THE HIGHWAYS AGENCY

TA 48/92

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

Layout of Grade Separated Junctions

Summary: This Advice Note updates and replaces TA 48/86. It gives recommendations for the geometric design of grade separated junctions and weaving areas with regard to traffic operation and safety.

Printed and Published by the
above Overseeing Departments

Price: £1.30

Volume 6 home page

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

VOLUME 6 ROAD GEOMETRY
SECTION 2 JUNCTIONS

PART 2

TA 48/92

LAYOUT OF GRADE SEPARATED JUNCTIONS

Contents

Chapter

August 1992

Volume 6 home page

1. INTRODUCTION

General

1.1 Standard TD 22 (DMRB 6.2.1) sets out the Overseeing Department's design standards and methodology for the geometric layout of grade separated junctions on trunk roads.

1.2 This Advice Note provides guidance on the principles for safety and traffic operation on which the Standard TD 22 (DMRB 6.2.1) is based and is intended to be read in conjunction with it.

1.3 Guidance on how the process of choosing a junction type may be structured is given more fully in Advice Note TA 30 (DMRB 5.1).

1.4 TA 48/86 is hereby superseded.

Scope

1.5 Recommendations are given on the siting of grade separated junctions in urban and rural areas, alternative layouts, geometric design and the treatment for pedestrians and cyclists. Some aspects of signs and road markings are included for completeness, though the full policy and detailed guidance on these matters are given in the Traffic Signs Manual and Standard TD 18 (DMRB 9.1).

Implementation

1.6 This Advice Note should be used forthwith on all schemes for the construction and improvement of trunk roads, including motorways, currently being prepared, provided that, in the opinion of the Overseeing Department, this would not result in significant additional expense or delay progress. Design Organisations should confirm its application to particular schemes with the Overseeing Department.

2. GENERAL PRINCIPLES

Urban/Rural

2.1 Grade separation design is based on the peak hourly flow which varies according to road type (TD 22 (DMRB 6.2.1) Para 3.1) and according to whether the road is motorway or all-purpose (TD 22 (DMRB 6.2.1) Table 3/1). Urban standards for most elements of road design are, however, lower than those applicable to rural roads, since lower driver expectation accompanied by higher perception offset the increased risks caused by reductions in standards. For grade separated junctions on dual carriageways, the presence of kerbs, frequent lack of hardstrips, narrow central reserve with safety fences, lighting and speed limits all confirm the urban nature of the road. The lower urban standards are shown within the hierarchy of geometric standards, ranging from rural motorways down to urban all purpose roads, related to Design Speed (TD 22 (DMRB 6.2.1) Table 4/4 and Table 4/5).

Siting

2.2 The siting of a grade separation can have a significant effect on both its operational performance and environmental impact. Therefore, consideration of the major contributing factors such as flow, geometric design, environmental effect, land take, maintenance, capital cost, topography and economics should be undertaken at the initial design stage to produce the optimum design for comparison with other junction types.

Departures

2.3 For rural schemes it should normally be possible to design options which conform to Departmental Standards. However, this may not be possible when considering urban schemes due to physical site constraints, which would result in very high costs and severe environmental damage if standards were to be maintained, and therefore Departures from Standards will be more likely. Proposals which might involve Departures should be discussed at an early stage in design with the Overseeing Department.

Safety

2.4 The main objective of grade separated junction design is to provide a junction which is safe for the forecast traffic levels. Research on the frequency and severity of motorway accidents at grade separated junctions has shown them to be comparable to the accidents occurring on the adjacent links, with no discernable clustering occurring in the merge/diverge areas. Other research has illustrated different relationships for accidents on motorway weaving lengths less then 3km, and grade separated junction loops (see Para 4.3). Certain layouts are not generally recommended for reasons of reduced safety and should be avoided in design. Examples are:

i. grade separated junctions on single carriageways (see TD 9 (DMRB 6.1))

ii. grade separation on dual carriageways within about 0.5km of the changeover from single carriageway standard, measured from the end of the merge taper to the beginning of the right hand lane hatching (see The Traffic Signs Manual Ch 4 Figure 4:28);

iii. offside merges and diverges;

iv. a major/minor junction with right turning movements on an otherwise grade separated route.

Layouts

2.5 Recommended layouts for consideration in order of traffic level are:

i. Diamond or half-cloverleaf;

ii. dumbbell roundabout;

iii. 2 bridge roundabout;

iv. 3 level roundabout;

v. interchange.

The design of an at grade junction within a grade separated junction is subject to the appropriate Departmental Standards and Advice Notes. For example, these are TA 23 (DMRB 6.2) for the determination of the size of roundabouts and major/minor junctions, TD 16 (DMRB 6.2) and TA 42 (DMRB 6.2) the Departmental Standard and Advice

