Chapter 31 Design Concepts

31.1 Introduction

This chapter deals with general principles relating to the design of highway networks in urban areas and is, to a large extent, based on the standards and advice provided by the Department of Transport [Sa]. Much of this information has now been compiled into a single multi–volumed document, known as the Design Manual for Roads and Bridges (DOT, DMRB).

When taking decisions on design, it is important to be aware of the overall strategy for the area through which a proposed road will pass. The funding of local transport by the Department of Transport [Sa] encourages proposals to be put forward, which are part of a package of measures for an area and not merely incidental road schemes considered in isolation.

In many instances, the Authority responsible for a road will have a transport strategy which may identify a hierarchy of priorities. These may vary depending on the location. Pedestrians may, for example, be the top priority on routes in the city centre but not necessarily in more remote locations. However, giving priority to one class of road–user often leads to a reduction in priority for other users. For example, cycle–friendly measures, such as widened nearside lanes, specially marked lanes on the carriageway and advanced stoplines, result in a reduction in the lane provision for other road–users. Similarly, the introduction of bus lanes on an existing carriageway is likely to lead to an increase in queue–lengths for the remaining traffic, which is restricted to fewer lanes.

Sometimes, priorities can be achieved for certain classes of vehicle, without the need to allocate roadspace solely for their use. The fitting of transponders to vehicles, coupled with the latest signal technology, can allow priority to be given to vehicles at traffic signals when they are detected in an approaching flow.

Pedestrian and cyclist measures should always be considered, particularly at road junctions. Carriageway widths can often be reduced to provide more footway area and to reduce both the distance and the time required for pedestrians to cross the road.

Local residents and operators of businesses in the vicinity of any road proposals should be given an opportunity to comment on alternatives being considered, in addition to any formal consultations carried out with organisations such as the police, emergency services and public transport authorities. A scheme which can achieve widespread support during the design process is likely to have fewer objections raised at the later stages.

The recommendations in the Design Manual for Roads and Bridges are sometimes difficult to achieve in dense urban areas, where there are many constraints in the form of buildings and public facilities. In applying these standards, it is necessary, therefore, to strike a balance between achieving desirable standards and their impact on the area.

31.2 Quality of Design and Construction

Quality in design and construction covers a range of issues, such as fitness for purpose, technical soundness and the choice of materials, as well as criteria such as aesthetics, durability, safety, ease and cost of maintenance, the effect on the environment and, not least, minimising the whole–life cost. Financial constraints will sometimes limit what can be achieved in terms of quality, although care and skill in both the design and construction processes will ensure the most satisfactory result.

Management of the design and construction process has usually been on an informal basis, with in–house systems of controls and checks aimed at eliminating error and thereby ensuring technical quality. Many organisations demonstrate their commitment to quality by seeking Quality Assurance (QA) accreditation under ISO 9001. The Government has encouraged this move towards QA accreditation, by making Quality Management a prerequisite for the highway works which it is procuring, either directly or through conditions attached to grant–aid. Many suppliers, and all materials laboratories, involved in Government–funded schemes must demonstrate a commitment to Quality Management.

Technical soundness, durability, maintenance and safety issues can be addressed by the application of appropriate standards. Care must be exercised in the

application of the individual standards to ensure compatibility of the results in any given set of circumstances. The aim of the design should be a scheme which is fit for its purpose, is aesthetically pleasing, and enhances, or at least does not detract from, the environment.

The strategy of national and local government, to remove through traffic from town centres by the construction of by–passes and traffic management, provides an opportunity to address the quality issues of design of the urban environmen – as it affects all classes of users, including vehicle drivers, cyclists, pedestrians and people with disabilities. Also, in a climate of environmental awareness, sensitive quality treatment of urban areas is expected by those who live and work in them. Utilitarian schemes are no longer acceptable. Manufacturers of construction materials have recognised the trend, and the demand, and offer a wide range of high quality materials for most aspects of highway construction, providing opportunities for innovation in design. Although there is a wide choice available, it is important to avoid the proliferation of products and styles. A co–ordinated approach, based on simplicity and the avoidance of clutter, is an important design principle. Schemes can be enhanced further by the addition of tasteful and sensitive hard and soft landscaping. Consideration should also be given, at the design stage, to future requirements for maintenance (see Chapter 12).

