Chapter 23 Cycling

23.1 Introduction

Cycling is an increasingly important element in transportation strategies to achieve sustainable development (DOT, 1996a). It offers health, environmental, economic and other benefits. It is suitable for many local journeys and can be used in combination with public transport for longer trips. The total number of journeys by bicycle in the UK is equivalent to those made on British Railways and London Underground combined (Morgan, 1991). In some towns, such as Cambridge, York and Oxford, cycling accounts for around 20% of journeys to work. Most cycle journeys (51%) are for commuting, business or education, with leisure accounting for 31% (Figure 23.1). By comparison, 31% of journeys by all modes are for commuting, business or education with 32% for leisure (DOT, 1994a). The overall level of cycle-use in the UK is low, being only two percent of all journeys, compared with some other European countries. The UK Government recognises a potential to transfer some short journeys from car to bicycle and has set a national target of doubling the number of journeys by bicycle by 2002, compared to the 1996 base, with a further doubling by 2012. The National Cycling Strategy sets out the framework to achieve this target (DOT, 1996b).

During the 1980s, a number of experimental and innovative cycle schemes were undertaken in the UK (Harland *et al*, 1993) and abroad. The results indicate that integrated physical and policy measures, including engineering, education, encouragement and enforcement, are required in order to increase cycle-use and to improve safety for cyclists (EFTE, 1994). For cycling to replace trips by car,

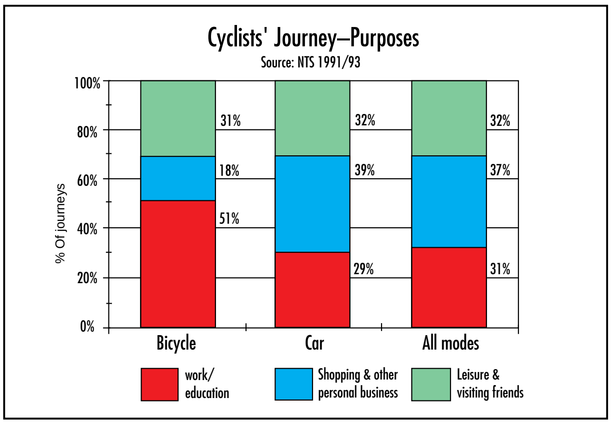


Figure 23.1: Cyclists' Journey–Purposes.

complementary demand management measures are also necessary. Investment in measures to assist cyclists is rising (Davies *et al*, 1995). It is important, therefore, that cycle–schemes meet their objectives and are cost–effective.

23.2 Objectives and Strategies

The principal objectives of providing for cyclists are:

- ❑ to maintain and, preferably, increase the level of cycle–use; and
- ❑ to reduce danger to cyclists, thereby reducing the accident rate per distance cycled and the perceived risk .

These objectives should be set in the context of wider sustainable transportation goals, including reducing the growth of car–use and promoting alternatives, such as those set out in PPG13 (DOE/DOT, 1994) (see also Chapter 6) [NIa] [Sa] [Wa].

To achieve these objectives, positive consideration of the needs of cyclists is required in all highway, traffic management, safety and maintenance programmes. Providing cycle facilities should not be an objective in itself. Cyclists require roads or cycle tracks that are safe, convenient and pleasant to use. Detailed guidance on making the existing road infrastructure more suitable for cyclists, and on developing new facilities, is provided in Cycle–friendly Infrastructure: Guidelines for Planning and Design, a collaborative project by the IHT, DOT and cycling organisations (IHT *et al*, 1996). In this, a hierarchical approach to improving conditions for cyclists is recommended.

Hierarchy of measures

Traffic reduction. Can traffic volumes be reduced sufficiently to achieve the desired improvements in attractiveness and safety for cyclists? Can heavy lorries be restricted or diverted?

Traffic calming. Can speeds be reduced and drivers' behaviour modified to achieve the desired improvements?

Junction treatment and traffic management. Can the problems that cyclists encounter, particularly accident–locations, be treated by specific junction treatment or other traffic management solutions, such as contra–flow cycle lanes?

Photograph 23.1: College Green, Bristol – now closed to motor vehicles Courtesy: Mike Ginger.

Re–allocation of the carriageway–space. Can the carriageway space be re–allocated to give more space to cyclists, perhaps in conjunction with buses?

Cycle–lanes and cycle–tracks. Having considered and, where possible, implemented the above, what specific cycle lanes or tracks are now necessary?

The specific measures which are adopted depend on the overall transportation strategy for the area and the local conditions. It is necessary to consider the intended function of the roads in the network, their physical form and their actual use. The design solution may involve adjusting one or more of these factors. For example, the appropriate design solution for a road that is used as a short–cut by through traffic may be to make a short length of the street one–way with a contra–flow cycle–lane, thus modifying both form and use.

There is no single correct solution to providing suitable infrastructure for cycling: much will depend on the broader traffic, environmental and planning objectives and on the available funds. Measures are likely to be more easily funded and implemented if they benefit the wider community, not just cyclists. Strategies that emphasise traffic restraint, speed reduction and promotion of environmentally–friendly modes will tend to benefit cyclists.

Cycle audit procedures are recommended, to ensure that opportunities to benefit cyclists are properly considered in all highway and traffic scheme design. A cycle audit is not the same as a safety audit. Cycle audits seek opportunities to improve cycling conditions, whereas safety audits seek to avoid dangerous design for all users, including cyclists. Further guidance can be found in the IHT guidelines (IHT *et al*, 1996).

23.3 Cycle Networks

The purpose of providing a cycle network is to concentrate resources to enable cyclists, of a wide range of abilities and experience, to move more safely and conveniently between all points in a town and also to reach the surrounding countryside. The basis of the cycle network is the existing road network, augmented by special facilities where appropriate.

A good cycle network will have the following features:

- ❑ 'coherence' – the cycling infrastructure should form a coherent entity, linking major trip origins and destinations; routes should be continuous and consistent in quality;
- ❑ 'directness' – routes should be as direct as possible, based on desire–lines, because detours and delays will deter use;
- ❑ 'attractiveness' – routes should be attractive to cyclists on subjective as well as objective criteria – good lighting, personal safety, aesthetics and integration with the surrounding area are important;
- ❑ 'safety' – designs should minimise casualties and perceived danger for cyclists and other road–users; and
- ❑ 'comfort – cyclists need smooth, well–maintained surfaces, with regular sweeping and gentle gradients and routes must be convenient to use, avoiding complicated manoeuvres and interruptions.