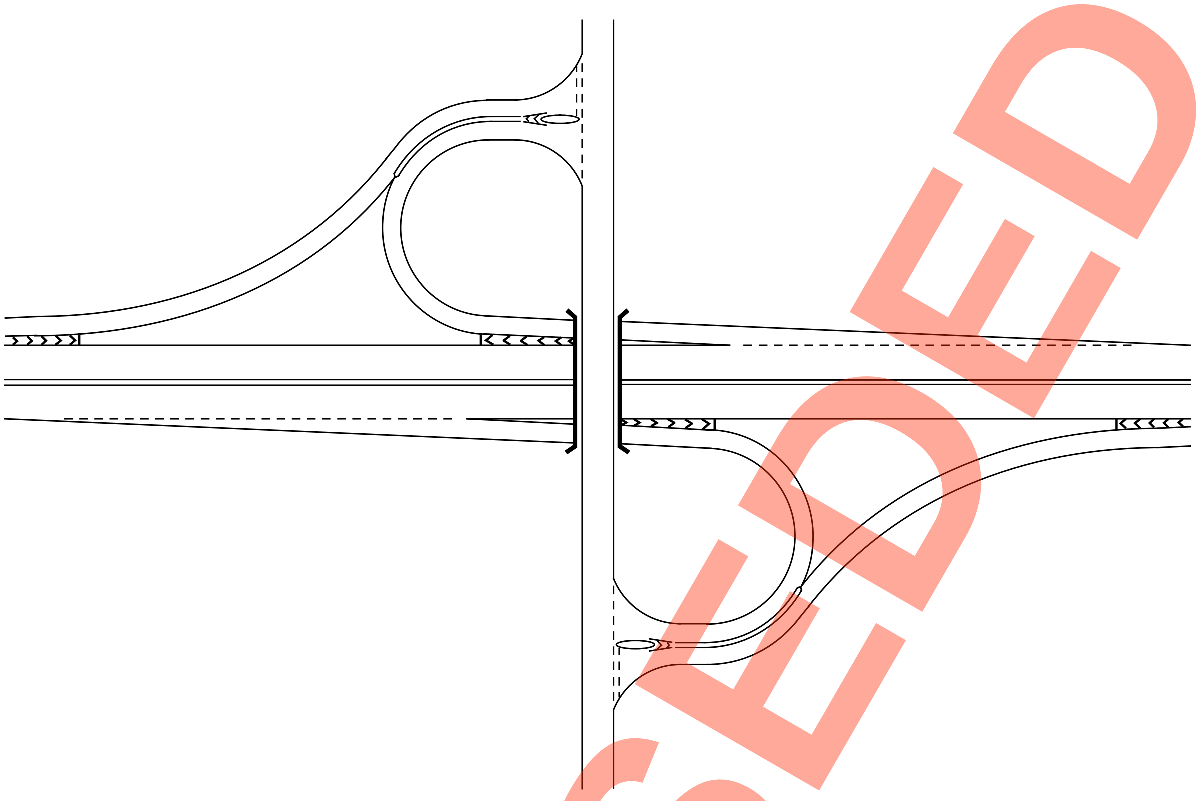
Note respectively, for the geometric design of roundabouts, and TA 20 (DMRB 6.2) for the layout of major/minor junctions.

All Purpose Road Alternatives

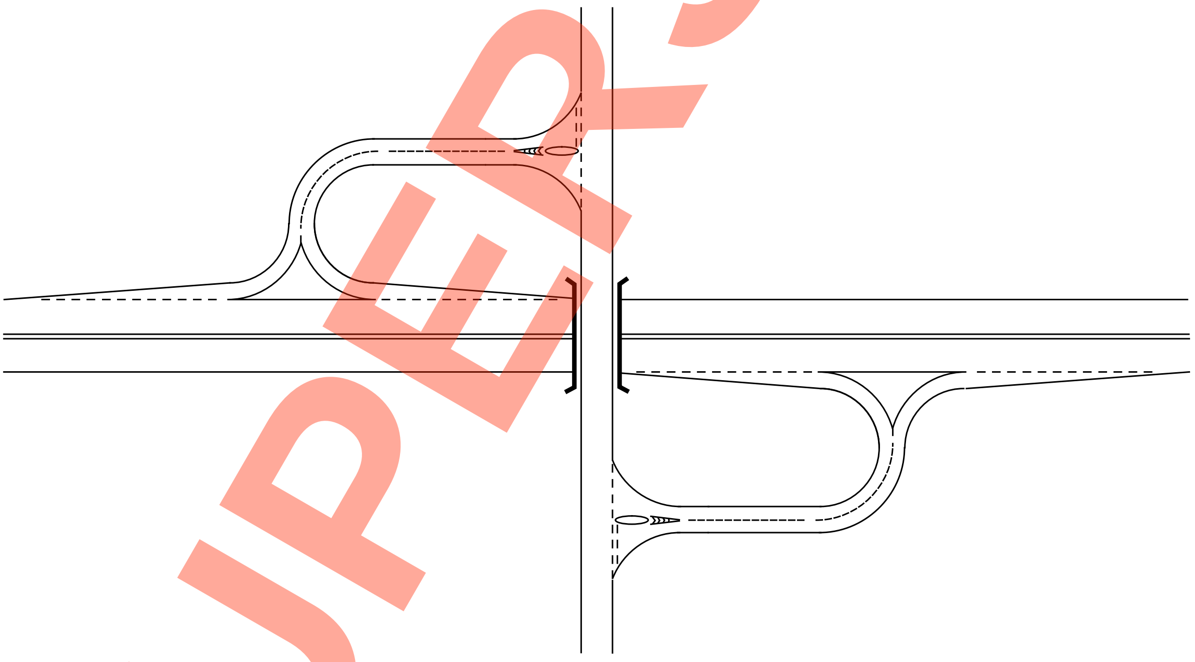
2.6 The geometric standards in TD 22 (DMRB 6.2.1) are specifically for grade separated junctions which have the appropriate signs and road markings as prescribed in the current edition of the **Traffic Signs Regulations and General Directions**, upon which advice is given in the **Traffic Signs Manual**. These standards are significantly higher than the merge/diverge recommendations given in TA 20/84, which should only be used when providing a low standard grade separated facility when the signing and road markings reflect the lower standard (see Figure 2/1). Using these lower standards, it has been found that grade separation can be economically justified at design flows of about 20000 AADT on the main line, depending on the turning traffic. This compares with a flow of about 30000 AADT if the geometric standards in TD 22 (DMRB 6.2.1) are used. These alternatives should be considered in accordance with TA 30 (DMRB 5.1). Grade separation should be pursued wherever it is economically possible and the environmental impact is not significant.