The choice of materials and treatment will require approval by the Planning Authority and, in preparing a design, due regard should be given to the Authority's planning policy or other strategies. Consideration should also be given to the scheme in its setting, as this will significantly influence the acceptability of design and materials. Later difficulties can be avoided by early consultation with the Planning Authority. Above all, quality control must be applied from design through specification and to construction.

31.3 Levels of Service

Levels of service describe the different operating conditions, which can occur on a road at different times, in terms of speed, safety, drivers' comfort and vehicle operating costs. The Design Manual for Roads and Bridges defines a sequence of service level standards in the form of a hierarchy of geometric design criteria related to design speed. A design based solely on maximum peak–hour travel demand and desirable minimum standards may result in a scheme which is unacceptable, because of its cost and the environmental impact that it may have in an urban area.

It is also vital that the designer considers the concept of level of service for all users, and not only drivers, at the outset and during the design process. The design brief for any urban scheme must embrace the need to accommodate and encourage movement by bus and on foot or cycle, to avoid the high degrees of severance often created in the past. A balance must be achieved in provision for all users which does not advantage one group by disadvantaging others. Generally, as traffic speeds increase, design standards need to be more generous in order to provide a given level of service.

Levels of service are normally deemed to be taken into account in the Department of Transport's [Sa] COBA [Sb] method of economic assessment, where higher levels of service, in terms of higher operating speeds, are traded–off against the additional costs involved. However, COBA was not designed specifically for use in urban areas. A general outline of demand modelling and of economic and environmental appraisal techniques is provided in Chapters 8 and 9.

31.4 Estimation of Future Traffic Demands

Future traffic demand for major urban roads is usually estimated using transportation models. These can take account of underlying growth in demand, assumed changes in land–use, parking strategy, the attractiveness of alternative modes of travel, the capacity of the surrounding road network and the design of the proposed scheme. The models can also estimate any likely increase in traffic demand resulting from the increased capacity provided by the scheme. Models can also be used to estimate future demand for public transport schemes. A fuller explanation of the role and capabilities of transportation models is provided in Chapter 8.

Traffic forecasts are subject to a considerable degree of uncertainty. Consequently, consideration should be given as to how sensitive the design is to variations in the predicted traffic flow. Forecasts may have been made using low and high traffic growth scenarios; in which case, these can be used as a basis for checking the robustness of the design. If a single scenario forecast has been made, it will be sensible to consider the effect that changes in the predictions would have on the design. A balanced view can then be taken about the appropriateness of the design, based on costs, the range of forecasts which the recommended

design could accommodate, the consequences of over or under–design and other such factors.

It may also be possible to minimise the consequences of under–estimating demand, by providing flexibility in the design for the provision of increased capacity. This might be achieved by making provision for the future construction of additional carriageway width or alterations to the layout or type of control employed at junctions. Such provision will generally involve some additional initial cost and judgement will have to be exercised as to whether this is justified.

31.5 Design Speed

Drivers regulate their speed in accordance with the road layout and their perception of prevailing road conditions. Apart from the amount of traffic on the road, weather and daylight conditions, the main factors that influence speed are visibility, curvature, road width, surface conditions, the presence of junctions and accesses and speed limits. In urban areas, traffic speeds are also influenced by frontage activities, pedestrians, pedestrian crossings, the presence of cyclists and buses and bus stops.

In selecting a design speed for a new road, account needs to be taken of the wide range of vehicular speeds exhibited in practice. Designing for the fastest drivers would be unnecessarily expensive and often environmentally unacceptable. It would also encourage higher average speeds by ordinary drivers, with a consequential decrease in safety at conflict points. To design for the much slower drivers could be unsafe for the faster drivers. The general practice is, therefore, to design for the 85th percentile speed (the speed below which 85% of vehicles travel, or may be expected to travel, in free–flow wet conditions) (see Chapter 36). The selected design speed should also be appropriate to the area through which the road passes and to the planned role of the route in the local road hierarchy (see Chapter 11).

The selected design speed should then be used as the basis for coordination of all the various elements of geometric design and the design should aim to create an operating environment that encourages drivers to conform to the chosen design speed.

31.6 Design Standards

The design of roads of national significance, ie those that form part of the trunk road network, is carried out in accordance with the requirements of the Department of Transport [Sa] [Wa]. The Department publishes a wide range of Circulars, Technical Standards and Advice Notes, many of which now comprise the Design Manual for Roads and Bridges (DOT, DMRB). The Design Manual covers a wide range of situations and local authorities need to consider, in each case, whether the standards are appropriate for their own roads.

