11 Countdown signs have a long-established use on the approach to motorway slip roads and on dual carriageway approaches to roundabouts. Trials of their use on village approaches have been carried out (Barker & Helliar-Symons, 1997) at eight test villages. Count-down signs to the commencement of speed limits were specially authorised and placed 300, 200 and 100 metres before the speed limit started, to warn drivers of the impending speed limit. Four of the sites were on ‘A’ class roads and the rest were on ‘B’ class or unclassified roads. The signs need authorisation, and DfT policy is that they would only be considered in very exceptional cases, for example if the speed limit sign is not fully visible and moving the start of the limit to a more conspicuous position is not possible.

Speed limit signs

10.2.12 Reduced speed limits (60 mph to 30 mph and 40 mph to 30 mph) have been trialled in 450 village sites in Suffolk (Jeanes, 1996). The policy was to introduce consistent speed limits in all residential areas, even tiny hamlets. It was hoped that drivers would no longer be confused about what the legal speed limit was in any residential area. The speed limits were introduced in batches of 30 villages. The limits were widely publicised, and the degree of police enforcement has not changed, but mobile speed cameras are in use.

10.2.13 Speed limits of 20 mph (see Section 3.2) can be used with or without speed reducing measures. Generally it is advised that 20 mph speed limits, without measures, are not suitable if the 85th percentile speeds are above 24 mph, as it is unlikely that the speed limit will be observed.

Traffic orders

10.2.14 Road closures, which require Traffic Orders to be made, were used in the Urban Safety Project (Mackie *et al*., 1990) as a means of limiting the traffic movements allowed in an area. It should be noted that enforcement of 'bus and access only' restrictions could vary throughout the country. Road closures can take many forms:

Total closure – This involves the road being totally closed off to all traffic by means of physical measures (Fig. 10.3).

Fig. 10.3 Road closure

No-entry order – The road can be closed to all traffic (full-time) by means of signing, but it can be accessible to the emergency services if required. Part-time entry restrictions could also be introduced using the appropriate signs in combination with rising bollards.

No motor vehicles order – This exempts pedal cycles and horse-drawn vehicles. Other classes of vehicles (e.g. buses) can also be exempted.

Buses only – The road can be closed to all vehicles except buses; they may distinguish between all buses and local buses.

Buses and cycles only – The road can be closed to all vehicles except buses and cycles.

Buses, cycles and taxis only – The road can be closed to all vehicles except buses, cycles and taxis.

Cycles only – Road closures can include a cycle gap, which allows cyclists access to the closed road.

Access only – The road can be closed to all vehicles except for access. This may be enforced using rising bollards (see TAL 04/97) or other forms of gate.

Width restrictions – A width restriction can effectively close the road to all HGVs and large vehicles, though how refuse vehicle can service the area needs to be given careful consideration. Width restrictions can be useful in areas near industrial estates to stop large vehicles taking short cuts through residential roads. These are often enforced by the use of physical narrowings (see Section 6).

Planters and bollards

10.2.15 Many traffic calming schemes rely solely on road humps to moderate traffic speeds. However, some schemes have used planters and other street furniture to enhance a scheme (Fig. 10.4). The bypass demonstration project (DoT, 1995c) contains useful information on the subject.

10.2.16 Planters and trees have been used in Europe (Hass-Klau *et al*., 1992) as a means of enhancing schemes and reducing carbon dioxide in the air, but plants can be vandalised and the roots of some types can damage underground services or pavements. Root containment systems and careful selection of plant species can reduce this latter problem.

Fig. 10.4 Traffic calming planting in the Methleys Home Zone

10.2.17 Encouraging community ownership of the scheme can reduce vandalism of plants and other street furniture. In the Morice Town Home Zone in Plymouth large planters were used like chicanes as traffic calming features (see Figure 3.1). Since the implementation of the planters, residents have set up a gardening club to maintain the plants.

10.2.18 Care should be taken when using plants as a traffic calming measure that they do not block a driver's view of any pedestrians, especially child pedestrians. As a general rule, bushy planting at heights between 600 and 2000 mm is best avoided. Note that this advice would not prohibit the use of street trees where the canopy was above 2000 mm.

10.2.19 The potential for reduced sightlines to bring about naturally a reduction in vehicle speed, and hence improved road safety, as a result of to increased driver uncertainty is being investigated as part of the Department's *Manual for Streets* project. This will be reported in later publications.

10.2.20 Various types of bollards are available, including self-illuminated and rising bollards. For example, wooden bollards have been used in Shrewsbury (Wheeler, 1999a) and metal bollards have been used in Bury St Edmunds (Wheeler, 1999b). Both of these reports show how the bollards blend in with the area. They can also be used to re-emphasise the local identity of an area, for example by using local materials or an area logo, such as those used in Devon which are made of local granite. However, whilst aesthetics are important regard must be had that people with visual impairment can distinguish between the bollard and other features.

10.3 Maintenance

10.3.1 Many of the techniques above will require periodic maintenance to ensure that the benefits of the treatment are not dissipated with time. In selecting which treatments to use, authorities should consider the future maintenance requirements as part of the design process. Where coloured or textured surfacing or other high-quality materials are used, appropriate surfacing that matches the original material should be used for reinstatement purposes.

10.3.2 The length of time that coloured surfacing will survive depends on factors such as the traffic flow, percentage of buses and HGVs, the materials used and the method by which they are laid. Coloured chippings with a permanent colour last longest, but these are expensive to lay, as the road surface must be planed off and re-laid. As the chippings are bedded in bitumen, the colour is of a relatively low intensity. The life of a coloured slurry seal will depend on the level of trafficking, and its poor skid resistance should be taken into consideration. Coloured anti-skid surfacing has a bright colour for the first few years, but this darkens over time. There can be major problems with this surfacing peeling off after a year or so if it is laid in damp conditions. Finally, there are coloured binders; these tend to deepen in colour after 2–3 years so that they appear black from the drivers' viewpoint. Some colours currently last longer than others do, but new materials continue to be developed.

10.4 Effectiveness

10.4.1 Speed roundel markings. The effectiveness of speed roundel markings can be summarised as follows:

- 40 mph roundels, 3 mph mean speed reduction (Barker & Helliar-Symons, 1997)
- 30 mph roundels, no effect on mean speed (Barker & Helliar-Symons, 1997)
- 20 mph roundels, four sites gave 1.5 mph mean speed reduction (Mackie, 1998)

10.4.2 It should be noted that the roundel markings monitored by Barker and Helliar-Symons were an initial trial, not all of the roundel markings were placed in conjunction with upright signs and they were not laid on a coloured background.

10.4.3 These results indicate that speed roundel markings can give slight speed reductions and need to be used as one element in a combination of measures to reinforce the effect. 30 mph roundels on a red surface were used at Craven Arms (TAL 02/97) where they maintained the reductions at the gateway; however, the 85th percentile speeds exceeded the new speed limit of 30 mph by about 7 mph for light vehicles and 3 mph for heavy goods vehicles.

10.4.4 Coloured/textured surfaces. The effect of coloured surfaces can be difficult to separate from other techniques used simultaneously, and their additional effect is likely to be small. In a recent simulator study carried out as part of research into 'psychological' traffic calming measures, the results suggested that coloured surfacing alone, however elaborate, did little to slow traffic (Kennedy *et al.*, 2005).

10.4.5 Block paved areas in Bury St Edmunds (Wheeler, 1999b) and in Shrewsbury (Wheeler, 1999a) gave speed reductions of 2 mph and 7 mph respectively, with both schemes having 85th percentile speeds reduced to below 20 mph. An analysis of personal injury accidents in Shrewsbury from 1989 to 1998 showed there has been a reduction from 3.9 to 2.2 per year, with serious injuries falling from 36 per cent to 25 per cent. There were no fatalities (EHTF, 2003).

10.4.6 In a village traffic calming scheme in Charlwood, a change to an imprinted surface had the effect of reducing 85th percentile speeds from 34 mph to 29 mph (Kennedy & Wheeler, 2001).

10.4.7 Removal of signs and markings. The trial that removed signs and markings in a village (Mayhew & Smith, 1998) showed that speeds were reduced during the trial but returned to their previous level when the signs and markings were reinstated. Further studies of this type have been carried out for DfT in Blakeney, Stiffkey and Wiveton. The results have shown that at these locations the mean inbound speeds were reduced by less than 2 mph (Kennedy & Wheeler, 2001).

10.4.8 Countdown signs. The countdown signs monitored at the eight test villages (Barker & Helliar-Symons, 1997) did not affect mean speeds, but accidents were reduced by 11 per cent. However, much longer-term monitoring than was carried out would be necessary to confirm the accident reductions. This minimal speed reduction and the potential for sign clutter has led to the Department's policy of not authorising countdown signs other than in extenuating circumstances (see TAL 01/04).

10.4.9 Signed-only speed limits. 20 mph speed limit signs, without any physical measures, were tried in four sites in Hull and nine sites in Liverpool (Mackie, 1998). Average speeds were reduced by 1 mph, but were still above the 20 mph limit. It was noted that the speeds at some sites increased slightly. This paragraph should be read in conjunction with TAL 09/99, as discussed in Section 3.2.

10.4.10 Signed-only 30 mph speed limits trialled in Suffolk have given variable results. The results from an earlier study by Jeanes (1996) showed that the speeds were reduced by 3.5 mph for areas that had previously had 40 mph speed limits, and by 6.2 mph for areas that had previously had 60 mph speed limits. However, there were only four out of the 44 sites where the 85th percentile speed was below 35 mph. A more recent study by Watson and Allsop (1999) for the same project has shown that a 4.3 mph speed reduction has been achieved and accidents have been reduced by 20 per cent.

10.4.11 Road closures. Total closures were effective at redistributing the traffic, but they caused the most public opposition in the Urban Safety Project (Mackie et al., 1990). Part-time and exemption closures were effective, but a substantial minority of drivers failed to comply, which resulted in the need for considerable police enforcement.

10.4.12 Planters and bollards. Trees and shrubs can be used to restrict sight lines in residential roads. There is currently a debate as to whether the restriction of sight lines removes driver certainty, reducing speed and improving safety, but this theory is not yet proven. Shrubs can cause problems if they are not maintained at their designed height or spread.

10.4.13 Bollards can be an effective way of reducing illegal parking. Care needs to be taken that bollards do not impede access for disabled people.

10.5 Environmental Impact

10.5.1 The use of additional speed roundel markings, coloured surfacing and hatched road markings may have a negative visual impact on the areas where they are implemented. They can also detract from historic environments and views. The significance of such impacts will depend on the sensitivity of the environment in which they are to be placed. The benefits in terms of speed reduction, which maybe small, should be balanced against the negative impacts.

10.5.2 Textured surfaces, including imprint surfacing and block paving, can increase traffic noise or change its character; in some cases this has led to noise disturbance for local residents. Again, this potential negative impact should be weighed against safety and aesthetic gains to be had.

10.5.3 Road closures can lead to environmental improvements in the region of the closed road. For example, the closure of Northgate Street as part of the Gloucester Safer City Project led to significant improvements in local air quality (Boulter *et al.*, 2003).

10.5.4 As mentioned in paragraph 10.2.15, trees and shrubs have been used to enhance the physical appearance of a scheme and reduce carbon dioxide levels. However, the addition of plants to a traffic calming scheme may also have other benefits, such as improvements in community acceptance and ownership of a scheme, increased route attractiveness to walkers and cyclists, enhancement of physical measures (for example to make a narrowing seem tighter) and improved quality of life.