Motorway Service Areas

2.7 The merge/diverge layout design and junction spacing of a service area, should be based on the geometric parameters within TD 22 (DMRB 6.2.1).



a) Grade Separated Junction to Absolute Minimum TD 22/92 Standards



b) Major/minor junction incorporating a grade separated facility

(see Paragraph 2.6)

Figure 2/1. Distinction between TD 22 (DMRB 6.2.1) and TA 20 (DMRB 6.2) Layouts

Alternative Layouts

General

2.8 Two forms of grade separation are considered, grade separated junctions and interchanges.

Grade Separated Junctions

2.9 This form of grade separation involves the use of an at grade junction at the commencement or termination of slip roads. The at grade junction element, whether a major/minor junction or roundabout and slip roads can produce 3 main types of grade separation, Diamond, Half-cloverleaf and Roundabout, these are discussed below.

Diamond

2.10 A diamond is the simplest form of grade separation, the normal layout will provide turning movements onto and off the slip roads by two staggered junctions (see Figure 2/2). The use of crossroads is not recommended - see TA 20 (DMRB 6.2).

Half-Cloverleaf

2.11 A half-cloverleaf is used at similar flow levels to a diamond, particularly where site conditions are difficult and the use of all four quadrants is not possible (see Figure 2/2). The at grade junction element normally utilises two ghost islands.

Roundabout

2.12 The two most common forms of grade separated roundabout are the two bridge and dumbbell types - see Fig 2/3 and TA 42 (DMRB 6.2). The dumbbell type can be adopted to fit either the diamond or half-cloverleaf layout. Where two main routes cross and an interchange is uneconomical or the necessary land is unavailable, a three level junction utilising a roundabout for turning movements should be considered (see Figure 2/2). Some very large two bridge roundabouts have been constructed, but there have been problems for traffic entering them due to the high circulating speeds, though there are examples of successful conversions to ring junctions. Large roundabouts are not therefore normally recommended for new designs.

2.13 Variants on these three basic types can occur if:

a. the junction is 3 way ie a T junction:

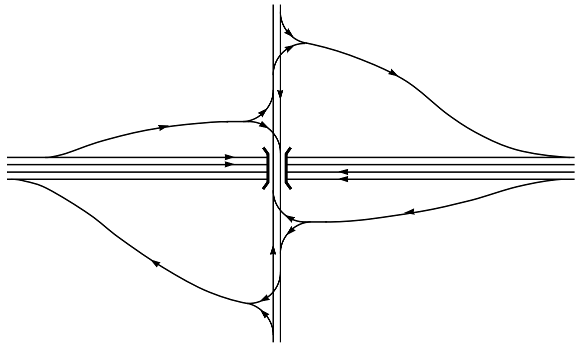
b. not all movements need catering for ie a half diamond:

c. traffic signals, either continuous or part time, are included to remove congestion on an existing grade separated junction. It is recommended that they should only normally be considered as an alternative to priority junction design:

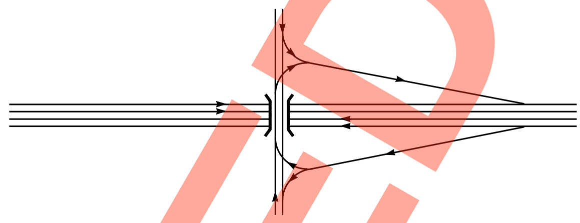
d. large flows are to be handled and a signalised gyratory form of junction is used.

Interchanges

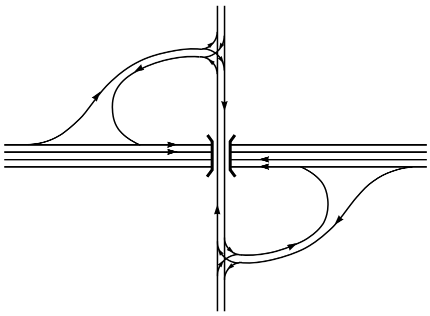
2.14 This form of grade separation does not involve the use of an at grade junction and thereby provides uninterrupted movement for all turning traffic by the use of interchange links. Typical layouts are shown in Figure 2/4 for 3 and 4 way interchanges, the advantages and disadvantages are outlined in Chapter 5.