Segregation of cyclists from motor vehicles is not essential as an objective. Broadly speaking, cyclists can mix safely with vehicular traffic of all kinds at speeds below 20 miles/h. They can also mix safely with vehicular traffic at speeds between 20 miles/h and 30 miles/h, unless volumes are high or there are significant numbers of Heavy Goods Vehicles (HGVs). Additional lane–width, or possibly segregation, is desirable where traffic flows are heavy. Where speeds are between 30 miles/h and 40 miles/h, some form of segregation or additional lane–width is preferable. Above 40 miles/h, segregation is necessary for the majority of cyclists. However, local circumstances, such as kerbside parking, lane–widths, side–road junctions, driveways and available space are crucial and consideration should first be given to reducing motor vehicle speeds. Segregation will rarely be appropriate on low–flow rural roads.

Cycle networks should be planned on the basis of cyclists' trip origins, destinations and desire–lines. Information on actual and suppressed demand, including leisure trips, should be collected. This can be obtained from the National Census journey–to–work data, classified traffic counts,

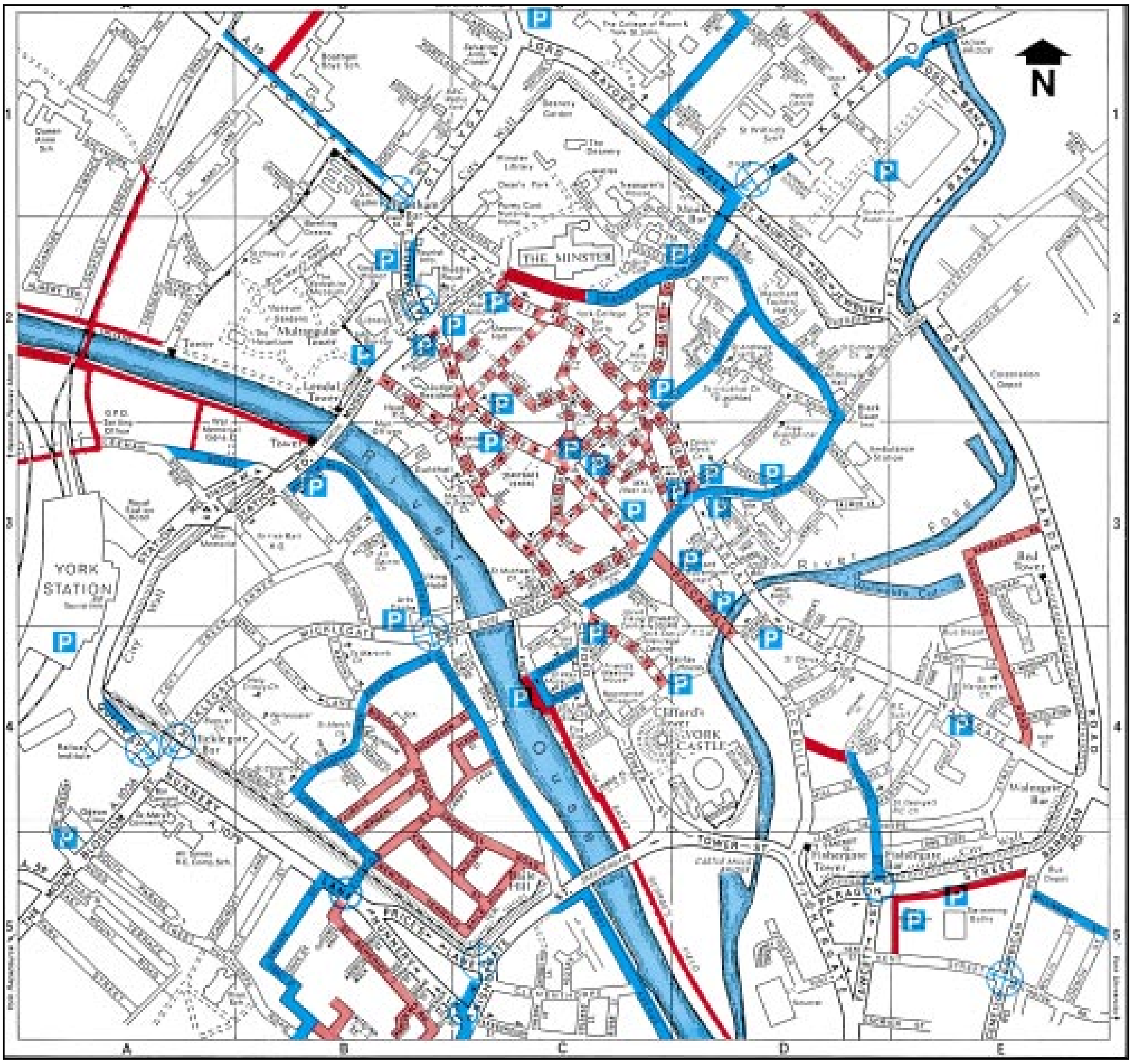
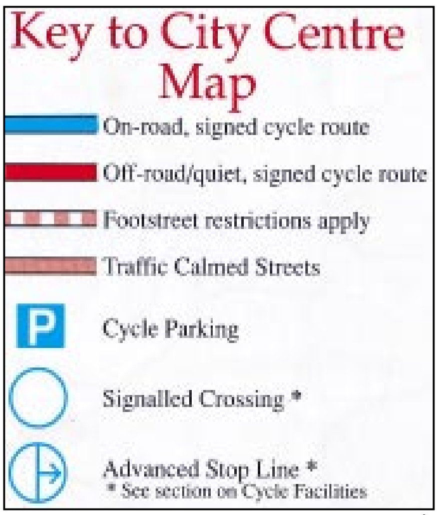


Figure 23.2: Cycle network map, York.