10.5.5 Excessive use of bollards should be avoided, as this can have a negative impact on the appearance of the area.

References

Abbott P G, Phillips S M and Layfield R E (1995a). *Vehicle and traffic noise surveys alongside speed control cushions in York.* TRL Project Report PR 103. Transport Research Laboratory, Crowthorne.

Abbott P G, Hartley S, Hickman A J, Layfield R E, McCrae I S, Nelson P M, Phillips S M and Wilson J (1995b). *The environmental assessment of traffic management schemes: A literature review.* TRL Report 174. Transport Research Laboratory, Crowthorne.

Abbott P G, Tyler J W and Layfield R E (1995c). *Traffic calming: vehicle noise emissions alongside speed control cushions and road humps.* TRL Report 180. Transport Research Laboratory, Crowthorne.

Abbott P, Taylor M and Layfield R (1997). *The effect of traffic calming measures on vehicle and traffic noise. Traffic Engineering and Control, 38(9) 447 - 453.*

Alexander D (1990). *Highways Act wrangle follows hump death.* New Civil Engineer, 16 August 1990.

Allott and Lomax (1998). *Urban street activity in 20 mph zones. Literature review report, first update, June 1998.* Babtie Group 1998.

Allott and Lomax (2001). *Urban Street Activity in 20 mph Zones, final report, August 2001.* Babtie Group 2001.

Amis G (1995). *Traffic calming in Cambridgeshire. Effects on accident frequency at calmed sites and on surrounding roads.* Cambridgeshire County Council, August 1995.

ANWB (1980). *Woonerf, A new approach to environmental management in residential areas and the related traffic legislation.* ANWB Traffic Department, The Hague.

Austroads (1999). *Guide to traffic engineering practice. Part 15 – Motorcycle safety.* Austroads, Sydney, 1999.

Auto Express (2001). *Cameras' slow blow.* Auto Express, Issue 645 Spring Special.

Barker J K and Helliar-Symons R D (1997). *Count-down signs and roundel markings trials.* TRL Report 201. Transport Research Laboratory, Crowthorne.

Barker J K (1997). *Trials of rural road safety engineering measures.* TRL Report 202. Transport Research Laboratory, Crowthorne.

Barker, Judith and Webster, David (2003). *The Safety Benefits of 20 mph Zones Located Outside London.* TRL Annual Research Review 2003.

Bellotti P (1998). *Gloucester safer city project.* A mid-term report. Gloucester, 1998.

Biddulph M (2001). *Home Zones a planning and design handbook.* Joseph Rowntree Foundation, York (ISBN 1 86134 371 X)

Binning J (2000). *ARCADY 5 (UK) user guide.* TRL Application Guide AG36. Transport Research Laboratory, Crowthorne.

Biora F (1995). *Integrated ATT strategies for urban arterials: DRIVE 11 project PRIMAVERA. The Corso Grosseto experiment.* Traffic Engineering and Control, November 1995.

Boulter P G (1999). *Remote sensing of vehicle emissions near two traffic calming measures in Gloucester.* TRL Report 423. Transport Research Laboratory, Crowthorne.

Boulter PG (2000) *The impacts of Safer City project on road traffic emissions in Gloucester 1996-1998.* TRL report 444. Transport Research Laboratory, Crowthorne.

Boulter P G and Webster D C (1997). *Traffic calming and vehicle emissions: A literature review.* TRL Report 307. Transport Research Laboratory, Crowthorne.

Boulter P G, Hickman A J, Latham S, Layfield R, Davies P (AEA Technology) and Whiteman P (AEA Technology) (2001). *The impacts of traffic calming measures on vehicle exhaust emissions.* TRL Report 482. Transport Research Laboratory, Crowthorne.

Boulter PG, Green J and Layfield R (2003). *Trends in speed, emissions and air quality during the Gloucester Safer City Project.* TRL Report PR SE/582/2002. Transport Research Laboratory, Crowthorne.

Bradford MDC (1998). *Accident reductions at traffic calming schemes in Bradford.* Fax from Mr Phil Heyes of Government Office of Yorks and Humberside 6/11/98.

Brennan D T (1994). *The evaluation of residential of residential traffic calming: a new multi-criteria approach.* Traffic Engineering and Control January 1994.

Brilon W and Blanke H (1994). *Area wide traffic calming measures and their effect on safety in Germany.* Conferenza Internazionale vivere e camminare in citta urbano p145 - 155. Italy 1994.

British Standards Institution (1992). *Road lighting.* British Standard BS 5489:1992. British Standards Institution, London.

Broughton J and Markey K A (1996). *In-car equipment to help drivers avoid accidents.* TRL Report 198. Transport Research Laboratory, Crowthorne.

Brown M (1995). *The design of roundabouts. TRL State of the art review.* HMSO London.

Burrow I (1999). *Accidents will happen*. Surveyor, 15th April 1999.

Carsten O (2001). *ISA – debunking some of the popular myths.* TEC February 2001.

Chorlton E et al. (1991). *Traffic calming guidelines.* Devon County Council.

Claessen J G and Jones D R (1994). *The road safety effectiveness of wide raised medians.* 17th ARRB Conference in Gold Coast, Queensland, 14 - 19 August 1994.

Cloke J, Webster D, Boulter P, Harris G, Stait R, Abbott P and Chinn L (1999). *Traffic calming: Environmental Assessment of the Leigh Park Area Safety Scheme.* TRL Report 397. Transport Research Laboratory, Crowthorne.

Cloke J and Davies G J (2001) *The impacts of Gloucester Safer City Project on Air Quality, 1997-1998.* TRL Report 488. Transport Research Laboratory, Crowthorne.

Coleman M A (1997). *The influence of traffic calming devices upon fire vehicle travel times.* Institute of Transportation Engineers 67th Annual Meeting. Boston, 3-7 August. Institute of Transport Engineers, Washington D.C.

Cooper D R C, Jordan P G and Young J C (1980). *The effect on traffic speeds of resurfacing a road.* TRRL Supplementary Report 571. Transport Research Laboratory, Crowthorne.

Cornwell P R and Mackay G M (1972). *Lighting and road traffic.* Traffic Engineering and Control, July 1972.

County Surveyors Society, Department of Transport, Association of Metropolitan District Engineers, Association of London Borough Engineers and Surveyors, Association of Chief Technical Officers (1994). *Traffic Calming in Practice.* Landor Publishing Ltd, London (updated 2005, see IHT 2005).

Crawford D (1997). *Working with the weather warning.* Surveyor, 23 October 1997.

CROW (1998). *Recommendations for traffic provisions in built-up areas.* ASVV Record 15.

CSS (1997). CSS, ATCO, CPT. *Traffic Calming and Buses.*

CSS (1999). CSS, ATCO,CPT. *Highway Infrastructure for Bus stops.*

CSS and IHT (2005). *Traffic Calming Techniques* Published jointly by The Institution of Highways and Transportation and the County Surveyors' Society ISBN 0902933 38 8.

Danish Road Directorate (1991). *Urban Traffic Areas, Part 7 - Speed reducers.* Road Data Laboratory, Stationsalleen 42, PO Box 40, DK-2730 Herlev, Denmark.

Davies D G, Ryley T J, Taylor S B and Halliday M (1997a). *Cyclists at road narrowings.* TRL Report 241. Transport Research Laboratory, Crowthorne.

Davies D G, Taylor M C, Ryley T J and Halliday M E (1997b). *Cyclists at roundabouts - the effects of 'continental' design on predicted safety and capacity.* TRL Report 285. Transport Research Laboratory, Crowthorne.

Davies D G, Chinn L, Buckle G S and Reid S J (2003). *Cycling in vehicle restricted areas.* TRL Report 583. Transport Research Laboratory, Crowthorne.

De Wit T (1993). *Dutch experiences with speed control humps.* ITE 63rd Annual Meeting, 1993 The Hague.

De Wit T and Slop M (1984). *Traffic humps as recommended by SVT: Design and effects.* PTRC Summer Meeting at University of Sussex, July, 1984.

Department for Transport (2002). *Inclusive Mobility: A Guide to Best Practice on Access to Pedestrian and Transport Infrastructure.* Department for Transport.

Department for Transport (2004a). *The Future of Transport: a network for 2030.* Department for Transport.

Department for Transport (2004b). *Walking and Cycling: an action plan.* Department for Transport.

Department for Transport (2004c). *Full guidance on Local Transport Plans - second edition.* DfT, London.

Department for Transport (2005 a). *The Government's Motorcycling Strategy.* Department for Transport.

Department for Transport (2005b). *Home Zones – Changing the future of our streets.* Department for Transport.

Department for Transport, Local Government, and the Regions (2001a). *A Road Safety Good Practice Guide.* DTLR, London.

Department for Transport, Local Government, and the Regions (2001b). *Road Accidents Great Britain: 2000 – The Casualty Report.*

Department of the Environment (1992). *Residential roads and footpaths.* Design Bulletin 32, Second edition, London.

Department of the Environment (1994). *PPG 15: Planning and the Historic Environment.* DOE, London.

Department of Transport (1995a). The assessment of pedestrian crossings. Local Transport Note 1/95. Department of Transport, The Welsh Office, The Scottish Office and the Department of the Environment for Northern Ireland. HMSO, London.

Department of Transport (1995b). *The design of pedestrian crossings. Local Transport Note 2/95.* Department of Transport, The Welsh Office, The Scottish Office and the Department of the Environment for Northern Ireland. HMSO, London.

Department of Transport (1995c). *Better places through bypasses.* DOT, London.

Department of Transport (1996). *National Cycling Strategy.* DOT, London.

Department of the Environment, Transport and the Regions (1998a). *Places streets and movement. A companion guide to Design Bulletin 32, residential roads and footpaths,* DETR, London.

Department of the Environment, Transport and the Regions (1998b). *Guidance on the use of Tactile Paving Surfaces.* DETR, London.

Department of the Environment, Transport and the Regions (2000a). *Our Towns and Cities: The Future - Delivering an Urban Renaissance.* DETR, London.

Department of the Environment, Transport & The Regions (2000b). *New Direction in Speed Management, a Review of Policy.* DETR, London.

Department of the Environment, Transport & The Regions (2000c). *Tomorrow's Roads-Safer for Everyone, The Government's road safety strategy and casualty reduction targets for 2000.* DETR, London.

Department of the Environment, Transport & The Regions (2000d). *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.* DETR, London.

Department of the Environment, Transport & The Regions (2001). *PPG 13 - A guide to better practice: Reducing the need to travel through land use and transport planning.* The Stationery Office, London.

DEFRA (2000). *Our countryside the future: Rural White Paper, November 2000.*

Dijkstra A and Bos J (1997). *ACEA – Dutch contribution; road safety effects of small infrastructural measures with emphasis on pedestrians.* SWOV, Netherlands.

Drdul R and Skene M (1994). *Traffic calming Do's and Don'ts.* ITE Compendium of Technical Papers (from Canada).

Elvik R (1997). *The effects on accidents of automatic speed enforcement in Norway.*

Transportation Research Board Annual Meeting, 1997.

EHTF (1999). *The Historic Core Zones Project.* English Historic Towns Forum, Bristol.

EHTF (2003) *Historic Core Zones Project Review.* Report no. 53, English Historic Towns Forum, Bristol.

English Heritage (2005). *Streets for all, manuals.*

Ewing R (1999). *Traffic calming. State of the Practice.* US Department of Transportation & Institute of Transportation Engineers.