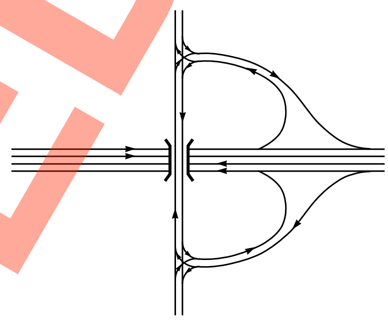
a) Diamond



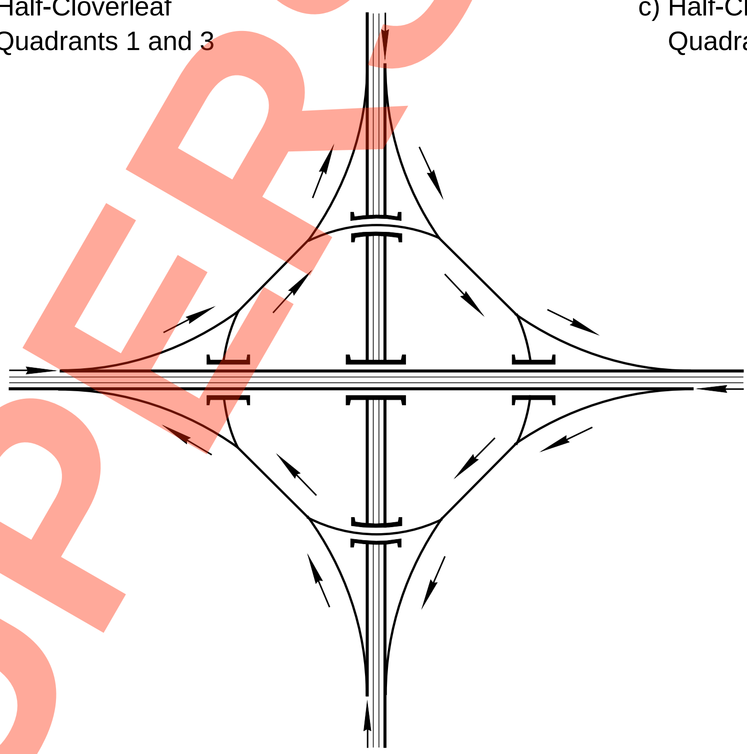
b) Half-Diamond



d) Half-Cloverleaf
Quadrants 1 and 3



c) Half-Cloverleaf
Quadrants 2 and 3

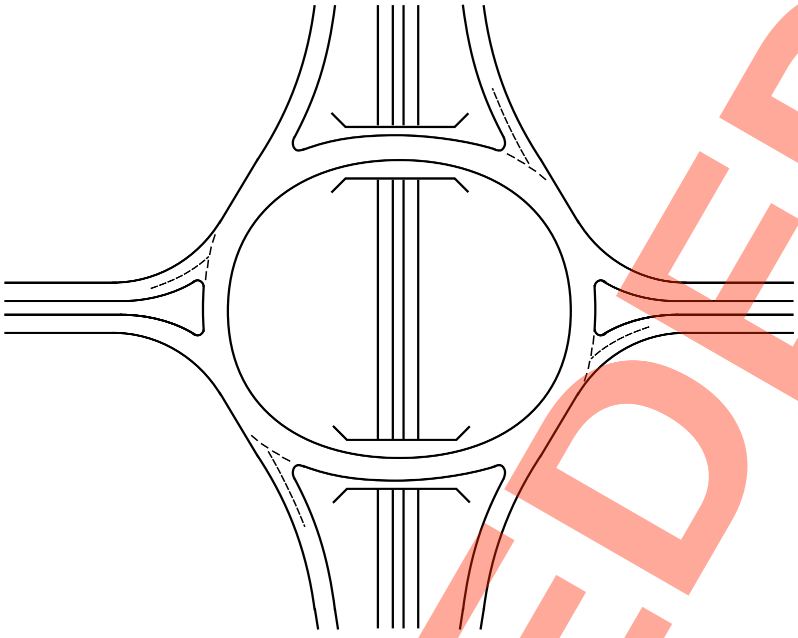


e) 3 Level Roundabout

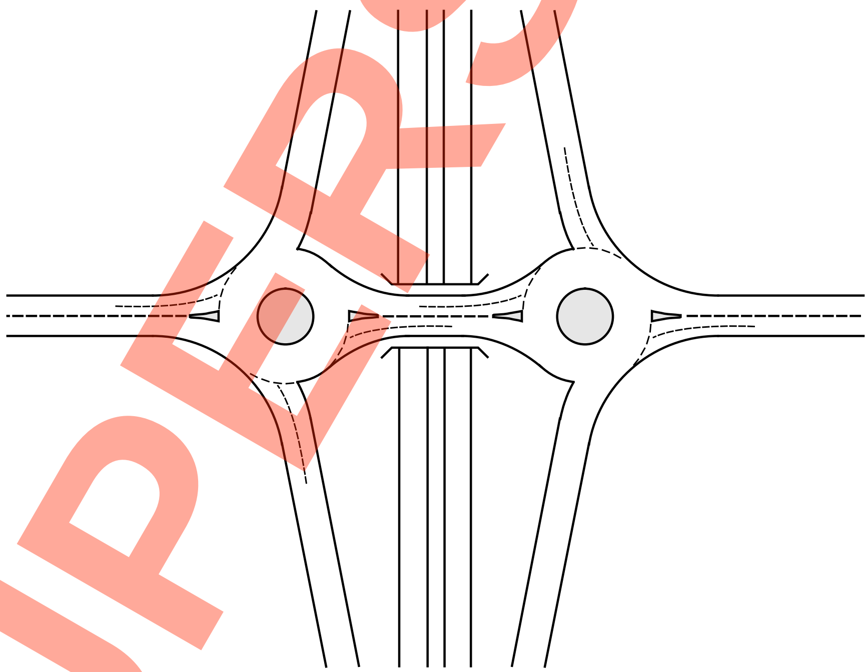
Note see also Figure 2/3

(See Paragraph 2.9)