Figures 23.2: Key to city centre map and road signs for cyclists.

specific surveys and consultation with local cyclists. Traffic models are available that can predict potential levels of cycle trips and assign these to the local road network, based on population and socio–economic data (Rickman, 1995). Accident–location plots can also be useful in identifying routes used by cyclists and sites requiring treatment.

Equipment exists for the collection of cycle flows on dedicated cycle–tracks. Automatic equipment for counting pedal cycles in mixed traffic streams has proved problematic but improvements are expected, due to new techniques and increased computing power. Manual classified counts should record pedal cycles but staff must be properly briefed or the data may be unreliable, particularly where cycles are a small proportion of the total traffic. Manual cycle–only counts are more reliable and can record additional factors, such as gender and age range. Inductive loops, used to detect bicycles at signals, can be linked to dataloggers to monitor the numbers of cyclists. Infra–red or microwave detectors can also be used. Other monitoring systems, using piezo–electric sensors, are also in use. The sensor is located in the surface of the cycle track, usually within a concrete pad or smooth tarmacadam surface. The detectors pass the information to data–recorders, which store it for future analysis.

Route–choice criteria must be taken into account. Cyclists will usually choose the quickest route for most journeys. They are reluctant to accept detours, unless there are significant compensating advantages. Cyclists will avoid routes that are hilly, perceived as dangerous or have bad riding surfaces (Hopkinson *et al*, 1989).

Once the pattern of demand has been established, opportunities for traffic management or construction measures should be assessed. In practice, this will be an iterative process. It is important that physical opportunities alone do not determine which measures come forward, in isolation from knowledge about cyclists' desire–lines.

A network proposal plan should be produced, that shows speed limits, traffic calmed routes/areas, traffic management and accident remedial schemes, cycle–lanes/tracks and cycle–parking locations. Maps and publicity are valuable in raising public and professional awareness of cycle–routes and cycling in general. An example is shown in Figure 23.2.

23.4 Construction and Maintenance

Relatively minor defects in road or cycle–track surfaces can be an accident hazard for cyclists, whereas for drivers they may be merely an inconvenience. A good quality riding surface is essential for comfort and safety and can also affect the speed at which cyclists can travel. Ideally, that part of the highway used by cyclists should be smooth and maintained to a higher standard than the remainder of the carriageway, otherwise cyclists may avoid it.

The surface of a cycleway should have an even profile. Defects in either longitudinal or transverse profile can cause loss of control. The surface should have a smooth macro–texture, to give a comfortable ride, and a harsh micro–texture, to ensure good skid–resistance for cornering and braking (IHT *et al*, 1996). Asphalt gives the best riding surface, provided it is properly laid on a good foundation. It is relatively cheap to lay and maintain, with laser–guided machines to achieve a sufficiently even surface. Hand–laid asphalt is usually uncomfortable at speeds above 10 miles/h. Dense Bitumen Macadam (DBM) is porous and may require an asphalt base–course to maintain the integrity of the construction. Materials with gravel content should be avoided, as these become polished and slippery in wet conditions. Concrete can provide an acceptable riding surface over short stretches and is almost maintenance free. Block paving can be acceptable for limited stretches, provided it is well laid and meets the criteria of evenness and texture. However, block paving tends to trap glass and other debris and can be uncomfortable. Paving slabs, or flags, tend to result in an uneven surface and often have poor skid–resistance.

Distinguishing different areas of carriageway by surface colour is useful. Red has been commonly used to indicate cycle–lanes or cycle–tracks, although green is now used more frequently. Coloured surfaces should be used consistently, so that road users know what to expect. It is recommended that coloured surfaces should be used for areas of the carriageway to discourage others vehicles from entering, such as at positioning lanes at junctions and bus/cycle lanes. Surface treatment is usually achieved by a pigmented slurry seal. It should be borne in mind that the application of slurry seal greatly reduces texture depth and can result in surfaces becoming slippery in the wet. A slightly more costly, but generally more satisfactory, alternative would be a 'Macamit'–type aggregate surface dressing, 12–15 mm thick. A more suitable material for use on carriageways would be a coloured surface dressing, using a small aggregate (3–6mm) and an epoxy resin binder.

The transition from cycle–track to carriageway is critical for cyclists' comfort and safety. The transition should be as smooth as possible with no upstand. This is best achieved by using full radius kerbs, minimum radius 2.0m, or dropped kerbs that are fully flush with the cycle track and the carriageway. An alternative, though less satisfactory arrangement, is to use channel squares or bull–nose kerbs laid flush. Dropped kerbs used upside down can give a reasonably smooth transition.

Where the road has a pronounced camber, reconstruction may be necessary to avoid an uneven transition from cycle–track to carriageway. As cyclists tend to use the edges of the carriageway, efficient drainage is very important; so, too, are well–constructed and maintained gullies and gratings. On minor roads, cyclists are normally able to cycle away from the road–edge. However, on busy roads, particularly those with sub–standard lane–widths, cyclists will be less able to avoid gullies. On such roads, it is recommended that the gully openings should be in the kerb–face, not in the carriageway surface. Improvements of this type should be phased–in with structural maintenance or other programmes.

Reinstatement of the paved surface, immediately after roadworks, should match existing levels. The New Roads and Streetworks Act (HMG, 1991) sets out standards for reinstatement by statutory undertakers [NIb]. Computerised maintenance management programmes can be used to set priorities. It is recommended that routes of importance to cyclists should be identified for priority maintenance. Provision should be made for cyclists at road–works, with appropriate signing and diversion routeing. Delays and detours for cyclists should be minimised. Routes used by cyclists require regular sweeping to remove glass, loose gravel, litter and other detritus. Cycle–tracks and cycle–lanes require more frequent sweeping than all–purpose roads, as they are not routinely 'swept' by motor vehicles. The costs and arrangements for adequate sweeping should be fully considered at the planning stage.