Fife Council (1996). *Innovative road humps trial report.* Fife Council Roads Service. *(Unpublished report available on direct personal application only).*

Fife Council (2004). *South Parks Road (East) Glenrothes Traffic Calming Scheme 1996/1997: Before and After Road Crash Results.* Fife Council Transportation Services *(Unpublished report available on direct personal application only).*

Fox K, Balmforth P, Franklin P, Montgomery F, Ling Siu Y, and Heywood R (1995). *Integrated ATT strategies for urban arterials: DRIVE 11 project PRIMAVERA. 3. The Dewsbury Road experiment.* Traffic Engineering and Control, July/August, 1995.

Gibbard A, Reid S, Mitchell J, Lawton B, Brown E and Harper H (2005). *The effect of road narrowings on cyclists.* TRL Report 621, Transport Research Laboratory, Crowthorne.

Good Motoring (1998). *Technological safety.* Good Motoring January/March 1998.

Gorrell R S J and Tootill W (2001). *Monitoring Local Authority Road Safety Schemes Using MOLASSES.* TRL Report 512. Transport Research Laboratory, Crowthorne

Greenshield S.F, and Webster D.C. (2004) *Trials of articulated bus and traffic calming measures.* Unpublished Report UPR/T/086/04. Transport Research Laboratory, Crowthorne.

Hall A C, Jerome P R and Lewis A M (1992). *Implementing traffic calming: the Wolverhampton experience.* Highways and Transportation, October 1992.

Hampshire County Council (1996). *Traffic calming in Hampshire.* Report of the County Surveyor, 29 April 1996.

Harris G J, Stait R E, Abbot PG and Watts G R (1999). *Traffic calming: Vehicle generated noise and ground-borne vibration alongside sinusoidal, round-top and flat-top humps.* TRL Report 416. Transport Research Laboratory, Crowthorne.

Harwood D W (1993). *Use of rumble strips to enhance safety.* NCHRP Synthesis of Highway Practice. Transportation Research Board.

Hass-Klau C and Nold I (1994). *Horizontal traffic calming measures - alternatives to road humps.* Environmental and Transport Planning, 10 Clermont Terrace, Brighton BN1 6SH.

Hass-Klau C, Nold I, Bocker G and Crampton G (1992). *Civilised streets. A guide to traffic calming.* Environmental and Transport Planning, 10 Clermont Terrace, Brighton BN1 6SH.

Hawley L, Henson C, Hulse A and Brindle R (1993). *Towards traffic calming: a practitioner's manual of implemented local area traffic management and black spot devices.* Western Sydney Regional Organisation of Councils Ltd.

Health and Safety Executive (1996). *In the driving seat. Advice to employers on reducing back pain in drivers and machinery operators.* Health and Safety Executive.

Herrstedt L, Kjemtrup K, Borges P and Andersen P (1993). *An improved Traffic Environment. A Catalogue of Ideas. Report 106.* Danish Road Directorate, Stationsalleen 42, DK-2730, Herlev, Denmark.

Hidas P (1993). *Speed management in local streets: a continuous physical control technique.* Road & Transport Research, Vol 2, No.4, December 1993.

Highways Agency (1993). Design Manual for Roads and Bridges, Volume 6, Section 2,*TD 16/93, Geometric Design of Roundabouts.*

Highways Agency (1999) Design Manual for Roads and Bridges, Volume 6, Section 3. *TA 81/99 Coloured surfacing of Road Layouts (excluding traffic calming).*

Highways Agency (2003) Design Manual for Roads and Bridges, Volume 6, Section 3, Part 5. *TA87/04 Traffic Calming on Trunk Roads - A Practical Guide.*

HMSO (2002). *The Traffic Signs Regulations and General Directions 2002.*

Hodge A R (1993). *Speed control humps - A trial at TRL.* TRL Project Report 32. Transport Research Laboratory, Crowthorne.

Hodgkinson M and Whitehouse J (1999). *Urban street activity in 20 mph zones. Emerging findings.* PTRC AET summer conference, 1999.

Hook D, Kirkwood A and Evans D (1995). *Speed cameras in Oxfordshire.* Highways and Transportation, February 1995.

Hooke A, Knox J and Portas D (1996). *Cost benefit analysis of traffic light and speed cameras.* Police Research Series paper 20, Home Office Police Research Group, London.

Howard A (1998). *Street lighting for road humps and traffic calming measures: a proposal. T*he Lighting Journal, February/March 1998.

Hunt S (ed) (1998). *Prospects for fuel saving devices in cars. The results of experiments with cruise controls, econometers and on-board computers.* The Netherlands Agency for Energy and the Environment, Novem Utrecht.

Hyden C, Odelid K and Varhelyi A (1995). *The effects of general speed calming in built-up areas. Results of a large scale experiment in Vaxjo. 1 Main Report.* Bulletin 131, University of Lund, Sweden.

Institute of Highway Incorporated Engineers (2002). *Home Zone Design Guidelines.* The Institute of Highway Incorporated Engineers.

Institute of Highway Incorporated Engineers (2005). *IHIE Guidelines for Motorcycling: improving safety through engineering and integration.* The Institute of Highway Incorporated Engineers.

Institution of Highways and Transportation (1990). *Guidelines for: Urban Safety Management.* The Institution of Highways and Transportation.

Institution of Highways and Transportation (1996). *Cycle friendly infrastructure: guidelines for planning and design.* IHT, London.

Institution of Highways and Transportation (1997). *Transport in the Urban Environment.* The Institution of Highways and Transportation.

Institution of Highways and Transportation, DETR, The Scottish Office, The Welsh Office, and DoE Northern Ireland (1998). *Guidelines for cycle audit and cycle review.* The Institution of Highways and Transportation.

Institution of Highways and Transportation, DfT, TRL (2003). *Urban Safety Management Guidelines: Road Safety Strategies for Urban Communities.*

Institution of Highways and Transportation and CSS (2005). *Traffic Calming Techniques.* ISBN 0902933388.

Institution of Lighting Engineers (2002). *Lighting for Traffic Calming Schemes Technical Report Number 25.* The Institution of Lighting Engineers.

Jarvis J R and Giummara G (1992). *Humps for use on bus routes.* Road and Transport Research, Australia.

Jeanes M (1996). *Suffolk's 30 mph speed limit initiative.* 24th PTRC European Transport Forum, September 1996.

Jones R (2001). *Gloucester Safer City.* Conference paper in June 2001.

Kassem E and Al-Nassar Y (1982). *Dynamic considerations of speed control humps.*

Transportation Research Board, Vol 16B, No 4 pp 291 - 302, 1982.

Kennedy J V, Hall R D and Barnard S R (1998). *Accidents at urban mini-roundabouts.* TRL Report 281. Transport Research Laboratory, Crowthorne.

Kennedy J V and Wheeler A H (2001). *Countryside Traffic Measures Group: demonstration schemes.* TRL Report 502. Transport Research Laboratory, Crowthorne.

Kennedy J V, Wheeler A H and Inwood C M (2004a) *Norfolk Quiet Lanes Scheme.* TRL Report 603. Transport Research Laboratory, Crowthorne.

Kennedy J V, Wheeler A H and Inwood C M (2004b) *Kent Quiet Lanes Scheme.* TRL Report 602. Transport Research Laboratory, Crowthorne.

Kennedy J V, Buttress S, and Inwood C (2004c) *Aesthetic appearance of road humps.* TRL Project report PR SE/857/04. Transport Research Laboratory, Crowthorne.

Kennedy J V, Wheeler A H and Inwood C (2004d) *Rural traffic calming in Bird Lane, Brentwood (Essex).* TRL Report 597. Transport Research Laboratory, Crowthorne.

Kennedy J V, Oakley C, Sumon S, Parry I (TRL) and Wilkinson E, Brown J (Millbrook) (2004e) *Impact of road humps on vehicles and their occupants.* TRL Report 614. Transport Research Laboratory, Crowthorne.

Kennedy J, Gorell R, Crinson L, Wheeler A and Elliot M (2005) *'Psychological' traffic calming.* TRL Report 641, September 2005. Transport Research Laboratory, Crowthorne.

Kent County Council, (1992) & (1996). *Review of traffic calming schemes in Kent.* 1st review 1992 and 2nd review 1996.

Kjemtrup K (1990). *Speed reducing measures.* Conference paper, Copenhagen 4/1990.

Lalani (1977). *Road safety at pedestrian refuges.* Traffic Engineering + Control, September, 1977.

Lawton B J, Webb P J, Wall G T and Davies D G (2004) *Cyclists at 'continental' style roundabouts.* TRL Report 584, Transport Research Laboratory, Crowthorne.

Layfield R E and Parry D I (1998). *Traffic calming - Speed cushion schemes.* TRL Report 312. Transport Research Laboratory, Crowthorne.

Layfield R E, Chinn L and Nicholls D (2003) *Pilot Home Zone schemes: Evaluation of the Methleys, Leeds.* TRL Report 586. Transport Research Laboratory, Crowthorne.

Layfield R, Webster D and Buttress S (2005). *Pilot home zone schemes: evaluation of Magor Village, Monmouthshire.* TRL Report No 633. Transport Research Laboratory, Crowthorne.

Lee, G (1998). *The effectiveness of signing and lining.* Traffic Engineering and Control, July/August, 1998.

Lewis D (1998). *The Do's and Don'ts of Traffic Calming.* Traffic Safety, March/April 1998.

Lockwood C R (1997). *Using the TRL driving simulator to evaluate traffic calming measures.* TRL Report 245. Transport Research Laboratory, Crowthorne.

Luoma J, Penttinen M, Rama P and Harjula V (1997). *Driver responses to variable road condition signs.* Tielaitoksen selvityhsia 22/97. Finnish National Road Administration.

Luoma J and Rama P (1998). *Effects of variable speed limit signs on speed behaviour and recall of signs.* Traffic Engineering + Control, April 1998.

Mackie A M, Ward H A and Walker R T (1990). *Urban Safety Project. 3 Overall evaluation of area wide schemes.* TRRL Research Report 263. Transport Research Laboratory, Crowthorne.

Mackie A (1997). *Progress report: MOLASSES: Monitoring of local authority safety schemes.* County Surveyors Society, 1997-03.TRL ref: P9711024.

Mackie A (1998). *Urban speed management methods.* TRL Report 363. Transport Research Laboratory, Crowthorne.

Mackie A and Wells P (2003). *Gloucester Safer City: Final Report.* TRL Report 589, Transport Research Laboratory, Crowthorne.

Mayhew N and Smith G (1998). *Village people.* Surveyor, 20 August 1998.

MOLASSES database (2004). *Analysis of MOLASSES database regarding accident reduction from roundabouts.* Personal communication September 2004.

Morgan J M (1998). *Roundabouts in Continental Europe designed with cycle facilities or 'cycle-thinking'.* TRL Report 302. Transport Research Laboratory, Crowthorne.

Nicodemus D (1991). *Safe and effective roadway humps. The Seminole County profile.* ITE Compendium of Technical Papers. Washington DC. Institute of Transportation Engineers.

Nilsson L and Nabo A (1996). *Evaluation of Application 3: Intelligent Cruise Control simulator experiment.* Swedish National Road and Transport Research Institute.

Northamptonshire County Council (1998). *Accident data for Billing Brook Road, Northampton.* Northants CC, Northampton.

Office of the Deputy Prime Minister (2002). *Living Places: Cleaner, Safer, and Greener.* ODPM, London.

Ogden K and Morgan R (2000). *Safety and motorcyclists.* Traffic Engineering + Control, March 2000.

Oxley P and Alexander J (1994). *Disability and mobility in London. A follow-up to the London area travel survey. Technical report.* TRL Project Report 34. Transport Research Laboratory, Crowthorne.

Pasanen E and Salmivaara H (1994). *40 kph (25 mph) speed limits in the inner city of Helsinki.* Helsinki City Planning Department, Traffic Planning Division.