Figure 2/2 Typical Layouts of Grade Separated Junctions

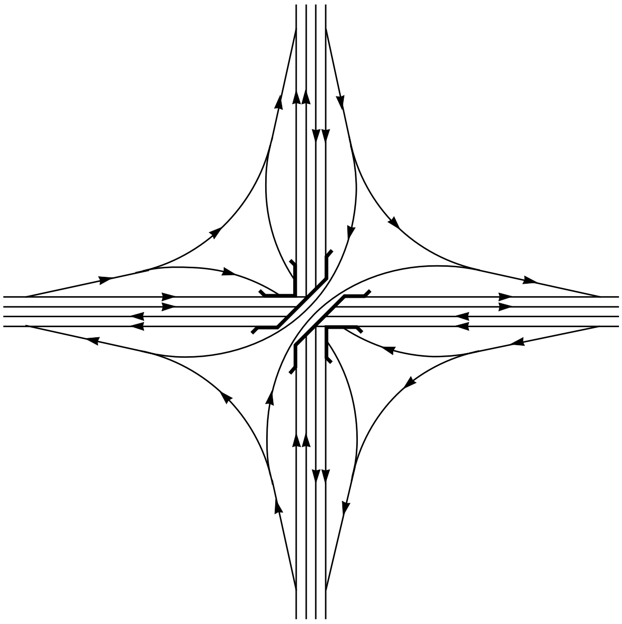


Two Bridge Roundabout



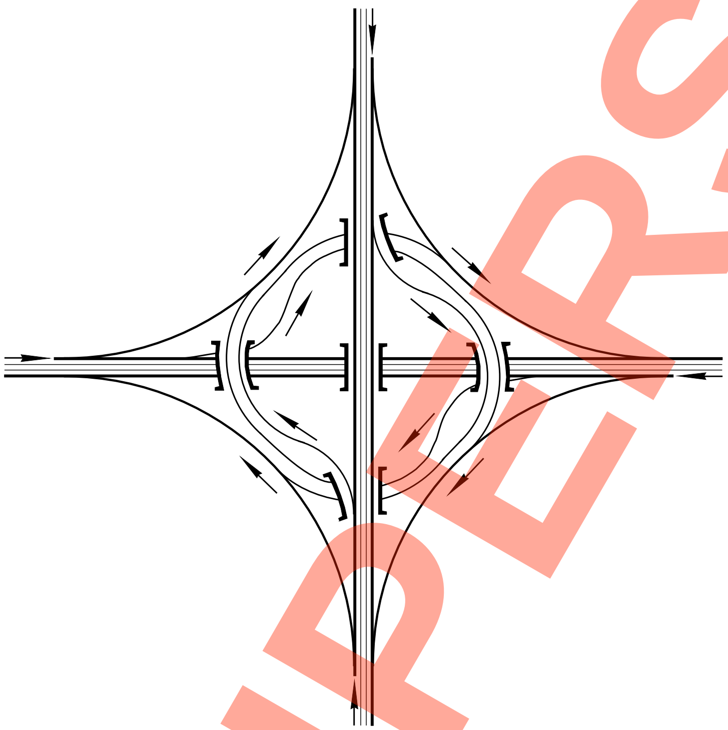
One Bridge and Two Roundabouts - "Dumbell"

Figure 2/3 Typical layouts of Grade Separated Junctions - Extract from TA 42 (DMRB 6.2)

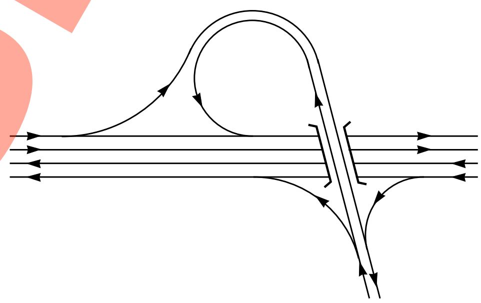


a) 4 way - 4 level

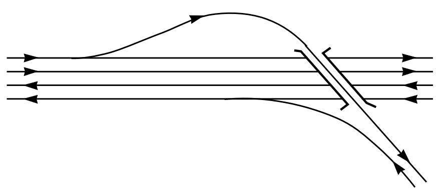
b) 4 way - 3 level



c) 4 way - 2 level



d) 3 way - 2 level



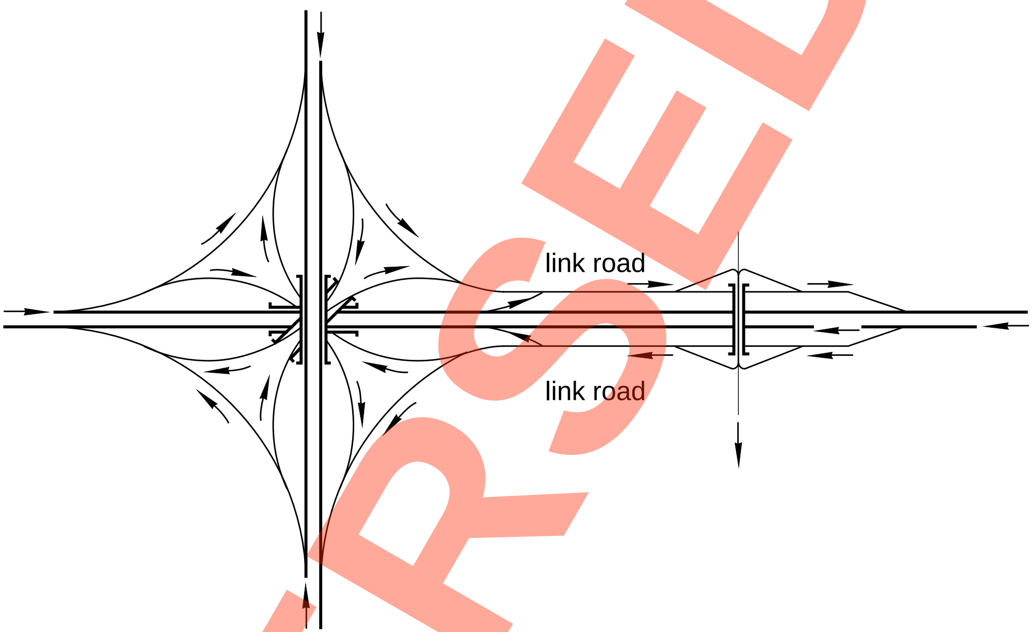
e) 3 way - 2 level
restricted movement

(See Paragraph 2.14)

Figure 2/4 Typical Layouts of Interchanges

Link Roads (formerly Collector-Distributor Roads)

2.15 When two grade separated junctions with high flows are closely spaced, potential weaving problems caused by the short length of carriageway available can be removed by the inclusion of link roads. An example is shown at Figure 2/5 for a diamond junction in close proximity to a free flow 4 level interchange.