23.5 Signing and Road–Marking

Consistent and high quality signing will assist cyclists with route–finding and advertise the presence of cyclists to other road–users. Cycle destination signs should normally include two destinations, the next destination and the major destination. It is helpful if primary routes are also identified by a name or number. Signs should conform to the current regulations (HMG, 1994 and DOT, 1994b) [NIc]. It is essential that signs should be made secure, so that they are not easily removed or turned around. Poles on cycle–tracks should be positioned at least 0.5m back from the edge, so as to maintain the effective path–width and they should not be located in the cycle–track. Signing should indicate route continuity and, where appropriate, cycle–route priority. 'Cyclists Dismount' signs should be used only where absolutely essential and the use of 'End' markings should be minimal. 'Give Way' markings may be more appropriate, supported by markings and upright signs. 'Cyclists Rejoin Carriageway', for which special authorisation is required, may be helpful to explain route continuity. The 'Except Cycles' plate should be added to 'No Through Road' signs where cyclists have a through route. Where a cycle–route passes through an unlit park or similar area, signs to indicate 'Alternative Route After Dark' may be indicated but need special authorisation.

Raised–rib road–markings consist of a continuous line marking, with ribs across the line at regular intervals. Concern that these would cause discomfort and possible accident problems for cyclists led to the development of an alternative design for use on all–purpose roads. They should not be used where cyclists are likely to cross the markings, including those locations where cyclists are likely to cross when riding parallel to the markings (DOT, 1995d) [Sb].

23.6 Safety for Cyclists

Cyclists present little danger to other road–users, other than pedestrians on shared facilities, but are particularly vulnerable to injury in collisions with motor vehicles. About eight percent of all reported road casualties are cyclists. In accidents involving an adult cyclist and a motor vehicle, only 17% were found to be the fault of the cyclist (Mills, 1989). Moreover, approximately three–quarters of cyclists' accidents are not reported to the police and therefore do not appear in the road traffic accident statistics, normally quoted. Accidents not involving a motor vehicle, and those occurring off the carriageway, such as on cycle–tracks, are also rarely reported.

The reported cyclist casualty–rate per distance travelled is twice that for a pedestrian and 16 times that for a car–occupant and the cyclist casualty–rate per journey stage is four times that for a car–occupant. However, comparisons between modes are not straightforward: one third of cyclist casualties are children under 16, yet the estimates of cycle traffic, on which the rates are calculated, exclude children's play in the street. The average cycle journey–length is also only one quarter of the length of the average car journey (O'Donoghue, 1993) (see also Chapter 16).

Casualty–rates per distance travelled for motor vehicle passengers have declined steadily, whereas the cyclist casualty–rate has remained static or increased. Fatality–rates, however, have fallen. More hazardous conditions have led to less cycling, which tends to increase the dangers to remaining cyclists as, with fewer of them, drivers are less alert to their presence. Cyclists' safety in the UK is about the same as in Germany but inferior to that in Denmark and the Netherlands.

Any significant increase in the amount of cycling may be expected to increase the number of cyclists injured, unless this can be offset by safety improvements. Indeed, if safety for cyclists is not improved it is unlikely that cycling will increase significantly. Evidence from Europe suggests that, where cycling increases, the accident–rate per distance cycled declines. In the UK, York City Council has encouraged cycling, maintained high levels of cycle–use and succeeded in meeting national casualty–reduction targets. If cycling were to increase, as a result of transfers from private cars, risks to other road–users should also diminish. The British Medical Association (BMA, 1992) points to the net gains in health and fitness that would arise through an increase in cycling. Evidence also suggests that, if the reductions in risk to other road–users are taken into account, more cycling need not lead to increased total casualties, so long as measures are implemented to provide for cyclists on the transport network.

Reducing the danger perceived by cyclists is also important if cycling is to increase. Perceived danger may be a good indicator of actual danger for cyclists (Sissons *et al*, 1993). Traditional procedures for selecting local safety schemes can overlook 'treatable' groups of cyclist accidents, because they are less numerous and appear more dispersed than motor vehicle accidents. Cyclist accidents tend to cluster along certain routes, as well as at junctions. It is necessary to consider each road–user group separately and to address their individual needs within an integrated framework (Hall *et al*, 1989). Appropriate methodologies are proposed by Hall (1993).

23.7 Training, Publicity and Promotion

Cycle Proficiency Training

Good cycle proficiency training for children is essential to enable them to cycle safely and independently. The most effective training schemes are those which involve stages, completed at different ages, with each stage conducted over several weeks (rather than intensively over a shorter period) and including on–road training (Savill *et al* 1996). Integrating cycle training with lessons on science, technology, environment and physical education will help to make it more relevant and memorable. Cycle training in schools is recommended for children aged nine to 11, although in Denmark and elsewhere it starts at a younger age. A cycle training code of practice was produced jointly in 1994 by the DOT, the Road Safety Officers Association, the Cyclists Touring Club (CTC) and the Royal Society for the Prevention of Accidents (RoSPA). Recognised training courses includes RoSPA's 'Rightrack'. Many local authority Road Safety Officers have developed or adapted their own cycle training schemes, often in conjunction with the police, local schools and cyclists' organisations.

There is some demand for adult cycle training, principally from those who have not ridden since childhood or who lack confidence to cycle in today's traffic. Successful schemes have been provided, involving riding skills, the Highway Code, route planning and cycle maintenance. Detailed advice for adult cyclists is provided by Franklin (1988).

Safety, Education and Publicity

Improving the status of cyclists is important to improving road safety and encouraging cycling. Safety education and publicity material should portray cyclists as legitimate and valued road–users, undertaking everyday journeys. Material aimed at drivers should emphasise the need for drivers to exercise appropriate care, particularly regarding speed, in the vicinity of cyclists. This approach is set out in the DOT's strategy for improving the safety and freedom of child pedestrians (DOT, 1996d) and is highly relevant to other vulnerable road–users, such as cyclists. For campaigns aimed at cyclists, material that has a high information content, such as cycle route maps and technical advice on equipment, is particularly valuable and likely to be of genuine interest. Danger should not be exaggerated (Davies *et al*, 1997). Factual information on cycle helmets – the types, their uses and limitations – can be helpful. If an accident occurs, wearing a helmet may prevent or reduce the extend of injury (Royles, 1994). However, the advantages of helmet–wearing should not be exaggerated. In Australia, where cycle helmet use became compulsory in 1991, the casualty reduction effect appears to have been slight. The main effect has been to reduce the amount of cycling (Robinson, 1996). The safety benefits of helmet–wearing may be outweighed by the loss of health benefits (Hillman, 1993).