Perrett K and Stevens A (1996). *Review of the potential benefits of road transport telematics.* TRL Report 220.

Transport Research Laboratory, Crowthorne.

Polus A and Craus J (1996). *Planning and geometric aspects of shared streets.*

Transportation Research Record 1523.

Rama P and Luoma J (1997). *Driver acceptance of weather-controlled road signs and displays.* Transportation Research Record 1573.

Reid S, Allen D, Brown E, Moreland V and Vance C (2004) *Cycle facilities and engineering: Summary of TRL research.* TRL Report 623. Transport Research Laboratory, Crowthorne.

ROSPA (2002). *Road safety engineering manual, 3rd Edition.* ROSPA, Birmingham.

Sawers C (1997). *Mini-roundabouts. Getting them right.* EMC, 94 High Street, Wingham, Canterbury, CT3 1DE.

Sayer I and Parry D I (1994). *Speed control using chicanes - a trial at TRL.* TRL Project Report PR 102. Transport Research Laboratory, Crowthorne.

Sayer I A, Parry D I and Barker J K (1998). *Traffic calming - An assessment of selected on-road chicane schemes.* TRL Report 313. Transport Research Laboratory, Crowthorne.

Sayer I A, Nicholls D A and Layfield R E (1999). *Traffic calming: Passenger and rider discomfort at sinusoidal, round-top and flat-top humps – a track trial at TRL.* TRL Report 417. Transport Research Laboratory, Crowthorne. In preparation.

Scottish Executive (1999a). *Natural traffic calming. Guidance and research report.* Scottish Executive, Edinburgh.

Scottish Executive (1999b). *The community impact of traffic calming schemes.* Central Research Unit, Scottish Executive, Edinburgh.

Scottish Executive (2001). *20 mph speed reduction initiative.* Scottish Executive Central Research Unit, Edinburgh.

Silke E (1996). *Traffic calming blocks way for winter maintenance.* Surveyor 10/10/96.

Slinn M, Guest P and Mathews P (1998). *Traffic engineering design. Principles and practice.* MVA Consultancy and Hill Cannon Partnership 1998.

Social Research Associates (1999). *Bypass demonstration project. Further research and analysis in relation to attitudes to walking.* Social Research associates in association with Ross Silcock, November 1999.

Stark D C (1995). *Speeding is an important urban problem.* Paper presented at PTRC Annual Meeting, September, 1995.

Stark D (1996). *Urban speed management, 2. Automatic speed enforcement.* Traffic engineering and control, November 1996.

Steen M and Hageback C (1999). *Buses and bumps. Presentation of the results from the research project concerning Public Transport and Traffic Calming Measures.* VBB VIAK, SWECO, Stockholm, Sweden.

Strathclyde (1993). *Road hump trials.* A joint report by Strathclyde Roads and Strathclyde Passenger Transport Executive. Glasgow.

Sustrans (1997). *National cycle network: Guidelines and practical details.* Sustrans, Bristol.

Sumner R and Shippey J (1977). *The use of rumble areas to alert drivers.* TRRL Report LR800, Transport Research Laboratory, Crowthorne.

Swali N (1993). *The effect of speed cameras in West London.* PTRC 21st Annual Summer Meeting, University of Manchester, September 1993.

SWOV (1985). *Reclassification and reconstruction of urban roads in the Netherlands. SWOV, 1985.*

Taylor M C, Lynam D A and Baruya A (2000). *The effects of drivers' speed on the frequency of road accidents.* TRL Report 421. Transport Research Laboratory, Crowthorne.

Taylor S and Tight M, (1996). *Feet First: Public attitudes and consultation in traffic calming schemes.* A report for Transport 2000 Trust.

The National Assembly For Wales, (1999). *Traffic calming trials. A review of traffic calming schemes on the trunk and principal road network of Wales.* The National Assembly for Wales.

Thompson S J, Heydon S J and Charnley C B (1990). *Pedestrian refuge schemes in Nottingham.* Traffic Engineering and Control, March 1990.

Tilly A, Webster D and Buttress S (2005). *Pilot home zone schemes: evaluation of Northmoor, Manchester.* TRL Report No 625. Transport Research Laboratory, Crowthorne

Totton B (2000). *Exorcising the speed demons.* Surveyor, 7 September 2000.

Transport for London (2005). *Traffic Calming Measures for Bus Routes 2005.*

Trench S and Ball R (1995). *Current issues in planning: Volume 2, 1995. Chapter 11. Buses and traffic calming.* Avebury, Ashgate publishing, Aldershot, Hants.

Trevelyan P and Morgan J (1993). *Cycling in pedestrian areas.* TRL Project Report 15. Transport Research Laboratory, Crowthorne.

Walker J S and Pittam S R (1989). *Accidents at mini-roundabouts: Frequencies and rates.* TRRL Contractor Report 161. Transport Research Laboratory, Crowthorne.

Watson D and Allsop R (1999). *Suffolk 30 mph speed limits – accident study.* Press release 12/10/99.

Watts G R (1990). *Traffic induced vibrations in buildings.* TRRL Research Report 246. Transport Research Laboratory, Crowthorne.

Watts G R (1973). *Road humps for the control of vehicle speeds.* TRRL Laboratory Report 597. Transport Research Laboratory, Crowthorne.

Watts G R and Harris G J (1996). *Traffic calming: Vehicle generated ground-borne vibration alongside speed control cushions and road humps.* TRL Report 235. Transport Research Laboratory, Crowthorne.

Watts G R and King R (2004). *Prediction of ground-borne vibration generated by heavy vehicles crossing a Rumblewave device (Rippleprint).* TRL Project Report PPR020. Transport Research Laboratory, Crowthorne.

Watts G R, Stait R E, Godfrey N S, Chinn L and Layfield R (2002). *Development of a novel traffic calming surface 'Rippleprint'.* TRL Report 545. Transport Research Laboratory, Crowthorne.

Webster D C (1993a). *Road humps for controlling vehicle speeds.* TRL Project Report 18. Transport Research Laboratory, Crowthorne.

Webster D C (1993b). *The grounding of vehicles on road humps.* Traffic Engineering and Control, July/August 1993.

Webster D C (1994a). *Speeds at 'thumps' and low height road humps.* TRL Project Report 101. Transport Research Laboratory, Crowthorne.

Webster D C (1995a). *Traffic calming - vehicle activated speed limit reminder signs.* TRL Report 177. Transport Research Laboratory, Crowthorne.

Webster D C (1995b). *Traffic calming - Four schemes on distributor roads.* TRL Report 182. Transport Research Laboratory, Crowthorne.

Webster D C (1998a). *Traffic calming – Effects on professional drivers, bus passengers and those with a mobility impairment – a literature review.* Unpublished Report PR/TT/111/98. Transport Research Laboratory, Crowthorne. Limited availability from DETR.

Webster D C (1998b). *Traffic calming - Public attitude studies: A literature review.* TRL Report 311. Transport Research Laboratory, Crowthorne.

Webster D C and Layfield R E (1993). *An assessment of rumble strips and rumble areas.* TRL Project Report PR 33. Transport Research Laboratory, Crowthorne.

Webster D C and Layfield R E (1996). *Traffic calming - Road hump schemes using 75 mm high humps.* TRL Report 186. Transport Research Laboratory, Crowthorne.

Webster D C and Layfield R E (1998). *Traffic calming - Sinusoidal, 'H' and 'S' humps.* TRL Report 377. Transport Research Laboratory, Crowthorne.

Webster D C and Mackie A M (1996). *Review of traffic calming schemes in 20 mph zones.* TRL Report 215. Transport Research Laboratory, Crowthorne.

Webster D, Tilly A and Buttress S (2005). *Pilot home zone schemes: evaluation of Cavell Way, Sittingbourne.* TRL Report No 626. Transport Research Laboratory, Crowthorne.

Wernsperger F and Sammer G (1995). *Results of a scientific investigation accompanying the pilot trial of 30 kph (19 mph) limit in side streets and 50 kph limit in priority streets.* 23rd PTRC European Transport Forum, September 1995.

Wheeler A H (1997). *Traffic calming in historic core zones: Crossley Street Halifax.* TRL Report 288. Transport Research Laboratory, Crowthorne.

Wheeler A H (1999a). *Traffic calming in historic core zones: High Street route, Shrewsbury.* TRL Report 374. Transport Research Laboratory, Crowthorne.

Wheeler A H (1999b). *Traffic calming in historic core zones: Bury St. Edmunds.* TRL Report 388. Transport Research Laboratory, Crowthorne.

Wheeler A H and Taylor M C (1999). *Traffic calming in villages on major roads: Final report.* TRL Report 385. Transport Research Laboratory, Crowthorne.

Wheeler A H and Taylor M C (2000). *Changes in accident frequency following the introduction of traffic calming in villages.* TRL Report 452. Transport Research Laboratory, Crowthorne.

Wheeler A H, Taylor M C and Payne A (1993). *The effectiveness of village 'gateways' in Devon and Gloucestershire.*

TRL Project Report PR 35. Transport Research Laboratory, Crowthorne.

Wheeler A H, Taylor M C and Barker J K (1994). *Speed reduction in 24 villages: details from the VISP study.* TRL Project Report PR 85. Transport Research Laboratory, Crowthorne.

Wheeler A H, Godfrey N S, Lawrence D J and Phillips S M (1996). *Traffic calming on major roads:A49 trunk road at Craven Arms.* TRL Report 212. Transport Research Laboratory, Crowthorne.

Wheeler A H, Abbott P G, Godfrey N S, Phillips S M and Stait R (1997). *Traffic calming on major roads: A47 trunk road at Thorney.* TRL Report 238. Transport Research Laboratory, Crowthorne.

Wheeler A H, Harris G, Chinn L, Taylor M and Abbott P (1998). *A traffic calming scheme at Costessey, Norfolk.* TRL Report 364. Transport Research Laboratory, Crowthorne.

Wheeler A H, Kennedy J V, Davies G J and Green J M (2001a) Countryside Traffic Measures Group: Traffic calming in Norfolk and Suffolk. TRL Report 500.

Wheeler A H, Kennedy J V, Davies G J, Green J M, Harris G and Stait R E (2001b) Countryside Traffic Measures Group: Traffic Calming in Charlwood, Surrey. TRL Report 501.

Wheeler A H, Kennedy J V and Inwood C M (2003) Pedestrian and driver interaction at road humps used as informal crossings. Unpublished report PR SE/695/03, Transport Research Laboratory, Crowthorne.

Wheeler A, Tilly A, Webster D, Rajesparan Y and Buttress S (2005) *Pilot home zone schemes: Evaluation of Morice Town, Plymouth.* TRL Report 640. Transport Research Laboratory, Crowthorne.

Winnett M A and Wheeler A H (2003). *Vehicle activated signs: a large scale evaluation.* TRL Report 548. Transport Research Laboratory, Crowthorne.

Winnett M A, Woodgate E and Mayhew N (1999). *Interactive fibre optic signing at a rural crossroad (B1149 Felthorpe, Norfolk CC).* TRL Report 401. Transport Research Laboratory, Crowthorne.

Appendices

Appendix A. DfT (including DTLR, DETR and DoT) publications

Statutory Instruments and Acts

Highways Act 1980.

Roads (Scotland) Act 1984.

Road Traffic Regulations Act 1984.

Traffic Calming Act 1992.

Traffic Signs Regulations and General Directions 1994 (SI 1994 No.1519).

Environment Act 1995.

The Local Authorities' Traffic Orders (Procedure) (England and Wales) Regulations 1996 (SI 1996, No. 2489).