(See Paragraph (2.15)

Figure 2/5 Example of Link Road Interchange

Volume 6 home page

3. FLOW STANDARDS

General

3.1 Grade separation design is based on the 30th, 50th or 200th highest hourly flow in the 15th year after opening for urban, inter-urban and recreational road types respectively. These flows have been shown to generate viable at grade junction options (TA 23 DMRB 6.2) and are used in grade separation to produce consistent designs. The hourly flow is normally derived from the 24 hour AADT flow, using the peak hour factors in the **Traffic Appraisal Manual** for England, Wales and Northern Ireland and the **Scottish Traffic and Environmental Appraisal Manual** in Scotland. The hourly flows thereby obtained have a high degree of uncertainty attached to them and should not be used inflexibly in design. The cost of being wrong should be borne in mind and a higher or lower standard considered where appropriate. Consideration should be given particularly to incorporating a higher standard in urban locations, where development up to the highway boundary will inevitably take place within a few years of the scheme opening, thereby inhibiting any future improvement.

Flow Levels

3.2 Maximum hourly flow levels of traffic on the motorway network have increased and this is reflected in the Standard TD 22 (DMRB 6.2.1.3.2) by converting flows into lane equivalents. But for the design of the elements of motorway junctions, a maximum figure of 1800 vphpl should be used. The figure for All Purpose Roads of 1600 vphpl remains the same. For new designs the maximum hourly flows are expected to have an HGV content of less than 10% in the future (15th year) and any flow correction (TD 22 (DMRB 6.2.1.), Table 3/2) will be minor. However, on improvement schemes the HGV flow correction could be up to 20%, depending on the gradient, representing a severe loss of level of service on that section unless allowed for. This emphasises the importance of the correct siting and spacing of junctions at the design stage (para 2.2) if the scheme life of 30 years is to be achieved without the need for costly interim improvement.

Merging and Diverging Lanes

3.3 The typical merging and diverging layouts illustrated in TD 22 (DMRB 6.2.1) are related to flow levels by the use of Figures 2/3 and 2/5 therein, using the flow levels in para 3.2 above. These figures have been further developed and refined from those shown in TRRL Report LR 679.

4. GEOMETRIC STANDARDS

Design Speed

Interchange Links (formerly Link Roads)

4.1 For rural interchange links a Desirable Minimum Design Speed Standard of 85 kph is recommended (TD 22 (DMRB 6.2.1), Table 4/2) as designs to lower standards have produced operational problems. This has been highlighted by vehicles shedding their loads at interchanges which involve tight reverse curves, similar to Fig 2/4c. The 85 kph Design Speed is in accordance with the speed/flow prediction contained in the appropriate Overseeing Departments' cost benefit models (**COBA** or **NESA**). However, if the presence of such a reduced Design Speed element cannot be made obvious to the driver, a higher value should be used.

Slip Roads

4.2 Adoption of an 85 kph Design Speed for slip roads would be an unnecessary waste of money and land. Diverging drivers have already made the decision to leave the mainline and should be given sufficient visibility to the at grade junction advance direction sign to enable them to reduce their speed accordingly. A Desirable Minimum Design Speed of 70 kph has therefore been adopted. It should be noted that slip roads in excess of 0.75 km length are defined as interchange links and accordingly have a Design Speed of 85 kph (TD 22 (DMRB 6.2.1), Table 4/2). At difficult sites further relaxations in Stopping Sight Distances etc, can be made under the provisions of TD 9 (DMRB 6.1).

Safety Studies

4.3 The research referred to in paragraph 2.4 is described below. It was undertaken to examine the accident risk of various geometric features.

Safety on Merging and Diverging Lanes

4.4 The accident risk in the merge/diverge area at motorway grade separated junctions was originally studied at 53 junctions over the period 1979-81. Three mainline carriageway standards were examined, namely D3M, D2M and D3/2M (with a lane drop), within the flow range 10-85000 24hr AADT. The accident rates and severities are shown in Table 4/1. The results indicated that there was some difference from the national motorway rate with the D3M behaving better than D2M. The higher severity proportion for the lane drop junction appeared to indicate the need for more effective signing by the use of gantries, etc, at this type of junction. The research also indicated that a reduction in the diverge and merge design parameters for motorways could be made without reducing safety. TD 22 (DMRB 6.2.1), Tables 4/4 and 4/5 reflect these results. Research on merging and diverging facilities continues.

Table 4/1 Accident Data for Traffic Through Motorway Junctions

Notes: Study Period 1979-81
There is a Gradual Reduction in Accident Rates with Time

TYPE OF JUNCTION (No in Study)	ACCIDENT RATE PIA/mvkm	SEVERITY PROPORTIONS		
		Fatal	Serious	Slight
Dual 3M (21)	0.11	0.05	0.20	0.75
Dual 2M (17)	0.16	0.04	0.18	0.78
Lane Drop D3→D2 (15)	0.13	0.06	0.27	0.67
GB Motorways 1981	0.14	0.05	0.26	0.69

Table 4/2 Accident Data on Short Motorway Weaving Lengths

Notes: Study Period 1979-81
There is a Gradual Reduction in Accident Rates with Time

WEAVING LENGTH		ACCIDENT RATE	SEVERITY PROPORTIONS		
km	No. in Study	PIA/mvkm	Fatal	Serious	Slight
< 1	16	0.15	0.04	0.16	0.80
> 1 < 2	39	0.11	0.03	0.19	0.78
> 2 < 3	38	0.12	0.05	0.21	0.74
GB Motorways 1981		0.14	0.05	0.26	0.69

Safety in Weaving Lengths

4.5 All rural motorway weaving lengths under 3km (93 no.) were examined for the years 1979-81 within the flow range 10-90000 24hr AADT. The accident rates and severity proportions for weaving lengths are shown in Table 4/2 split into three separate lengths. As no increase in accident risk was then indicated with decreasing the weaving length, the Desirable Minimum weaving length of 3km, previously used in design, was reduced to 2km. The Absolute Minimum weaving length of 1km remained (TD (DMRB 6.2.1.4.22). Research on weaving facilities continues.