Promoting Cycling

Organisational, financial and attitudinal factors can havea major influence on people's willingness to cycle. In order to encourage cycling, policy and promotional initiatives are required, in addition to infrastructure and safety measures. Attitudes to cycling are influenced by peer presure and the culture of employers and society (Davies *et al,* 1997). The Department of Transport's Cycle Challenge fund has supported innovative schemes which address these issues, including cycle–friendly employer schemes, school cycling projects and cycle centres, which provide comprehensive back–up services. Cycling is also being encouraged as an integral part of 'green' commuter plans and travel awareness campaigns. In these contexts, cycling is seen as part of the solution to wider objectives, rather than as a single issue campaign.

23.8 Traffic Calming

Traffic calming can assist cyclists and other road–users, by reducing motor vehicle speeds and encouraging drivers to pay greater attention to vulnerable road–users. As well as reducing casualties, well–designed area–wide traffic calming can help to increase levels of cycle–use (Hass–Klau *et al*, 1990). Consideration of cyclists in traffic–calming programmes may help to determine priorities: for example, schemes that provide safe routes to schools may be given higher priority. Bus routes and routes followed by emergency vehicles should be taken into account, when developing area–wide traffic–calming schemes. The definition of a hierarchy of routes can assist this process. Some routes may be important through routes for cyclists and these should be designed accordingly (see also Chapters 13 and 20).

Most traffic–calming schemes originate as safety or environmental schemes, in which cycling is only one consideration. The specific needs of cyclists should always be considered from the outset, so that traffic calming can improve routes for cyclists and so reduce accidents and promote cycling. Badly–designed traffic–calming measures can increase dangers to cyclists and cause them to divert to other routes, which might also be unsatisfactory.

The IHT guidelines provide advice on good design for cyclists in traffic–calming schemes (IHT *et al*, 1996). Examples of provision for cyclists are illustrated in the County Surveyors' Society report (CSS, 1994).

Recommended general principles are:

- ❑ that traffic–calming schemes should be seen as an opportunity to encourage and facilitate cycling, as a means of transport, and the specific needs of riders should be considered from the outset. This

Photograph 23.2: Road closure with cycle–gap, Oxford.

Photograph 23.3: Rumble strip with cycle–gap, Kensington. Courtesy: TRL.

Photograph 23.4: Cycle by–pass at traffic throttle, Oxford.

may require special features, such as cycle–bypasses, ie short stretches of segregated route, allowing cyclists to bypass the traffic–calming features, or it may simply mean paying attention to the design and construction details of standard traffic–calming features;

❑ that designs in which the presence of cyclists becomes the principal speed–reducing feature should be avoided – for example, a road narrowing that leaves insufficient width for drivers to pass a cyclist. Even if all drivers behave considerately, some cyclists will feel intimidated in these situations, particularly by large vehicles;

❑ that features that endanger the stability of cyclists, such as rumble strips and upstands on turning manoeuvres, should not be used unless a satisfactory alternative is provided for cyclists;

❑ that designs should take account of likely obstructions, particularly illegally parked vehicles, and maintenance operations, which may limit the use of cycle by–passes;

❑ that surface materials should be skid–resistant, particularly in wet weather, and obstructions in the carriageway, including all ramp–faces, should be clearly visible after dark;

❑ that access restrictions imposed on motor traffic, such as banned turns, one–way streets and road closures, should provide an exemption for cyclists, unless there are overriding safety reasons which prevent this (see Photograph 23.2); and

❑ that local cyclists and cycling groups should be consulted at an early stage on the appropriateness and design of all proposed traffic–calming schemes.

Specific design recommendations can be made, in relation to particular features, as follows:

❑ 'road humps' – transitions and gradients should be gentle, with no upstands; 75mm high round–top humps, or road humps with cycle by–pass facilities, such as speed–cushions, are preferred in asphalt. Humps with a sinusoidal profile have been installed in Edinburgh and have been more widely used on the Continent (CROW, 1993);

❑ 'rumble strips'– a gap 0.75m–1.5m wide should be provided for cyclists and positioning should take account of cyclists' desire lines and any provision for parked cars (see Photograph 23.3);

❑ 'horizontal deflections' – at pinch points, traffic islands and chicanes, a cycle by–pass or a shared running lane 4.5m wide is recommended. The latter is likely to have little or no traffic–calming effect but may still provide a satisfactory pedestrian crossing refuge. If neither is possible, a shared running lane of three metres or less, in which overtaking is not possible, may be preferable, provided that vehicle speeds are low. This may require a prior speed–reducing feature. Where cyclists' safety would be compromised by traffic islands or central refuges, alternative measures should be sought. Chicanes should be designed so that the paths of cyclists and motor vehicles do not conflict on exit; and

❑ 'cycle by–passes' – these should be 1.0m – 1.5m wide between faces. They should be straight through and as short as possible. Where they are more than a few metres in length, or are kinked, the full width will be more important. They should remain at carriageway, not footway, height. Where cycle flows are heavy, 1.8 m width, or an alternative design, may be necessary (see Photograph 23.4).

23.9 Cycle–Lanes

Cycle–lanes, bus/cycle–lanes and wide nearside lanes are all useful techniques for assisting cyclists in appropriate circumstances. Cycle–lanes help to alert drivers to the presence of cyclists and give cyclists greater confidence. They help cyclists to pass queueing traffic and lead cyclists to special facilities at junctions, such as advanced stop–lines. They are most useful where there are few side–roads and no parking or loading requirements. Cycle–lanes can be used to narrow the carriageway visually, particularly where the objective is to reduce the number of running lanes. However, they do not necessarily induce drivers to give cyclists greater clearance when overtaking. They are not kept clear of debris by the passage of motor vehicles, so additional sweeping is required. If used in unsuitable locations or have a substandard width, cycle–lanes can lead to increased accident–rates (Wegman *et al*, 1992). They are unnecessary on roads with low vehicular traffic flows

Photograph 23.5 Bus/cycle–lane, Shrewsbury. Courtesy: Peter Foster.

and on roads with 20 miles/h speed limits. Cycle–lanes should be a minimum of 1.5m wide and preferably two metres. If 1.5m cannot be accommodated, 1.2m may be acceptable for very short sections, such as at the approach to advanced stop–lines.