The Zebra, Pelican and Puffin Pedestrian Crossing Regulations and General Directions 1997 (SI 1997, No. 2400).

Crime and Disorder Act, 1998.

Pelican and Puffin Pedestrian Crossings General (Amendment) Directions 1998 (SI 1998, No. 901).

The Highways (Road Humps) Regulations 1999 (SI 1999, No.1025).

The Highways (Traffic Calming) Regulations 1999 (SI 1999, No. 1026).

The Road Traffic Regulation Act 1984 (Amendment) Act Order 1999.

The Traffic Signs Regulations General (Amendment) Directions 1999 (SI 1999, No 1723).

Greater London Authority Act, 1999.

Transport Act 2000.

The Traffic Signs Regulations and General Directions (TSRGD) 2002 (SI 2002 No. 3113).

The Traffic Signs (Amendment) General Directions 2003 (SI 2003 No. 393).

The Air Quality Limit Values Regulations 2003 (SI 2003 Number 2121).

The Traffic Signs (Amendment) General Directions 2004 (SI 2004 No. 1275).

The Traffic Signs (Amendment) Regulations and General Directions (SI 2005 No. 1670).

The Quiet Lanes and Home Zones (England) Regulations 2006 (SI 2006, No. 2082).

The Traffic Signs (Amendment) Regulations 2006 (S.I. 2006, No. 2083).

Circular Roads

Circular Roads 01/93, *Road Traffic Regulations Act 1984:Sections 81–85 Local Speed Limits* (cancelled, except in Wales).

Circular Roads 05/99, *20 mph speed limits.*

Circular 02/2003, *The Traffic Signs Regulations and General Directions (TSRGD) 2002.*

Department for Transport Circulars

Circular 01/2006, *Setting Local Speed Limits* (cancels Circular Roads 1/93 'Setting Local Speed Limits' except in Wales).

Circular 02/2006, *The Quiet Lanes and Home Zones (England) Regulations 2006.*

Local Transport Notes

Local Transport Note 01/78, *Ways of helping cyclists in built up areas.*

Local Transport Note 02/78, *Notes on the preparation of pedestrianisation schemes.*

Local Transport Note 01/83, *Signs for cycle facilities.*

Local Transport Note 01/86, *Cyclists at road crossings and junctions.*

Local Transport Note 02/86, *Shared use by cyclists and pedestrians.*

Local Transport Note 01/87, *Getting the right balance: Guidance on vehicle restriction in pedestrian zones.*

Local Transport Note 02/87, *Signs for cycle facilities.*

Local Transport Note 01/89, *Making way for cyclists: Planning, design and legal aspects of providing for cyclists.*

Local Transport Note 01/94, *The design and use of directional informatory signs.*

Local Transport Note 01/95, *The assessment of pedestrian crossings.*

Local Transport Note 02/95, *The design of pedestrian crossings.*

Local Transport Note 01/97, *Keeping buses moving: a guide to traffic management to assist buses in urban areas.*

Other guidance

Departmental Advice Note, TA 22/81. *Vehicle speed measurement on all purpose roads.*

Design Manual for Roads and Bridges, Volume 6, Section 2, Part 3. TD 16/93, Geometric Design of Roundabouts.

Design Manual for Roads and Bridges, Volume 6, Section 3, part 4. TA 81/99, Coloured Surfacing in Road Layout.

Design Manual for Roads and Bridges, TA 87/04. Traffic Calming on Trunk Roads - A Practical Guide.

Guidance on the use of tactile paving surfaces (DETR, 1998)

Road Casualties Great Britain: Annual Report (Revised annually) The Stationery Office.

UK National Air Quality Strategy (DETR, 1999).

A Road Safety Good Practice Guide (DTLR, 2001).

Traffic Signs Manual:

Chapter 3 Regulatory Signs

Chapter 4 Warning Signs

Chapter 5 Road Markings

Chapter 7 The Design of Traffic Signs

Traffic Advisory Leaflets

03/90 *Urban Safety Management Guidelines from IHT.*

04/90 *Tactile markings for segregated shared use by cyclists and pedestrians.*

03/91 *Speed Control Humps (Scottish version).*

07/91 *20 mph Speed Limit Zones* (see TAL 09/99).

02/92 *The Carfax, Horsham 20 mph Zone.*

02/93 *20 mph Speed Limit Zone Signs* (see TAL 09/99).

03/93 *Traffic Calming Special Authorisations.*

07/93 *Traffic Calming Regulations.*

08/93 *Advanced Stop Lines for Cyclists.*

09/93 *Cycling in Pedestrian Areas.*

10/93 *'TOUCAN' An Unsegregated Crossing for Pedestrians and Cyclists.*

11/93 *Rumble devices.*

12/93 *Overrun areas.*

13/93 *Gateways.*

01/94 *VISP – A Summary.*

02/94 *Entry treatments.*

03/94 *Fire and Ambulance Services – Traffic Calming: A Code of Practice .*

04/94 *Speed cushions* (see TAL 01/98).

07/94 *'Thumps' Thermoplastic Road Humps.*

09/94 *Horizontal Deflections* (see also TAL 12/97).

11/94 *Traffic Calming Regulations – Scotland.*

01/95 *Speed Limit Signs – A Guide to Good Practice.*

02/95 *Raised Rib Markings.*

03/95 *Cycle Routes.*

04/95 *The 'SCOOT' Urban Traffic Control System.*

05/95 *Parking for disabled people.*

06/95 *Pedestrian crossings – Assessment and Design.*

07/95 *Traffic Islands For Speed Control.*

08/95 *Traffic Models for Cycling.*

01/96 *Traffic Management in Historic Areas.*

02/96 *75 mm high Road Humps.*

03/96 *Bike and ride.*

04/96 *Traffic Management and Emissions.*

05/96 *Further Development of Advanced Stop Lines.*

06/96 *Traffic Calming: Traffic and Vehicle Noise.*

07/96 *Highways (Road Humps) Regulations 1996.*

08/96 *Road Humps and Ground-borne Vibrations.*

01/97 *Cyclists at road narrowings.*

02/97 *Traffic Calming on Major Roads: A49 Craven Arms, Shropshire.*

03/97 *The 'MOVA' Signal Control System.*

04/97 *Rising Bollards.*

05/97 *Cycles and Lorries.*

06/97 *Traffic Calming on Major Roads: A47 Thorney, Cambridgeshire.*

09/97 *Cyclists at roundabouts continental design geometry.*

10/97 *Halifax Historic Core Zone.*

12/97 *Chicane schemes.*

01/98 *Speed cushion schemes.*

02/98 *Lincoln Historic Core Zone, Newport Arch.*

04/98 *Toucan crossing development.*

06/98 *Contraflow cycling.*

07/98 *Cycle audit and review.*

08/98 *The High Street route, Shrewsbury.*

09/98 *Sinusoidal, 'H' and 'S' humps.*

01/99 *Monitoring Local Cycle Use.*

02/99 *Leigh Park Area safety scheme, Havant, Hants.*

05/99 *Bikerail – combined journeys by cycle and rail.*

06/99 *Cycle parking. Examples of good practice.*

07/99 *The 'SCOOT' Urban Traffic Control System.*

08/99 *Urban Safety Management Using SAFE*NET.

09/99 *20 mph speed limits and zones.*

13/99 *Historic Core Zone: Bury St Edmunds.*

14/99 *Traffic calming on Major Roads: A Traffic calming scheme at Costessey, Norfolk.*

01/00 *Traffic calming in villages on major roads.*

02/00 *Framework for a local walking strategy.*

06/00 *Monitoring walking.*

10/00 *Road humps: discomfort, noise and ground-borne vibration.*

11/00 *Village traffic calming – reducing accidents.*

12/00 *Urban street activity in 20 mph zones. Ayres Road area, Old Trafford.*

01/01 *Puffin pedestrian crossing.*

03/01 *Urban street activity in 20 mph zones. Seedley, Salford.*

09/01 *The Nottingham Cycle Friendly Employers Project.*

10/01 *Home Zones – Planning and Design.*

01/02 *The Installation of Puffin Pedestrian Crossings.*

02/02 *Motorcycle Parking.*

04/02 *Benchmarking of Local Cycling Policy.*

05/02 *Key elements of cycle parking provision.*

06/02 *Inclusive Mobility: A Guide to best practice on access to pedestrian and transport infrastructure.*

07/02 *New Technology for Transport.*

08/02 *Home Zones -i Public Participation.*

01/03 *Vehicle activated signs.*

02/03 *Signal-control at junctions on high speed roads.*

03/03 *Equestrian crossings.*

01/04 *Village Speed Limits.*

02/04 *Rural traffic calming: Bird Lane, Essex.*

03/04 *Quiet Lanes.*

01/05 *Rumblewave surfacing.*

02/05 *Traffic calming bibliography* (Revised regularly).

03/05 *Cycling bibliography* (Revised regularly).

04/05 *Walking bibliography* (Revised regularly).

05/05 *Pedestrian Facilities at Signal-Controlled Junctions.*

06/05 *Traditional direction signs.*

01/06 *General principles of traffic control by light signals.*

02/06 *Speed assessment framework.*

03/06 *High Occupancy Vehicle Lanes.*

Web pages

Countryside Agency : **www.countryside.gov.uk**

Department for Transport: **www.dft.gov.uk**

Highways Agency: **www.highways.gov.uk**

MOLASSES: **www.trl.co.uk/molasses**

Department for Communities and Local Government: **www.communities.gov.uk**

RoSPA: **www.rospa.com/CMS/index.asp**

Technical Advisers Group: **www.t-a-g.org.uk**

Transport Research Laboratory: **www.trl.co.uk**

Quiet Lanes: Technical Guidance: **www.countryside.gov.uk/LAR/Recreation/Greenways/quietlanes**

Home Zones: **www.homezones.org.uk**

Appendix B. Developing a traffic calming scheme

(This Appendix has been adapted from *Traffic Calming in Practice* by IHT *et al.*, 2005)

1. Establish policy framework in Local Transport Plan, Road Safety Plan and Structure Plan.

2. Establish road hierarchy for area. Determine appropriate measures for roads in consultation particularly with emergency services, bus operators and residents.

3. Is the priority of the scheme environmental or road safety related or both? Set objectives for the scheme including any speed reductions required.

4. Prepare concept designs.

5. Informal consultation with emergency services and bus operators.

6. Initial consultation with local people - residents, businesses and community organisations.

7. Evaluate feedback.
   If not beneficial overall, **ABANDON** scheme or **REVISE** designs.
   If scheme is beneficial overall, continue.

8. Commission detailed design taking account of consultation feedback.

9. Carry out formal consultation with groups affected by the scheme particularly emergency services, bus operators, residents, public, commercial and road user groups.

10. Evaluate feedback.
    If not beneficial overall, **ABANDON** scheme or **REVISE** designs.
    If scheme is beneficial overall, continue.

11. Obtain formal authority to implement including special authorisation from DfT if measures or signs are not covered by current regulations. Authorisation may not be automatic and may require informal talks.

12. Programme scheme.

13. Issue notification of scheme.

14. Implement the scheme.

15. Monitor scheme but allow a few months for the public to adjust to the new layout before taking any measurements or opinions unless serious problems are identified.

16. Review scheme after monitoring to see if any modifications are required and to add any experience gained to subsequent schemes. Report results of review particularly to public.

17. Review again after three years to determine the effect on accidents particularly for schemes designed primarily to reduce accidents. Report results of review particularly to public.