Choice of Road Layout

The choice of layout and lane–provision for a major urban road will be derived from careful consideration of the desired level of provision, in terms of capacity, operating efficiency, safety, the constraints imposed by the urban environment, the effects of the proposals on that environment and the available sources of finance.

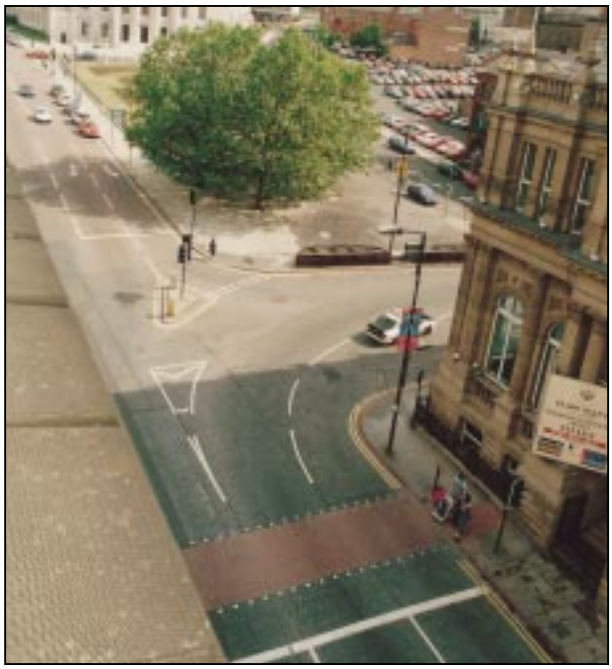
The alignment of a new urban road, or major improvement to an existing road, is normally constrained to a 'corridor of opportunity' determined by the extent of the land which can realistically be acquired. Also, the valid needs of particular vehicle–types or user–groups, such as pedestrians, cyclists and bus passengers, may constrain the design of alignment and layout.

Geometric Standards

The alignment for a new urban road should, whenever possible, be so designed that the various geometric elements, such as curvature, superelevation and sight distances, provide at least the minimum values consistent with the chosen design speed of the road. It is equally important that these geometric elements are not excessive, as this can lead to operating speeds, in practice, much higher than the intended design speed.

The severe constraints on road alignment, frequently encountered in urban areas, may mean that it is not possible to achieve the desirable design standards without prohibitive cost or environmental damage (see Photograph 31.1). The Design Manual recognises the need for a flexible approach to design in order to avoid unacceptable consequences, in terms of cost and environmental impact, which could result from rigid application of the desirable minimum standards. The Manual makes provision, therefore, for relaxations to, or departures from, the desirable minimum standard (see also Chapter 36).

Each situation where a relaxation is proposed should be considered on its merits, with regard to cost, environmental impact, safety and the effect on the various geometric parameters. Situations requiring exceptional reduction of standards, beyond those appropriate to 'relaxation', constitute 'departures'.



Photograph 31.1: Inner city one–way circulation–reduced standards on 90° bend.

Whilst relaxations are still considered to conform broadly to acceptable standards and provide a satisfactory level of service, without appreciable reduction in safety, departures can reduce safety significantly and careful consideration and approval is required before their adoption. Some of the adverse consequences of departures may be mitigated by adopting measures to improve safety by introducing, for example, special carriageway surfacing, additional signing, restrictive road marking or lower mandatory speed limits. For trunk roads, all proposed departures must be submitted to the Department of Transport [Sa] [Wb] for assessment and approval.

31.7 Frequency of Intersections

In urban situations, the requirements of access have a major influence on scheme design. It is essential to maintain access to existing land and property. The frequency with which junctions should be provided along a new or improved road depends on its role in the road hierarchy (see Chapter 11). The more important routes, ie primary distributor roads, should ideally have intersections with roads only of the same, or immediately lower, category. Existing roads of even lower categories which cross these roads should be diverted under or over the new road or closed to traffic. Where this is not a practical proposition, because of the constraints imposed by the urban environment, alternative solutions may have to be sought. Often an acceptable compromise can be achieved which will permit a higher frequency of intersections, at–grade, by incorporating a signalised Urban Traffic Control (UTC) scheme linking the junctions, in order to maximise flow, regulate speed and maintain safety (see Chapter 41).