Mandatory cycle–lanes, marked by a solid white line and backed by a traffic regulation Order, prohibiting motor vehicles from using the lane, are better respected by drivers than advisory cycle–lanes, marked only by a broken white line. Coloured surfacing helps to keep motor vehicles out of cycle–lanes (see IHT *et al*, 1996 and DOT, 1989). Mandatory cycle–lanes must be discontinued at side–road junctions. Discontinuing advisory lanes, where they cross side–road junctions, encourages motor vehicles turning left into the minor road to do so at the junction and not encroach into the cycle–lane. However, it may also lead to abrupt turning movements by vehicles, rather than a gradual merge with bicycle traffic. Other options worth considering are: continuing an advisory lane through the junction (emphasised by a coloured surface); or allowing motor vehicles to merge with the cycle lane, in advance of the junction (Wilkinson *et al*, 1994).

Cyclists should be permitted to use bus–lanes unless there are overriding safety reasons to exclude them. On busy roads in urban areas, a bus–lane will give cyclists greater separation from general traffic than would a cycle–lane on its own. It may also be easier to justify a combined bus/cycle–lane than a lane exclusively for one mode (see Photograph 23.5). Introducing and enforcing parking restrictions in bus–lanes is likely to be more successful than in cycle–lanes. Where there is adequate carriageway width, bus–lanes should be 4.25m – 4.6m wide to

Photograph 23.6 Advanced stop–line for cyclists, Edinburgh. Courtesy Philip Noble and Edinburgh City Council

Photograph 23.7 Staggered stop–lines, Cambridge.

allow safe passing within the lane. However, narrower widths can work satisfactorily, depending on the flows of buses and cycles and traffic in the adjacent lane. Instead of peak–hour arrangements 12–hour or 24–hour bus–lanes are preferable. Permitting motor–cyclists to use bus–lanes is not recommended.

Wide nearside lanes allow large vehicles to pass cyclists in relative safety and comfort. They are useful on roads where there is occasional parking or loading or where there are significant numbers of heavy goods vehicles or buses. They are usually inexpensive to install, particularly if carried out when resurfacing or repainting carriageway markings. No traffic regulation Orders or additional signs are required. They should be 4.25m wide. If narrower, cyclists will have insufficient clearance from passing traffic and, if wider, traffic may form two lanes. Additional width can usually be taken from outer lanes. However, wide nearside lanes do not have the same attraction for

Photograph 23.8 Bypass to traffic signals and entry restriction.

'new' cyclists as cycle–lanes and they do not channel traffic.

23.10 Signal–Controlled Junctions

Signal–controlled junctions offer designers various possibilities for installing features to assist cyclists (see also Chapter 40).

'Advanced stop–lines' for cyclists enable them to position themselves, more safely, ahead of motor vehicles, thus reducing conflicts between left–turning vehicles and straight–ahead or right–turning cyclists (see Photograph 23.6). The position of the approach cycle–lane (nearside or central) needs to be carefully considered. There is no evidence that advanced stop–lines reduce the capacity of the junction. On roads with three or more lanes, a two–stage, 'jug handle' turn will assist less–confident cyclists to turn right (DOT, 1993a and 1996c) [Sb].

'Staggered stop–lines', where the cycle–lane is continued one or two metres ahead of the main stop–line but without a widened reservoir, can also be beneficial to cyclists. These help to place the cyclists in the driver's view. Staggered stop–lines may be appropriate where the right turn is not available or where, for some local reason, a standard advanced stop–line cannot be accommodated (see Photograph 23.7).

'Cycle by–passes' may also be incorporated into signal–controlled junctions to enable cyclists to bypass the signals, particularly for cyclists turning left or going straight ahead at T–junctions. Cyclists' speed and manoeuvres should be considered when determining signal–phasing, cycle times and linking of sets of signals. The length of the intergreen on staggered junctions is particularly important. Signal–controlled junctions are generally preferred to roundabouts by cyclists, for safety reasons and because their rights of way are better respected (see Photograph 23.8).

23.11 Roundabouts

Some types of roundabout can be particularly hazardous and intimidating for cyclists. Problems tend to arise due to uncertainty, as to whether or not drivers will give way to cyclists, and also because of the high speeds of motor vehicles through some types of roundabout. Over 50% of cyclist accidents at roundabouts are due to an entering vehicle striking a circulating cyclist. Turning right on large roundabouts is particularly difficult for cyclists. Roundabouts have a substantially worse accident–rate than other junction–types for cyclists – about four times the rate for traffic signals. However, the accident–rate for motor vehicles (other than motor cycles) at roundabouts is generally good. Large roundabouts cause the most concern, although small roundabouts with flared entries and inadequate deflection also have a poor record for cyclist accidents (Layfield *et al*, 1986). Segregated left–turn lanes are also unsafe for cyclists. Conventional and signalised roundabouts have a better cyclist accident record. In some circumstances, mini roundabouts can form useful features in traffic–calming schemes, although they are not always 'cycle–friendly' (see also Chapters 16 and 39).

Experience of unsegregated roundabouts in Continental Europe suggests that roundabouts can be a reasonably safe junction–type for cyclists, if they have:

- ❑ a 24m – 32m external diameter;
- ❑ a circulatory carriageway that prevents overtaking, ie less than 8m wide; and
- ❑ radial entry arms, slightly curved towards the centre island (Balsiger, 1995).

These designs can accommodate flows of 2000 motor vehicles per hour and substantial numbers of cyclists. This suggests that it is the design of roundabouts, rather than roundabouts *per se*, that determines the risk to cyclists. Other Continental roundabout layouts give circulating cyclists priority over entering and exiting motor vehicles. These work best where there is a high flow of cyclists, to achieve drivers' observance of the cyclists' priority. Their use in the UK would need to be accompanied by intensive and effective driver–information.