Appendix C1. Scheme assessment framework

(This Appendix has been adapted from *Traffic Calming in Practice* by CSS *et al.*, 1994)
(Note: the framework is not included in IHT 2005)

Objectives

- achievement of Road Safety Plan objectives.
- achievement of Transport Policy and Strategy objectives.
- achievement of Planning and Environment objectives.
- achievement of Local Transport Plan objectives.

Safety

- total number of injury accidents.
- number of injury accidents to pedestrians, cyclists and motorcyclists (child injury accidents could be considered separately).
- number of injury accidents where excessive vehicle speed a factor.
- perceived risk and exposure to traffic particularly pedestrians, cyclists and motorcyclists.

Traffic characteristics

- traffic speeds.
- emergency vehicle and public transport routes.
- volume of through traffic.
- day-time and night-time vehicle flows.
- number of HGVs.
- pedestrian flows at junctions and crossings (during school terms and holidays if close to a school).
- pedestrian desire lines.
- cycle flows (during school terms and holidays if close to a school).

Physical characteristics of road

- width of road.
- alignment (gradient, radii and camber).
- provision for cyclists and pedestrians (both along the road and crossing it).
- parking provision.
- provision for people with disabilities.
- footway provision.
- location, width and accessibility at bus stops.
- location of schools, shops, hospitals, fire stations.

Environment

- distance of houses from the road.
- traffic noise.
- traffic emissions.
- traffic vibrations.
- number of residents/properties affected.
- quality of the streetscape.

Value for money

- cost of design, construction and maintenance.
- cost of consultation (before and after construction).
- cost of alternative strategies.
- overall effect (benefits and disbenefits).
- estimated overall cost based on benefits and disbenefits which will vary for each local authority depending on their priorities.

Appendix C2. Example of priority factors for traffic calming schemes on 30 mph roads

(This Appendix has been adapted from Slinn *et al.*, 1998.)

Note: This is an example of the type of factors that can be used to determine the priority for traffic calming schemes. However, it is not intended as DfT guidelines.

CRITERION	RANGE	PRIORITY FACTOR
Vehicle speed (mph) (85th percentile)	over 45	12
	41–45	10
	36–40	8
	31–35	6
	26–30	4
	20–25	2
	Under 20	0
Vehicle flow (vehicles/hour) (average for peak hours)	per 100	1
	over 1000	10
Cyclists (average per hour over 4 highest hours in any day	per 10	1
Pedestrians crossing road (pedestrian/km/highest hour over 4 hours in any day)	per 100	3
Number of frontage residents/km	per 100	1
Accident level (personal injury accidents/km/year averaged over 3 years)	per accident	5
	under 1	0
Potentially hazardous locations within scheme	school entrances	6
	bus stops	3
	community centres	3
	doctor surgeries	3
	elderly, nursing homes	3
	hospitals	3
	elderly lunch clubs	3
	nurseries, play groups	3
	post office, local shops	3
	recreation grounds	3

Appendix D. Checklist of issues to consider in questionnaire compilation

(This checklist is taken from Webster (1998b)

Notes

1. All methods of questioning can be susceptible to vociferous people who are against the scheme.

2. Minority groups might also require specific questions.

ISSUE	COMMENTS	CHECK
Method of questioning	**Interview** Advantage: Detailed questions can be asked Disadvantage: Cost	
	Postal Advantage: Cost may be less than for a face to face interview Disadvantage: May be less representative due to low response rate	
	Telephone Advantage: Immediate response Disadvantage: No photographs can be shown (see below)	
Road user group	If the scheme is likely to have implications for particular groups, are specific questions required for the group?	
	a) Pedestrians; with mobility problems? children? all pedestrians?	
	b) Cyclists?	
	c) Residents?	
	d) Emergency services?	
	e) Bus operators/passengers?	
	f) Motorists?	
	g) All general public, including non-local motorists?	
Photographs	Photographs of 'before' and 'after' installation are useful to show respondents so that they can consider the differences. Very important for large schemes or if the environment was enhanced.	
Effectiveness	The perceived effectiveness will depend on the respondents' expectations. Before and after attitude surveys would therefore be useful but would double the cost of monitoring and would only be worthwhile for innovative schemes.	
	Is the effectiveness the same for all types of vehicles?	
	Prompts may be required if specific information relating to cars, buses, goods vehicles, bicycles and motorcycles is wanted.	
Safety	The safety of the scheme should be considered, because it may be that pedestrians or cyclists felt very vulnerable before the scheme was implemented but it did not show up in the accident statistics. This could lead to the effect 'risk compensation' in which they may feel safer afterwards and take less care.	
Feedback	This can be considered to be the most important part of any survey because it allows the local authority to analyse comments from the respondents and then to:	
	a) Consider if the comments are justified.	
	b) Adjust the scheme if required.	
	c) Review any adjustments made and add to local knowledge.	
	d) Share experiences with others in the same field.	

Appendix E. Summary of design factors, advantages and disadvantages of the use of road humps (not including speed cushions)

Advantages:

- Road humps are a proven speed control device used in 20 mph zones and on 30 mph roads resulting in reductions in injury accidents of about 60 per cent.
- Speeds of vehicles over humps are influenced by vehicle type and hump dimensions (height, length, and ramp gradient for flat-top humps).
- Speeds of vehicles between humps are influenced by 'before' speed, hump dimensions and hump spacing.
- Lower heights and shallower ramp gradients can be used on bus routes to reduce discomfort for bus drivers and passengers and reduce delays to emergency services. However, this is likely to increase the speed of cars.
- The use of humps reduces traffic flows on average by 25 per cent.
- Humps can be parked on and thus there is no loss of parking space for simple hump designs.
- Flat-top humps (kerb-to-kerb) can provide good crossing places for pedestrians.
- Humps and raised junctions can enhance the appearance of a road if designed and built to a high standard and help crossing pedestrians.

Disadvantages:

- Discomfort is experienced by riders of two-wheeled vehicles and drivers and passengers of other vehicles. The degree of discomfort varies among vehicles and is governed by vehicle type, vehicle speed and hump design.
- Driver and passenger discomfort in buses, ambulances and commercial vehicles is usually higher than that in cars.
- Buses, ambulances and commercial vehicles cross at a slower speed than cars.
- The use of humps on bus/emergency routes can increase journey times for buses and cause delay for the emergency services.
- The flow of vehicles may increase on surrounding untreated roads (although studies indicate that not all flow reduction can be attributed to traffic being diverted onto surrounding roads).
- Noise and vibration levels may be a nuisance at locations adjacent to humps particularly if there is a significant flow of commercial vehicles in the traffic stream.
- Grounding may be a problem on high humps with steep ramp gradients.

- Road humps can be unpopular with some residents and drivers due to discomfort, fear of damage to vehicles and a perception of increased noise and vibration. However, attitude studies suggest that other physical traffic calming measures (e.g. speed cushions, chicanes and mini-roundabouts) are more unpopular.

- Humps need marking, signing and lighting except in 20 mph zones.

- Some hump schemes may not be visually attractive and may be considered ‘urbanising’ in rural areas.

- Poorly designed schemes may lead to aggressive driver behaviour with high levels of braking and acceleration. This can increase the noise and pollutant emissions from individual vehicles.

- Additional drainage will be required for kerb-to-kerb road humps.

Appendix F. Summary of design factors, advantages and disadvantages of the use of speed cushions

Advantages:

- Less discomfort than road humps to occupants of large buses and commercial vehicles.
- Less delay to fire appliances and buses.
- Effective speed control device, but not quite as effective as round or flat-top road humps.
- Speed of vehicles over cushions is mainly determined by cushion width.
- Cushion dimensions and spacing can be varied depending upon the road type and 'target' speed required.
- Narrower cushions can be used to reduce discomfort to passengers in mini-buses and ambulances.
- Cushion layouts can be varied to suit road width.
- The use of cushions removes through traffic with flows reduced on average by 25 per cent.
- Drainage not a problem.
- Different colours and materials can be used to increase the visual impact.
- Cyclists and motorcyclists can avoid the cushions.

Disadvantages:

- Not suitable for reducing speeds of two-wheeled motor vehicles.
- Discomfort is experienced by drivers and passengers in smaller vehicles (cars, light commercial vehicles, minibuses and some ambulances). The degree of discomfort varies between vehicles and is governed by vehicle type, vehicle track width, vehicle speed, cushion dimensions and vehicle path over the cushions.
- Wide cushions may cause greater discomfort to passengers in mini buses and ambulances.
- Vehicles with wide wheel tracks can travel over narrow cushions faster than narrower tracked vehicles.
- Waiting restrictions or build-outs may be required to ensure vehicles can straddle the cushions and thereby gain the benefit in terms of discomfort reduction.
- Noise and vibration levels may be a nuisance at locations adjacent to cushions, where there is a significant flow of commercial vehicles in the traffic stream, especially if the commercial vehicles do not fully straddle the cushions.
- Some car drivers may drive in the centre of the road if the gap between the cushions is too wide. If the gap is too narrow, opposing vehicles may not be able to pass each other with both vehicles straddling the cushions.
- Depending on the layout used, some car drivers may drive closer to the kerb or deviate towards the kerb to fully straddle the cushions. This may be intimidating for cyclists.

- Grounding may be a problem if cushions are particularly narrow (less than 1.6 m wide) or short (less than 2000 mm long). In these instances lower height cushions may be required which will have a knock-on effect on vehicle speeds.
- Not suitable at pedestrian crossing places because pedestrians might trip on them.
- Speed cushions can be unpopular with some residents due to discomfort, concern about the speed of motorcycles and large vehicles, fear of damage to vehicles, vehicles parked near the cushions, some drivers travelling in the centre of the road, and a perception of increased noise and vibration.
- Speed cushions need marking, signing and lighting except in 20 mph zones.
- Streets fitted with some types of cushions may not be regarded as being visually attractive.
- Poorly designed schemes may not fit in with the character of the street and may be considered ‘urbanising’ in rural areas.

Appendix G. Summary of design factors, advantages and disadvantages of the use of chicanes

Advantages:

- Less discomfort than road humps to occupants of large buses and commercial vehicles.
- Less delay to fire appliances.
- Effective speed control device, but not quite as effective as road humps.
- Chicane width and path angle through chicane can be used to influence the speed of vehicles through a chicane.
- Chicane dimensions and spacing can be varied depending upon the road type and 'target' speed required.
- Wider chicanes can be used to reduce discomfort to passengers in buses (including articulated buses) and ambulances. However, this is likely to increase the speed of cars.
- Chicane layouts can be varied to suit road width.
- The use of chicanes may remove some through traffic but the effect on traffic flows on roads with chicanes may be small (about 7–15 per cent overall).
- Different colours and materials can be used to increase effectiveness and offer greater opportunity to improve the street scene with planting.

Disadvantages:

- May not reduce speeds of two-wheeled motor vehicles.
- Discomfort may be experienced by passengers in buses and ambulances. The degree of discomfort varies between vehicles and is governed by vehicle type, vehicle wheelbase, vehicle speed and chicane dimensions.
- Large vehicles may have difficulty, and cause damage, if chicane dimensions are too restrictive. Alternatively, chicanes designed to accommodate wider vehicles are unlikely to have the desired speed reducing effect on cars.
- Drainage can be a problem.
- Chicanes may interfere with accesses if not designed properly and the number of on-street parking spaces for vehicles may be reduced.
- Noise and vibration levels may be a nuisance at locations adjacent to chicanes, where there is a significant flow of commercial vehicles in the traffic stream, especially if the commercial vehicles have an overrun area.
- Some car drivers may drive on the opposite side of the carriageway to obtain the 'racing line' through the chicane.
- Chicanes can be unpopular with some residents due to concern about the speed of motorcycles, fear of collisions through the chicane due to drivers travelling in the centre of the road, reduction in parking and difficulty in using accesses.