Type of Junction

The type of junction required will depend on a number of factors, such as the number of roads to be connected, their various roles in the road hierarchy, the volume and composition of traffic on each (on– and off–peak), turning movements and, not least, what can physically be accommodated.

Consideration should be given to all the options; ie grade–separation, signal–controlled gyratory junctions, roundabouts, priority 'T' junctions (with and without signal control) and the linking of junctions through UTC (see Photographs 31.2 and 31.3) (see Chapters 37 to 43).

Photograph 31.2: Complex inner city signal–controlled junction with quality paving materials, architectural features and planters.

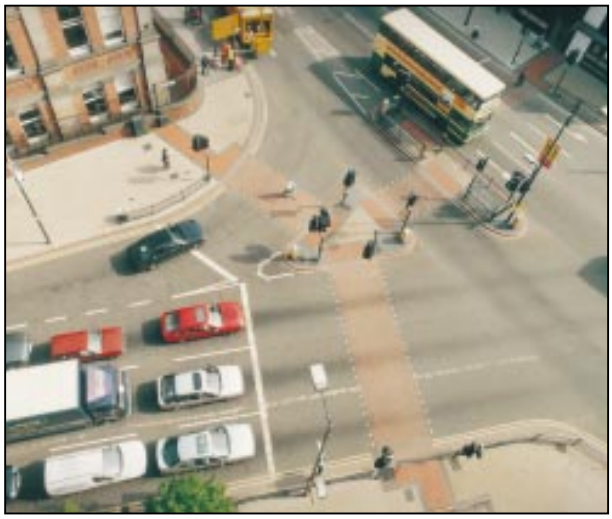
Photograph 31.3: Major signal–controlled roundabout with block paved crossings, architectural features and planters.

31.8 Provision for Pedestrians

Safe and convenient paths for pedestrians alongside and across major routes in urban areas are essential and these must be planned during the earliest stages of design (see Chapter 22).

On national routes and primary distributors, the aim should be to segregate pedestrian routes from the carriageway. In providing crossings to the carriageway, consideration should be given to the most appropriate form; ie grade–separation or at–grade. It should be borne in mind that there is, amongst many users, a fear of using subways and, if grade–separation is adopted, it should be made as attractive as possible to encourage use and to discourage pedestrians from crossing at unsuitable or unsafe locations. On district distributor roads in established urban areas, especially those with bus routes, significant pedestrian flows should be anticipated, particularly in the vicinity of bus stops, and the widths of footways should be increased. Elsewhere, for example in sub–urban areas, it may be acceptable to provide only the minimum width of 1.8m. Safety measures, such as short lengths of guardrails to channelise pedestrian movements and signal–controlled crossings at appropriate locations, should be incorporated from the start where safety would be improved. Staggering the two halves of a signal–controlled crossing frequently allows for more pedestrian green time than a straight crossing, although these can produce longer overall walking distances. The balance between pedestrians and other traffic should be assessed and pedestrian facilities should be provided at signal–controlled junctions, other than by exception (see Photograph 31.4).

Wherever possible, the urban environment should be made less intimidating and more accommodating to disabled people. Guidance has been produced by the Department of Transport Disability Unit (DOT, 1991) and by the Institution of Highways and Transportation (IHT, 1991). Designs to cater for the needs of people with different disabilities can sometimes conflict and designers should liaise closely with the groups representing their interests (see Chapter 22).



Photograph 31.4: Block paved signal–controlled crossing.

31.9 Provision for Cyclists

The Royal Commission on Environmental Pollution (HMG, 1994a) has recommended that comprehensive networks of safe cycle–routes should be developed in all urban areas. Many local authorities have already introduced cycle–priority schemes and more are planned.

Cyclists are legitimate, but highly vulnerable, road - users and should be catered for in ways which promote their safety and, where possible, their comfort and convenience. Highway authorities are increasingly developing strategies and policies to provide better accommodation for cyclists in the urban scene (see Chapter 23). The Highways Agency [Sc] [Wc] and many local authorities have appointed a Cycling Officer, to act as a focus and to provide specialist advice to policy–makers and designers.