Safety Research on Loops

4.6 The safety of loops continues to be monitored. This shows no change from earlier work. The earlier work examined safety on 88 motorway and all purpose sites for the period 1974-78. These ranged from 15 to 75m in radius, from 40 to 350m in length and from 200-10000 24hr AADT in flow. Only a qualitative assessment of accident rates and proportions took place. Because of the inherent characteristics of loops, it was expected that the overall accident rate would be high in comparison with the link rate, and it was found to be nearly five times higher. The proportion of serious accidents for motorway loops was high and this probably reflects the higher vehicle speed on motorways. Therefore the minimum loop radius required to maintain safety on motorways is greater than that for loops on all-purpose roads. (This result was also reinforced by an investigation at a heavily overloaded motorway interchange which displayed the same effect.) The results also showed that for all-purpose roads, off-loops require a higher radius than on-loops (see TD 22 (DMRB 6.2.1.4.8). For lower levels of radius, cautionary measures to maintain safety become necessary, and points to consider include:

a. provision of clear visibility over the whole of the loop on the approaches, especially beyond an underbridge;

b. advisory speed limits and/or bend signs and chevron boards;

c. widening of lanes on the loops in accordance with lower radii as quoted in TA 20 (DMRB 6.2) (para 8.13.2)

d. the provision of safety fences or safety barriers on the outside;

e. physical separation of opposing traffic streams, including for central reserve safety fencing

f. lighting;

g. high skid resistant surfacing.

5. LAYOUT OPTIONS

General

5.1 The most efficient form of grade separation is that which presents the driver with the minimum number of clear unambiguous decision points as they traverse any at-grade component of the junction and in merging and diverging. Additionally, on a motorway or an all purpose road that is generally grade separated, consistency of design for successive junctions is an important consideration involving the adoption of the same Design Speed. This need for consistency also applies to the signing and road markings to be adopted particularly where responsibility for the road is divided between different Highway Authorities.

5.2 The siting of a grade separated junction on a hill top should be avoided if possible as this will inevitably mean the inclusion of approach gradients, sometimes relatively steep, which can cause operational problems in the diverge area, even when the percentage of HGVs is small. In addition this location could be environmentally damaging to the skyline and might present difficulty to drivers in comprehending road signs which are silhouetted against the skyline. There is also the risk of drivers being blinded when the sun is low in the sky.

5.3 Efficiency, consistency, location, maintenance and environmental effects are all aspects to be taken into account in choosing the most appropriate layout. They should be included, together with other important aspects such as land take, capital cost and the results of an economic assessment, in a decision framework.

5.4 The provision of safety fencing and safety barriers within a junction should be in accordance with Standards TD 19 (DMRB 2.2), TD 32 (DMRB 2.2) and as shown in **"Highway Construction Details"** (MCHW 3.2).

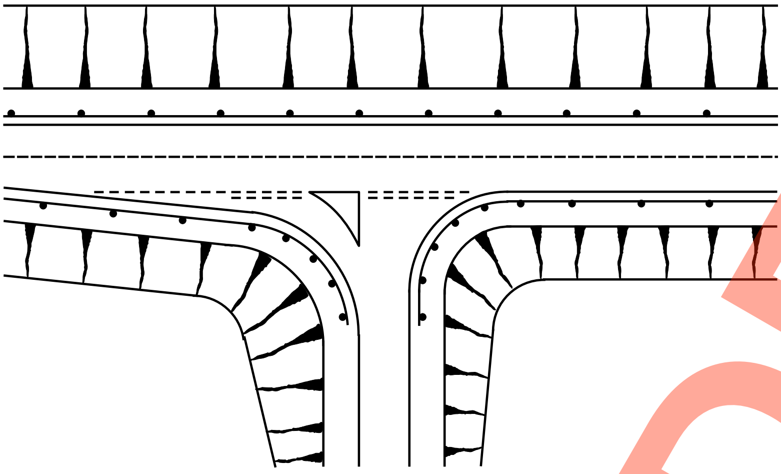
Grade Separated Junctions

5.5 For low turning flows the diamond or half-cloverleaf junction is acceptable (Figure 2/2). The diamond has the advantage that land take can be kept to a minimum and slip road design remains as simple as possible. The disadvantage is that all four quadrants are used to provide turning movements which for difficult sites, especially in urban areas, may create severe environmental problems. The half-cloverleaf overcomes this problem by requiring the use of only 2 quadrants, which if possible should be chosen so as to minimise the right turn movements. A further advantage of both these types is that costs are minimised as only one bridge is required, but consideration should be given for future inclusion of a ghost island on the crossing road, as bridge widening at a later stage will be expensive.

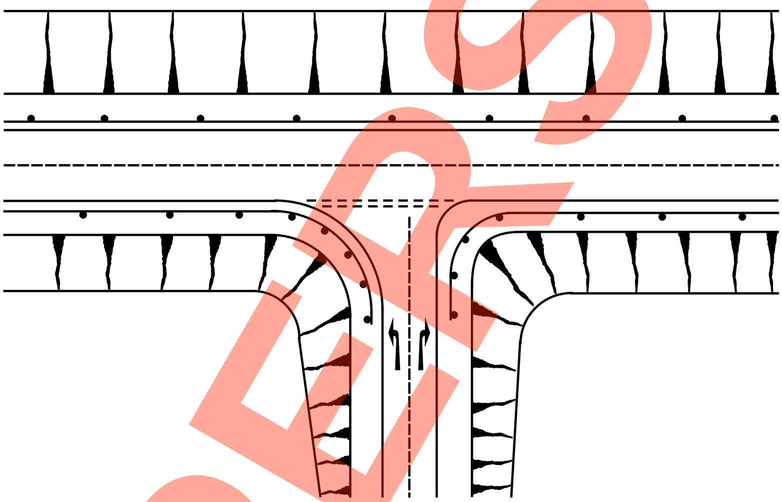
5.6 Overdesign of single carriageway priority junctions has sometimes created safety problems for vehicles leaving uphill slip roads subsequent to a diverge. Such a situation is shown in Figure 5/1a where drivers, approaching the left turn splitter island with a merging lane, have misperceived the facing safety fence (required by the height of the embankment) as being on a dual carriageway central reserve and merging vehicles have moved straight over into the path of oncoming traffic. This effect has been most noticeable at junctions where drivers have left long lengths of fully grade separated road. For junctions in this type of location, consideration of a dumbell roundabout is recommended. If this is not achievable, the priority junction should be made square to the side road as shown in Figure 5/1b, with no merging lanes or splitter islands and corner radii in accordance with TA 20 (DMRB 6.2) to emphasise to the driver the impression of a single, not dual carriageway. This needs to be reinforced by clear unambiguous signing that this is a two way road.