- Chicanes need marking, signing and lighting. All of which should be checked regularly to minimise any vehicle collisions with kerb build-outs.
- Chicanes without cycle bypasses can be intimidating for cyclists.
- Streets fitted with some types of chicanes are not visually attractive.
- Vehicles travelling at inappropriate speeds can damage bollards, planters and the build-outs themselves. This can lead to a scheme looking untidy and high maintenance costs.
- Narrow chicanes on roads where there is high traffic flow may cause localised congestion.

Appendix H. Glossary of traffic calming terms

20 mph zone A zone where traffic calming measures (spaced less than 100 metres apart) are used to limit at least average vehicle speeds to below 20 mph. The zones may be single roads or a number of roads in an area.

Advanced stop line An area reserved for cyclists to wait ahead of other vehicles when all traffic is stopped at traffic light signals.

Anti-skid surface A road surface with a high coefficient of friction, which enables vehicles to stop in a shorter distance than on other surfaces which, is especially important on the approaches to pedestrian crossings and roundabouts. The term anti-skid is misleading because it does not prevent vehicles from skidding, only anti-lock brakes can do this.

Area wide traffic calming Traffic calming carried out over a self contained area of a village, town or city.

Bar markings Coloured transverse strips to alert drivers. These should not be confused with rumble bars but they can be the same.

Berlin plate or Berlin pillow The original names used for speed cushions first used in Berlin, Germany.

Build-out A section of kerb built out into the carriageway on one side only to narrow the road.

Bus gate A route, which can not be used by other vehicles. May have a measure to deter other vehicles.

Central contrast strip A central strip, which is raised slightly to deter drivers from crossing the centre line.

Chicane Staggered build-outs used to break up long straight sections of roads. One-way working chicanes may require priority signing which should be clear and visible. Two-way working chicanes can be used on more major roads, which carry larger vehicles.

Choker Another name for a pinch point.

Combination measure Combination of more than one measure such as a cushion or hump in a narrowing.

Combi-hump A combination hump which is now known as an ‘H’ hump.

Continental roundabout Roundabouts used in Continental Europe, which generally have fewer entry lanes, more deflection and are more compact than those used in the UK. Continental roundabouts may incorporate cycle facilities.

Countdown signs These have been used to indicate the approach of a village speed limit. The signs are similar to countdown signs on the approaches to roundabouts.

Cycle bypass Cyclists can be vulnerable at narrowings and therefore a cycle bypass can be used to ease the passage of cyclists. Can also be used at road humps.

Cycle slip Another name for a cycle bypass.

Dragon’s teeth markings Triangular road markings perpendicular to the edge of the carriageway often used at gateways to give the effect of a road narrowing.

Dropped kerb The footway is lowered to meet the carriageway at the same level to aid mobility impaired persons and cyclists particularly at crossings.

DfT The Department for Transport formerly the Department for Transport, Local Government and the Regions UK (DTLR).

Entry treatment Any measure used on the entrance to a traffic calmed area to alert drivers to the changed status of the road such as on entry to a 20 mph zone. Coloured surfacing, signs, a single road hump and narrowing are common treatments.

False cattle grid a series of around 5 rumble strips of a similar colour to the road used to simulate the effect of a cattle grid, with the aim of reducing vehicle speeds. These have been used in rural areas, for example in the Kent Quiet Lanes scheme

False ford A dip in the road, which looks like a 'Ford' but does not contain water. Suitable in rural areas where new housing developments are built.

False roundabout A roundabout, which is used as a slowing feature but it only, has two arms. Often used in new housing developments. May be called a speed control island. Note: the mini-roundabout sign may not be used as this instructs drivers how to behave when entering a certain type of junction.

Flat-top road hump A road hump with a trapezoidal cross section. Heights of 25-100 mm are allowed but dimensions of 50-75 mm are generally recommended with on/off ramps of 1:10 or shallower. A minimum plateau of 2.5 metres (6 metres on bus routes).

Footway extension Essentially a road narrowing.

Full chicane Another name for a chicane. Sometimes a single build-out is called a 'Half' chicane.

Full-width road hump Any road hump that is not a speed cushion.

Gateway A gateway is a form of entry treatment to a traffic calmed area and the term was originally used on the entrance to villages where some features resembled 'gateways' as a way of announcing the entry to a village.

'Gatso' camera The trade name of the original type of speed control camera.

'H' hump This type of hump is a combination of a standard hump with outer ramps which are shallower than the inner ramps thus giving wider track vehicles (e.g. buses) a smoother ride over the hump. Sometimes called a 'Combi-hump'.

Half chicane Another name for a build-out on one side of the road only.

Hatching Hatching can be painted on the road to deter drivers from using the full road width by making the road appear narrower. Can be used in combination with other measures.

Home Zone Designated under the Transport Act 2000, with the aim of extending benefits of slow traffic speeds within residential areas and give greater priority to non-motorised users; encouraging them to use streets in different ways

Horizontal deflection This is a 'general' term which describes any measure which alters the horizontal alignment of the carriageway over a short distance. Examples include:- build-outs, chicanes, mini-roundabouts, narrowings and pinch points.

Humped Pelican crossing A flat-top hump combined with a Pelican crossing.

Humped Zebra crossing A flat-top hump combined with a Zebra crossing.

Imprinted surfacing road surfacing stamped with a particular pattern or texture. Often used to denote a different type of street environment.

Jiggle bars A form of rumble device.

Junction platform Another name for a raised junction.

Kerb extension Another name for a build-out.

Lateral shift Another name for a horizontal deflection.

Mechanical hump Any hump, used on the highway, which adjusts according to the speed of vehicles on the approach or passing over it. It would require special authorisation from DfT. A road hump, which has a mechanically variable height, width or length, is also likely to require special authorisation.

Mini-hump Another name which is sometimes used to describe a 'Thump'

Mini-roundabout Mini-roundabouts can be used at the entry to a traffic calmed scheme or within it. The mini-roundabout may be flat, domed or domed with an overrun area depending on the degree of speed reduction required and also the type of vehicles, which may use the junction. Prescribed by the Traffic Signs Regulations and General Directions.

Mountable shoulder Another name for an overrun area.

Narrowing This is a general term which includes:- build-outs, chicanes, pinch points, throttles and reallocation of road space along a route.

Natural traffic calming Design to influence speed and behaviour of drivers by the use of features which would 'naturally' occur in the street.

Necking Another name for a pinch point.

Nub Another name for a build-out.

Optical width This is the same as visual width and is the width of the road as seen by a driver. The road may appear to be narrower than it really is by means of road markings and vertical features.

Overrun area An overrun area can be used to make the carriageway appear narrower by constructing a slightly raised area which can be overrun by vehicles if required at low speeds. Car drivers will generally be discouraged due to the texture of the area. Two wheeled vehicles need to be considered in the design.

Pedestrian refuge These refuges are designed to assist pedestrians crossing the carriageway, but they also serve to reduce the carriageway width in the same way as an island.

Pegasus crossing Another name for a signal controlled equestrian crossing.

Pelican crossing A pedestrian crossing incorporating traffic lights operated by pedestrians.

Peninsula Another name for a build-out.

Pinch point A narrowing formed by two build-outs opposite one another.

Plateau Another name for a flat-top hump.

Platform Another name for a flat-top hump.

Priority system This gives priority to one direction of traffic and is often used at chicanes or narrowings.

Protected parking Another name for sheltered parking.

Puffin crossing A pedestrian crossing incorporating traffic lights operated by pedestrians and detectors to detect pedestrians crossing and waiting to cross so that vehicles are not stopped when there are no pedestrians waiting to cross.

Quiet Lanes Minor rural roads designated under the Transport Act 2000 with an aim of maintaining the tranquillity and character of rural areas through community involvement, re-routing of traffic and network signing. They should be appropriate for shared use by walkers, cyclists, horse riders and motorised users and should have low levels of traffic travelling at low speeds. Ideally these schemes should be networks of roads and they should link with public rights of way.

Raised junction A junction where flat-top humps are used to raise the whole junction area.

Ramp The incline of a flat-top hump or speed cushion, or an abbreviated version of Ramped plateau.

Ramped plateau Another name for a flat-top hump.

Rat-runner A driver/rider who uses a short cut route through a residential area (may also travel at an inappropriate speed).

Red light camera A camera used to detect drivers who go through a red light at traffic signals.

Red light runner A driver/rider who ignores a red light at traffic lights or at a Pelican/Puffin crossing.

Regression to the mean The effect where accidents can appear to have reduced at a site (even though no measures were introduced) due to a randomly high ‘before’ number of accidents.

Riblines Another name for rumble strips.

Rippleprint A proprietary name for rumblewave surfacing.

Risk compensation The unproven belief that road users take extra risks to compensate for road safety measures which are installed to reduce speeds, injuries and accidents.

Road closure A road closure can be for all vehicles at all times or it may have time/vehicle restrictions.

Road depression A negative hump where a dip is used instead of a raised area. This would need special authorisation from DfT before it could be used in the UK.

Road hierarchy The classification of roads according to their land use and desirable traffic volumes.

Road hump The term road hump covers vertical deflections which comply with the Highway (Road Humps) Regulations 1999. These must be between 25 and 100 mm in height with a minimum length of 900 mm and no vertical face greater than 6 mm.

Road safety plan An integrated strategy plan to road safety i.e. not done on a ‘piecemeal’ basis.

Roundel markings These road markings (to diagram 1065 of the Traffic Signs Regulations and General Directions 2002) are painted on the carriageway to remind drivers of the speed limit. Roundels may only be used to supplement upright signs, either at the start of a speed limit or where upright repeater signs are used.

Round-top road hump The round-top hump with a profile formed from the segment of a circle was originally designed by ‘Watts’ at TRL and was 3.7 metres long with a round profile length and a height of 100 mm. The latest regulations allow longer humps but 3.7 metres is still the recommended maximum.

Route action plan Proposal for measures used along a route with a high accident frequency.

Rumble area A form of rumble device, which is constructed from a coarser aggregate than the rest of the road to give a vibration effect. Rumble areas can be installed at decreasing spacing to give drivers the illusion that their speed is increasing.

Rumble bars Another name for rumble strips.

Rumble device Rumble devices are designed to alert drivers by giving a vibratory effect through the vehicle. They do not give much speed reduction and, with the exception of rumblewave surfacing, are not generally suitable in residential areas due to noise problems. They are most suitable in rural areas on approaches to villages.

Rumble strip A form of rumble device which are generally made of a thermoplastic material applied to the road surface in strips. Rumble strips can be installed at decreasing spacing to give drivers the illusion that their speed is increasing.

Rumblewave surfacing A form of rumble device made of hot-rolled bitumen shape to form an optimised sinusoidal profile with a maximum wave height of 6-7 mm. Rumblewave is designed to create noise and vibration within a vehicle but not increase external noise levels (a problem with traditional rumble strips).

‘S’ hump This hump profile was developed by Fife Council in Scotland as an alternative to the conventional road hump and speed cushion for bus routes. The ‘S’ hump has the advantage over the speed cushion that it can be used as a pedestrian crossing.

Safety audit A system for checking highway engineering schemes for potential safety problems.

Safety cameras Enforcement cameras e.g. red light and speed cameras.

Segregated use Where different road user groups are segregated within the highway. This may be cyclists and pedestrians.

Shared surfaces Roads where pedestrians and vehicles share the available space. Only suitable in low flow/ speed roads, for example Home Zones and Quiet Lanes.

Sheltered parking Parking which has build-outs to designate and protect the parking area, this may form part of a chicane system.