Highway and traffic management schemes should be designed to relieve situations which are hazardous and intimidating to cyclists and should avoid creating new ones. Many techniques are available and the Department of Transport [Sa] has published useful guidance (see Chapter 23). This includes the design of cycle lanes, cycle tracks, road crossings and junctions sharing space with pedestrians and the use of signs and surfacing materials (see Photograph 31.5). The aim is to assist those seeking to make the general

highway infrastructure safer and more convenient for cyclists. Dedicated cycle routes are an important part of this, but only a part. The emphasis should be on reducing motor vehicle volumes and speeds and on using traffic management techniques to reduce accidents and to give cyclists a positive advantage. Planning for cyclists should be considered as part of mainstream transportation planning and not as an afterthought (see Chapter 23).

31.10 Provision for Buses

The majority of public transport journeys in urban areas are made by bus. With the introduction of the 'Package Approach' to funding by the Department of

Photograph 31.5: Toucan crossing, cycleway and bus lane highlighted in red calcined bauxite.

Transport [Sd], highway authorities are now giving more priority to schemes which assist buses. A number of innovative measures are available including pre–signals, queue relocation, gap generation, detection of buses stopping and tidal flow arrangements. Signal technology can also be used, together with loop detection or AVL transponders fitted to the buses, to give priority to buses even where there are no physical measures such as bus lanes (see Chapter 24).

Attention should be given to the siting of bus stops and shelters, the provision of adequate footpath widths and to the routes used by pedestrians moving to and from bus stops.

Bus priorities should be seen as part of an overall package of measures to enhance bus services, along with improvements to bus stations and passenger information. A park–and–ride site may be complementary to bus priority measures in order to attract drivers from their cars and onto buses at an earlier stage of their journey.

Public transport operators should be consulted at as early a stage as possible about any facilities that are planned.

31.11 Fixed–Track Systems

The increase in congestion and pollution in urban areas has encouraged renewed interest in the benefits of fixed–track mass transit systems, which have operating characteristics different from normal railways. Such systems are collectively known as 'Light Rapid Transit', sometimes abbreviated to LRT (see Chapter 34).

Design standards for fixed–track systems vary greatly across the range of different systems, which makes any attempt at standardisation difficult. Nevertheless, an at–grade intersection between an LRT system and a road can be treated as a kind of highway junction. The layout of the junction may be priority, roundabout or signalled but the best form of control will depend on the nature of the LRT system and on the traffic and pedestrian flows.

The level of priority which can be given to a fixed–track system will depend on the nature and layout of the junction that is adopted, the traffic flows and degrees of saturation of the approaches, the frequency of the fixed–track service and the direction and densities of all public transport services.

31.12 Minimising Environmental Impact

The impact of new road schemes and road improvement schemes on the environment can be minimised, if environmental assessment forms an integral and iterative part of the planning and design process and especially if care is taken in the design stages. The intention should be to avoid, wherever possible, sensitive locations, for example sites of scientific interest and sites of special scientific interest (SSIs and SSSIs), conservation areas, archaeological sites, housing areas, hospitals and schools and to blend the new/improved road into its surroundings (see Chapter 17).

Particular consideration should be given to the following aspects of design:

- ❑ selection of alignment and profiles for the new road and its structures which enable it to blend with its surroundings;
- ❑ sympathetic design of lighting and signing;
- ❑ sensitive reinstatement of buildings and an appropriate choice of materials and street furniture to match and blend with the existing townscape, including the use of coloured or textured materials to enhance the attractiveness of the area (see Photograph 31.6);
- ❑ avoiding, wherever possible, splitting buildings and carefully designing the remedial treatment of any truncated structure, such that the final appearance is aesthetically balanced;
- ❑ softening areas of hard landscaping by the planting of grass, shrubs and trees;
- ❑ minimising noise impact by the incorporation of sympathetically designed barriers and/or by the use of cuttings. Where possible, landscaped and planted mounds, or a combination of mound and wall, should be used. Walls and barriers should be

Photograph 31.6: Quality seating, fencing and paving material incorporated in a city centre highway scheme.

constructed of appropriate materials to blend attractively with the surroundings and care should be taken that reflected noise from these barriers does not adversely affect other sensitive areas;

- ❑ minimising air quality problems in sensitive locations, as far as possible, by utilising traffic management measures to keep traffic flowing smoothly and avoiding congestion and interrupted flow situations;
- ❑ determining the likely future pedestrian desire–lines once the scheme is completed and ensuring that adequate and suitably–located footways and crossing facilities are provided. Care should be taken to allow for the needs of disabled persons in these provisions;
- ❑ avoiding undue severance of communities; and
- ❑ anticipating problems and disruption, which may arise during the construction period, and making provision in the design and the contract to minimise these effects.