Alternative techniques to improve the safety of existing roundabouts for cyclists have been well established in the UK (Allott & Lomax, 1993) and include:

- ❑ signalising the roundabout (Lines, 1995) and providing advanced stop–lines;
- ❑ altering the geometry, particularly reducing entry–widths, increasing deflection and narrowing the circulatory carriageway;
- ❑ reducing vehicle–speeds on entry;
- ❑ altering sight–lines and conspicuity; and
- ❑ attending to road markings and signs, particularly circulatory lane–markings.

Peripheral cycle tracks, segregated from the carriageway, can be useful at some large roundabouts. However, they may introduce delays at crossing points with each approach arm such that cyclists do not use them. Signal–controlled 'Toucan' crossings of the arms may be necessary but should be located carefully to prevent blocking of the junction exit (see Section 22.7). Cycle–lanes on the outer edge of the carriageway encourage cyclists to ride in the area that entering drivers find most difficult to see. Therefore, continuing cycle–lanes onto roundabouts is not recommended.

23.12 Grade–Separated Junctions

Crossing the mouth of an entry, or exit, slip–road at a grade–separated junction is particularly hazardous, as motor vehicles will often cross a cyclist's path at high speeds. Junction designs that reduce entry speeds and increase deflection on entry will help to reduce risks to cyclists. Advisory dog–leg cycle–crossings can be provided at existing junctions (DOT, 1988) [Sb], although this is not entirely satisfactory. Alternative routes that avoid such junctions should be made available wherever possible (see also Chapter 43).

23.13 Priority Junctions

Cycle–lanes on the minor road should normally be discontinued well before a junction with a major road, with the distance depending on the turning movements at the junction. Traffic islands and bollards can protect right–turning cyclists. Cyclists should normally be exempted from prohibited turns (see Photograph 23.9). Converting three–arm priority junctions to mini–roundabouts can lead to an increased accident–risk to cyclists. It seems that junctions with clear priorities are preferable for cyclists (Summersgill,1989) (see also Chapter 38).

Photograph 23.9 Exemption from right–turn restriction, Birmingham.

23.14 Cycle–Tracks

Cycle–tracks are most useful where the volume and/or speed of motor traffic is high and where there are few side–roads or other interruptions. Route continuity and safe and convenient crossings of side–roads are crucial. Cycle–tracks tend to reduce accidents on links but increase accidents at junctions, particularly in urban areas and where intervisibility is poor (Wegman *et al*, 1992). Good quality riding–surfaces and frequent sweeping are essential.

A cycle–track alongside the carriageway should be 2m – 3m wide. Where provided, they should be installed on both sides of the road for safety and convenience. One–way cycle–tracks are safer than two–way, as accidents tend to occur between traffic turning into side–roads and cyclists travelling contra–flow on the cycle–track. Where two–way use is likely, the design should accommodate this (DOT 1986b and DOT 1989) [Sc].

Cycle–tracks should be given priority at junctions with minor side–roads, wherever this can be achieved safely. Where space permits, the cycle–track should be bent gradually away from the main carriageway by 4m – 8m. Priority can be emphasised by the use of a raised crossing. Where there is sufficient space to accord priority, by 'bending out' the cycle–track, it may be preferable to maintain priority by merging cyclists back onto the carriageway into an advisory cycle–lane prior to the side road. If cyclists are not accorded priority, 'Give Way' signs should be used. 'Cyclists Dismount' signs should not be used (see Section 23.5). Dropped kerbs should be flush, with no upstand. Guidance on side–road crossings can be found in the IHT guidelines (IHT *et al*, 1996).

Footways converted to shared use in urban areas rarely provide a good quality cycle–facility and may inconvenience pedestrians. Space should first be sought within the carriageway. If footways are converted they should have light pedestrian flows, few driveways or minor road crossings and good intervisibility.

Cycle–tracks away from the carriageway, such as those created on disused railway lines, will have different characteristics but should still conform to high standards of safety and design, particularly regarding sight–lines, personal security and maintenance (Sustrans, 1994). Where they are intended as commuter routes, lighting is desirable. This should normally be provided to footway lighting standards and BS 5489.

23.15 Road Crossings

The Department of Transport provides advice on the range of facilities that can be provided to enable cyclists and pedestrians to cross roads (DOT 1986a, 1995a and 1995b) [Sc]. These include unsignalled and signal–controlled crossings, such as the Toucan, which is an unsegregated crossing for cyclists and pedestrians. Useful layout details for a number of crossing arrangements are provided in the National Cycle Network guidelines (Arup and Sustrans, 1997). To meet the needs of cyclists, dropped kerbs should be fully flush, with no upstand (DOT, 1991) [Sd].

23.16 Cycling and Pedestrians

Cyclists and pedestrians have many common characteristics and interests. Both groups, in their contribution to transport, are environment–friendly, cause few accidents to others but are vulnerable to injury from motor vehicles. Cycling and walking are highly efficient modes for local trips and can form an important component of longer journeys. However, despite common interests, they cannot be regarded as a single mode (CTC *et al*, 1995).

Provision for cyclists should normally be made within the carriageway. If no satisfactory on–carriageway solution can be found, it may be appropriate to consider converting the footway to shared use or to seek an off–road alternative. Consultation with local organisations is important, particularly with those representing people with mobility difficulties, such as blind and partially–sighted people. Guidance is provided by the DOT (1986b and 1990) [Sc] [Sb] . Segregation requirements tend to be dependent on the types of user and the flow levels. Where new facilities are created, such as cycle–paths away from roads, unsegregated use is more likely to be acceptable but personal security issues should be considered carefully.

Where streets are pedestrianised, cyclists should not necessarily be excluded unless there are good reasons and suitable alternative routes (DOT 1993b) [Sb]. When pedestrian densities are high, cyclists tend to modify their behaviour (Trevelyan *et al*, 1993). Segregating cyclists and pedestrians in pedestrianised areas will not always be necessary or desirable. Where it is desirable, cycle–movements can be combined with selected motor vehicles, such as buses and service vehicles, permitted at particular times of day or channelled by defined paths. Admitting cyclists to pedestrian zones can help to maintain their vitality outside shopping hours.