Side strips Overrun space along the side of a road for large vehicles to use.

Signs and markings Signs prescribed by the Traffic Signs Regulations and General Directions 2002.

Signs authorisation Required from the Overseeing Authority before using non-prescribed traffic signs on a public road.

Sinusoidal profile road hump A road hump which is similar to a round-top hump but the profile is sinusoidal which means that it has a shallower initial rise.

Sleeping policemen Another name for round-top humps.

Speed (Design speed) The speed used in selection of traffic calming measures.

Speed (Mean speed) The average of all speed measurements.

Speed (Median speed) The speed which 50 per cent of vehicles travel below.

Speed (85th percentile speed) The speed which 85 per cent of vehicles travel below.

Speed control camera Used to record vehicles which exceed a preset speed. The housing and signing can be effective at reducing speeds even when the camera is not installed.

Speed control island Another name for a false roundabout.

Speed cushion A hump which occupies only part of a traffic lane having a width which is less than the front wheeltrack of a conventional bus but is greater than the wheeltrack of an average car. Can be used in various layouts including single, double, triple, and double pairs to suit the road width and layout.

Speed hump Another name for a road hump.

Speed table Another name for a flat-top hump.

Splitter island A traffic island, which splits the road as at the entry/exit to a roundabout.

Street furniture Permanent objects located on the highway.

Tactile surface Part of the footway with a raised texture which can be used by visually impaired pedestrians to give them helpful messages such as the location of crossing points.

Tapered edge hump A hump which does not go right across the full road width but allows a drainage channel between the kerb and the hump. Note that full width humps, e.g. humped crossings, require additional drainage.

Target speed The speed at or below which the measures implemented are intended to hold vehicles.

Threshold A raised footway across a side road entrance to a traffic calmed area.

Throttle Another name for a pinch point.

Through traffic Traffic which travels through an area and does not stop apart from at junctions. It may be desirable to minimise through traffic, which may include rat-runners, in residential areas.

Thump A ‘thump’ is a road hump, which is made of thermoplastic material and is 900-1500 mm in length and 35-45 mm in height. They are not suitable for achieving low target speeds but are adequate for 30 mph roads.

Toucan crossing A crossing with traffic lights which enables both pedestrians and cyclists (either walking or riding) to cross the road together.

Traffic calming Self enforcing engineering measures, which reduce and control vehicle speeds to a target speed.

Traffic island Traffic islands are similar to pedestrian refuges but not intended for pedestrian use. They are primarily used to narrow the available road width and to prevent or discourage overtaking. They may also be used to protect segregated lanes such as bus or cycle lanes.

Traffic management Combinations of measures which alter the routes used by drivers and/or the speed at which they travel.

Transverse yellow bar markings Transverse bar markings used on the approaches to roundabouts to alert drivers. Need special authorisation. Not to be confused with rumble bars.

Type approval Type approval by the Secretary of State is required for the equipment used in connection with variable message signs.

Uncontrolled crossing point A place for people to cross which is not controlled by traffic light signals or Zebra crossings.

Variable message signs A sign that displays 2 or more aspects as described in regulation 58 of the Traffic Signs Regulations and General Directions 2002.

Vehicle activated signs A variable message sign which is triggered by a vehicle which exceeds a certain pre-set limit. These may be of two types, speed enforcing or warning of a hazard. The sign is illuminated to show the speed limit or one of the warning signs permitted by the Traffic Signs Regulations and General Directions; a 'SLOW DOWN' message may also be used with certain signs.

Vertical deflection A general term for any measure which alters the vertical alignment of the carriageway over a short distance. Includes road humps and rumble strips.

Vertical element Vertical features such as bollards, lighting columns, poles, signs, trees used to emphasise a change in the character of the road. These are often included as part of a gateway feature.

Visual width This is the same as optical width and is the width of the road as seen by a driver. The road may appear to be narrower than it really is by means of road markings and vertical features.

Visual load/psychological load Providing measures, which stimulate a driver's visual and psychological perception of a road encouraging the driver to adopt a slower speed.

Vulnerable road users Vulnerable road users are those who are likely to be seriously injured in accidents including pedestrians, cyclists, motorcyclists, equestrians, children and the elderly.

'Watts profile' road hump The original round-top hump designed by Watts at TRL.

Woonerf This is a Dutch word which means a 'living space' street where speeds are kept very low (15 kph). These gave rise to Home Zones in the UK.

A selection of American names for measures

Note. There are many minor differences that are not listed below.

Bulbout – A bulbout is a narrowing of the road from both sides.

Bump – The road marking 'bump' and sign 'speed bump' have sometimes been used to mark road humps.

Parallel choker – A pinch point.

Seminole County profile road hump – A flat-top hump with a 3.048 metre plateau and 1.829 metre (round profile ramps). Essentially an round-top hump extended by inserting a flat-top in the middle.

Speed bumps – Vertical deflections of less than 900 mm in length and 50-75 mm high.

Traffic circle – This is similar to a roundabout but the main road has priority over the minor road.

Twisted choker – A chicane.

A selection of Australian names for measures

Note. There are many minor differences that are not listed below.

Angled slow point A chicane.

Centre blister A splitter island.

Centre-Pede A painted wide centre median for pedestrians crossing at non-specific locations mostly near playgrounds shops and other pedestrian generators.

Diagonal closure A closure used at a junction.

Squeeze point A narrowing.

‘Tadpole’ A two lane chicane with a centre blister island.

Wombat crossing Pedestrian crossing.

Appendix J. Appraisal of traffic calming measures

In the preparation of any case for installing traffic calming schemes, local authorities should provide an appraisal of the impacts of the scheme, including the social and environmental gains.

Appraisal

The Guidance on Full Local Transport Plans incorporates advice on the Local Transport Plan process, including how to appraise schemes in line with the New Approach to Appraisal (NATA) – introduced in the White Paper A New Deal for Transport – Better for Everyone – and how to prepare a case for Government or joint funding.

Good practice demands that every transport project be appraised at a level of detail appropriate to the value of the project and the scale of its impact. As traffic calming proposals will generally fall below the 'major scheme' threshold, detailed justification is not required and DfT does not need to specifically sanction LTP expenditure on such schemes. But local authorities will need to demonstrate that even low-cost traffic calming schemes are suitable and effective in tackling local transport problems, and DfT recommends that this is done against the five NATA objectives – safety, economy, environment, accessibility and integration – and their relevant sub-objectives, shown below.

The objectives and sub-objectives to be used in transport applications of NATA are:

Environment – to protect the built and natural environment

- to reduce noise
- to improve local air quality
- to minimise climate change
- to protect and minimise impacts on the landscape
- to protect and enhance the townscape
- to protect and minimise impacts on heritage
- to support and minimise impacts on biodiversity
- to minimise impacts on water resources
- to increase the physical activity benefits from walking and cycling
- to improve journey ambience

Safety – to improve safety

- to reduce accidents
- to improve security

Economy – to support sustainable economic activity and obtain good value for money

- to improve the economic efficiency of the transport system
- to improve reliability

- to provide beneficial wider economic impacts

Accessibility – to improve access to facilities for those without a car and to reduce severance

- to increase option values (that is, the value to individuals of having available options which they do not use)
- to reduce severance
- to improve access to the transport system

Integration – to ensure that all decisions are taken in the context of the Government's integrated transport policy

- to improve transport interchange
- to integrate transport policy with land-use policy
- to integrate transport policy with other Government policies

DfT's Guidance on the Methodology for Multi-Modal Studies (GOMMMS) provides further information on the new approach to appraisal. It makes clear that, alongside the formal appraisal to judge whether the project is worthwhile, there are inevitably other practical considerations, such as affordability, effectiveness in solving identified problems and public acceptability.

The Highways Agency has devised a Project Appraisal Report system specifically for appraising smaller road schemes. It is intended to reduce the information and analysis requirements for smaller projects and is thus likely to be of particular value for the appraisal of traffic calming projects. The system requires a preliminary assessment of each impact to be judged to be 'beneficial', 'neutral' or 'adverse'. Each non-neutral impact is then classified as 'slight', 'moderate' or 'substantial'.

One of the principles of NATA and hence the PAR system is that a single sheet summary of the relevant information should be prepared for decision-makers. This should clearly state the problem that the project is intended to solve, the other solutions that have been considered, and the project impacts.

The assessment is used as follows. If the benefits of the project clearly outweigh the adverse impacts, and none of the adverse impacts is more than 'slight', the preliminary assessment is considered sufficient to enable a sound decision to be taken. However, if some of the adverse impacts are 'moderate' or 'substantial', more detailed appraisal is required of those aspects only. Further details of the Project Appraisal Report system and GOMMMS are available on the website:

www.dft.gov.uk/pgr/economics/rdg/multimodal/

or from Integrated Transport Economics and Appraisal (ITEA) division.

In applying this system to Traffic Calming measures, the main impacts are likely to be as follows:

- Traffic calming results in reduced speeds and hence a reduced number of accidents and the severity of any accidents that do occur.
- Reduced vehicle speeds will improve conditions for pedestrians and cyclists, making these activities more attractive, providing the design of the measures take pedestrians and cyclists into account. Some calming schemes may provide specific facilities for non-motorised users such as safe crossing points or widened pavements.
- The installation of traffic calming measures may have an adverse impact on emergency service and bus operations as a result of the reduction in speed of vehicles used for these purposes.

- Because of lower speeds overall traffic and vehicle noise should be reduced. However, the character of the noise may be changed which, at least initially, may result in some complaints. Where large vehicles make up 10 per cent or more of the traffic composition, body rattle noise may predominate which may increase traffic noise if full width road humps are installed.

- Ground-borne vibrations resulting from traffic calming measures will not cause structural damage but may result in a nuisance arising where the sub-grade is of a softer soil type and, for example, road humps are located near to frontage properties.

- Traffic calming is likely to decrease traffic flows on the roads where it is applied, reducing severance. However, it may increase traffic flows on surrounding roads.

- Traffic calming has been shown to increase individual vehicle emissions because of slower vehicle speeds. However, as traffic calming also results in reduced traffic flows the overall vehicle emissions are not generally increased. Care may be necessary if the traffic calming schemes occur in an Air Quality Management Area In these areas particular attention will need to be given to balance between reductions in injury accidents and increases in vehicle emissions. It is unlikely that vehicles diverted to other roads will significantly effect the emissions on those roads.

- Sympathetic materials, appropriate planting and high quality design can help to protect and enhance land and townscapes. Conversely, features such as brightly coloured surfacing, signs and markings can have a negative visual impact, especially in rural or historic areas.

- Traffic calming is unlikely to have any impact on bio-diversity or water resources.

Costs

Both capital and maintenance costs should be identified and estimated.

Social costs and benefits

Benefits to users should be realistic and it may well be the case that for some traffic calming measures some road users may be worse off. This does not imply that such schemes should not be pursued but an honest assessment of the effects compared to the existing situation should be prepared.

Wider social benefits such as reduced crime or fear of crime, improved community cohesion, increases in house prices in an area, effects on local businesses, and development of a sense of place, may be hard to quantify. Assessment may be possible by using analysis from similar schemes implemented elsewhere.

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Department for Transport
Department for Regional Development (Northern Ireland)
Scottish Executive
Welsh Assembly Government

This Local Transport Note (LTN) brings together in one comprehensive document a summary of the research commissioned by the Department for Transport (DfT, formerly the DTLR, DETR and DoT), together with some research from external sources, to provide advice on the use of traffic calming measures today. It covers relevant legislation and the design, effectiveness and installation (including signing and lighting) of measures. This LTN does not aim to cover issues such as driver education or speed limit enforcement.

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