Clearly, some of these objectives are more easily achieved with a new road than when improving an existing corridor. However, designers have the responsibility to minimise the environmental impact of their design, whatever the circumstances. With sensitive design, the improvement of an existing corridor can result in an enhanced environment.

31.13 The Management of Construction

Building an urban road scheme will inevitably cause disruption and, usually, the bigger the scheme the greater the disruption. Clearly, this disruption should be kept to a minimum and liaison should be maintained continuously with the local community through the design and construction period.

The management of construction to avoid disruption begins during the design and contract preparation stage, when the designer should give careful consideration to how the scheme can be built. It is important to consider each element of the works individually, and in combination, to ensure that conflicts are avoided. Sufficient provision must be included in the contract to enable supervisory staff, in conjunction with the contractor, to exercise control over the construction. However, strict control to avoid disruption through the provisions of the contract will frequently inhibit efficient working and a balance has to be sought.

Advance contracts and/or temporary works, for example the temporary diversion of traffic, can provide additional capacity to facilitate construction of a scheme. Alternative routes should be provided wherever possible. Temporary signing, temporary traffic control, staged completions and delayed possessions are all means by which disruption can be reduced. It may be necessary to restrict construction to off–peak or night–time; in which case careful consideration of the environmental consequences is required.

Irrespective of the size of the scheme, strict limitations on nuisances caused by noise, vibration, dust etc. should be imposed by the contract. Reference should be made to Health and Safety Executive guidance and, where appropriate, advice should be sought from the local Environmental Health Officer. It is important also to consult and work closely with the police, emergency services, passenger transport and statutory undertakers at all stages of design. Ducts for cables should be considered when improvements are undertaken, in order to minimise future maintenance problems.

The construction industry has one of the worst accident records, with the highest number of fatalities, of any industry. Good management of the construction process is essential to prevent accidents. The Construction (Design and Management) Regulations (HMG, 1994b) is important legislation aimed at making the construction industry safer. The Regulations require the management of health and safety, through risk identification and assessment, and the management of risk at all stages of a scheme up to, and including, demolition at the end of its life to eliminate, avoid, or lessen the foreseeable risks. The Regulations apply to all parties associated with construction projects, ie clients, designers, contractors and workers, and identify the duties and responsibilities of each in the management of health and safety.

31.14 Maintenance Liabilities

The general maintenance of the new or improved highway and of the associated street furniture, traffic signs and street lights should be considered during the design process. Closure of a carriageway or even a traffic lane, to accommodate maintenance vehicles and equipment and to provide a safety margin for workmen, can impose additional operating costs and delays on other road–users. Temporary traffic arrangements, increasing capacity or making provision for maintenance, where the opportunity and budget allow, can provide flexibility for these occasions. Whole life costs, including the delay costs associated with maintenance, should be established when determining minimum carriageway construction thickness. Additional depth of pavement, for a longer design life, may be more cost–effective, in order to defer or obviate the costs involved in strengthening the pavement at a later stage.

The use of a needlessly wide range of materials will make maintenance more difficult and designers should be aware that specially manufactured products or 'one–off' materials may be difficult and/or expensive to replace when they are damaged. Temporary repairs should be avoided, where possible, because they tend to become 'semi–permanent' and an otherwise attractive environment can soon take on an air of neglect. In undertaking a repair, it is important to obtain the best possible match in the replacement materials. Many of the proprietary or specialist materials may have long delivery periods and it is important that a sufficient stock of these materials is available, not only for use by the Authority, but also, for example, by statutory undertakers, to enable them to effect a matching repair.

31.15 References

DOT (DMRB) 'The Design Manual for Roads and Bridges', Stationery Office.

DOT (1991) Disability Unit Circular 1/91, 'The Use of Dropped Kerbs and Tactile Surfaces at Pedestrian Crossing Points', DOT.

HMG (1994a) Royal Commission on Environmental Pollution 18th Report – 'Transport and the Environment', Stationery Office.

HMG (1994b) Statutory Instrument No. 3140, 'The Construction (Design and Management) Regulations 1994', Stationery Office.

IHT (1991) 'Reducing Mobility Handicaps', The Institution of Highways & Transportation.

31.16 Further Information

DOT 'The Manual of Contract Documents for Highway Works', Stationery Office.