23.17 Grade–Separated Crossings

Where high quality grade–separation can be achieved, this will be superior to crossing at grade. Detours, gradients, accident–risks and personal security all need to be considered.

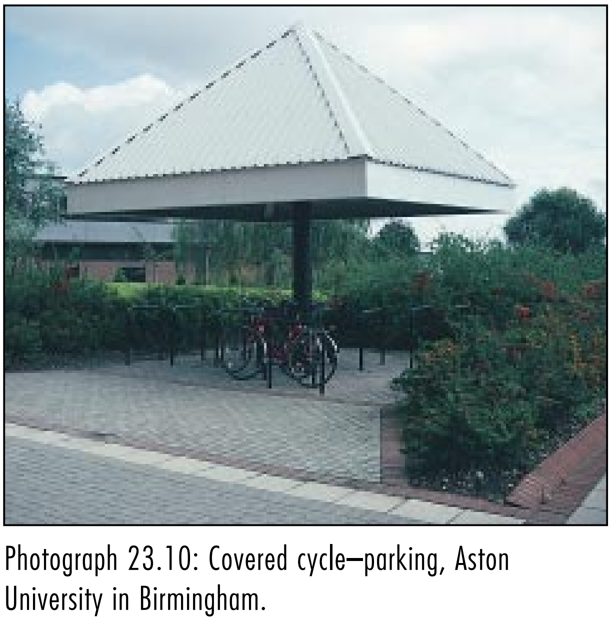
For new subways, the DOT standard for trunk road construction (DOT, 1993c) indicates suitable dimensions and layout. Straight approaches, straight–through visibility, flared entries and good lighting will improve their safety and acceptability. Converting existing pedestrian subways to shared use is recommended only where a useful and high quality outcome can be achieved. Guidelines on dimensions are recommended by the DOT (DOT, 1986a) [Sc].

Bridges can be useful to cyclists, depending on the on–ramp gradients and detours. Parapet heights should be 1.4m–1.5m and adequate forward visibility on entry and exit is also important (see also DOT, 1995c).

23.18 Cycle–Parking

Good quality cycle–parking can encourage cycle–use, particularly at workplaces, at railway stations and in town centres (see Photograph 23.10). Theft is a major problem; some 200,000 pedal cycles are reported stolen each year and the total number stolen each year is estimated at 600,000 (DOT, 1996e) and usually less than 10% are recovered. This is a burden for the police and a deterrent to cycling.

Cycle–parking standards should be included in development control guidance, issued by local planning authorities. Commuted payments may be



Photograph 23.10: Covered cycle–parking, Aston University in Birmingham.

MINIMUM NUMBER OF PARKED CYCLES THAT SHOULD BE ACCOMMODATED

SAMPLE CITY	(1991 population)	Bristol (370,300)	Cambridge (101,000)	Oxford (109,000)	York* (100,600)
% journeys to work by cycle (1991 Census)		4%	28%	18%	19%
TYPE OF LAND USE	per				
Shops, Services (A1/A2)	100 m² (staff) 100 m²	2 2	4	4	1 2
Restaurants, Cafes, Public Houses (A3)	(bar area) 50 m² (dining area) 50 m² staff	4	30 5	15 1 per 3	1 1 per 4
Business offices (B1)	100 m² 1,000 m² (staff) 1,000 m²	 1 5	3	4	 20
Industry (B2)	200 m² 1,000 m² 5,000 m²	4 4 12	5 25 125	5 25 125	4 20 100
Warehouses (B8)	200 m² 1,000 m² 5,000 m²	4 4 6	5 25 125	5 25 125	2 10 50
Hotels, Guesthouses (C1)	20 beds 100 beds staff	2 10	 1 per 2	 1 per 2	 1 per 4
Hospitals, Nursing Homes (C2)	100 beds staff	10 (in above)	 1 per 2	33 1 per 2	5 1 per 4
Clinics, Health Centres (D1)	treatment room staff	2 (in above)	2	2 2	
Secondary Schools (D1)	500 students staff	100	300	300	166 1 per 6
Colleges, Universities (D1)	500 students staff	100	500	500	166 1 per 6
Halls of Residence (C2)	student			1	
Other dwellings, Flats (C3)	unit bedroom	1	 1	 1	1
Libraries, Museums (D1)	200 m² staff	2	25	6 1 per 2	1 per 20 seats 1 per 4
Theatres, Cinemas (D2)	100 seats staff	2		25	5 1 per 4
Sports, Leisure centres (D2)	 staff	1 per 10 players	1 per 15 seats	use dependent 1 per 2	use dependent 1 per 4

*figures slightly lower in outer areas

NOTES:
1. Where figures were given for square feet, these have been translated to the nearest value for square metres.
2. Not all figures submitted by the local authorities have been included here; some have provided more details.
3. Specific land-use circumstances may alter some of the figures given.
4. Staff numbers given are for non-residential staff.

Fig 23.3: Examples of Local Authority cycle–parking standards for new developments. Source: Cyclists' Touring Club.

appropriate where on–site provision cannot be made in full (see also Chapter 27). 'Sheffield' parking stands are generally adequate for short–term parking; lockers and supervised cycle–parks provide better security and weather protection for medium to long–term parking. Guidance on development control standards and technical details is published by the Cyclists' Touring Club (CTC, 1993) and the London Cycling Campaign (LCC, 1995).

23.19 Bike–and–Ride

The combination of cycling and public transport, particularly trains, can be very effective and can increase, substantially, the catchment area of railway stations. 'Bicycle stations', where cycles can be parked, hired, repaired and bought are increasingly common in continental Europe. At smaller stations, cycle lockers are often provided for secure commuter parking. Considerable scope exists for improving access and provision for cyclists at railway stations in the UK.

23.20 Legislation

Legislative references regarding cyclists, and provision for cyclists, in England and Wales are provided in Cycle–friendly Infrastructure (IHT *et al*, 1996). Guidelines for Scotland are contained in the Scottish Office Cycling Advice Note 1/90 Making Way for Cyclists (SODD, 1990).

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The proceedings of the international Velo–City cycle–planning conferences, normally held every two years, are a valuable source of information and best practice, for example, Velo–City '93 in Nottingham and Velo–City '95 in Basel.