5.7 The most common type of grade separation is the two bridge roundabout. Observation has shown that operational problems arise if they are constructed too large and therefore every effort should be made to achieve a compact design (TA 42 (DMRB 6.2). The dumbell roundabout which is an intermediate layout between the diamond and the two bridge roundabout has the advantages of reduced cost (only one bridge) and less landtake than the two bridge roundabout. It also has increased junction capacity and reduced landtake compared with the diamond. But close to urban locations where large flows have to be accommodated, signalised gyratories can be considered.

5.8 Where two main roads cross, a 3 level roundabout should be considered as an alternative to an interchange. Its advantages are that both the overall landtake and the carriageway area are greatly reduced.



a) Over design leading to driver misperception



b) Simple junction obvious to driver

(See Paragraph 5.6)

Figure 5/1 Example of Over Design Reducing Safety at Diamond Junction

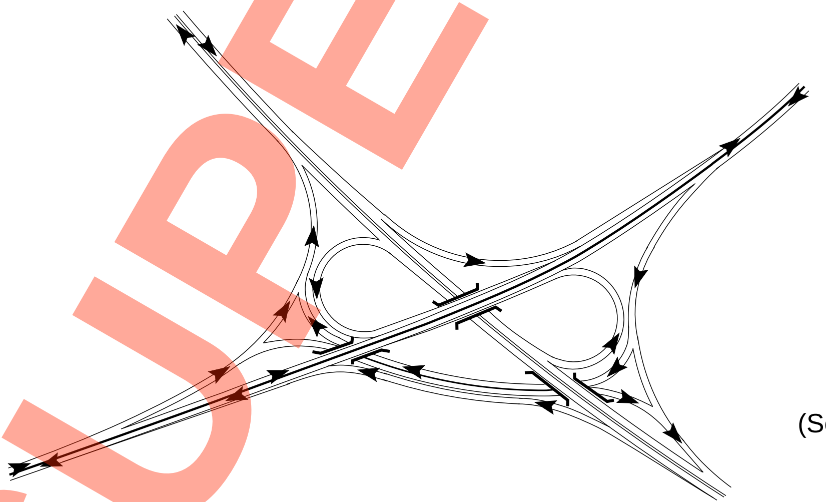
The disadvantages are that structure costs are high and if the turning movements become greater than predicted, operational problems such as queuing on the roundabout entries, can result. If queuing does become a problem, dedicated left hand lanes and a restricted circulatory carriageway should be considered before traffic signals are installed. The inclusion of a specific link, as a remedial measure to remove a heavy right turn movement, is rarely a practical solution on either cost or environmental grounds.

5.9 A junction such as the half diamond (Figure 2/2b), can be designed for restricted traffic movements. However, if there is a possibility that future conversion to provide all movements will be required, then the original design should be capable of conversion without alteration to the built layout.

Interchanges

5.10 An interchange provides uninterrupted movements for vehicles moving from one mainline to another, by the use of link roads with a succession of diverging and merging manoeuvres. Good design minimises these conflict points and ensures that the path between them is easily understood by drivers, by effective signing and road marking. This aim should be assessed within the overall framework of the points in Para 2.2.

5.11 Figure 2/4 shows three different 4 way interchanges. The 4 level interchange layout has the advantages of reduced landtake, absence of loops and low structural content, but is visually highly intrusive, has the greater number of conflict points and has therefore been used infrequently. The 3 level interchange introduces two loops and reduces conflict points but increases both structural content and cost, whist still being visually intrusive. A variant of Figure 2/4b is shown at Figure 5/2 and is an example of how environmental impact and structural content can be substantially reduced without a great increase in landtake, by taking advantage of the skew of the intersecting mainlines. Figure 2/4c shows a 2 level or "cyclic" interchange which utilises reverse curves and a low number of conflict points, the landtake is extensive and there is a high structural content, however, since this form of interchange fits easily into the topography it is a suitable solution for schemes where land is not at a premium. Figure 2/4c shows two successive diverges off and one merge on to the mainline as the layout. A variant of this uses one diverge and two merges but the distance between the merges should be as great as possible to avoid potential conflicts. One principal connection on the mainline for the diverge, and one for the merge, is actually to be preferred with the final route selection occurring on the slip road. This reduces turbulence on the mainline. It would need a suitable multiple lane layout for the actual connection. Site constraints can make it not always possible to have the one connection.



(See Paragraph 5.11)

Figure 5/2 Variant of Figure 2/4b Restricted in height to Reduce Environmental Damage

5.12 The three way "trumpet" interchange should be designed to enable future conversion to a four way without alteration if this is considered a possibility. Figure 2/4e shows a three way interchange with restricted movement, this enables high vehicle speeds to be maintained with low landtake, but it requires a costly skew structure and prohibits any future conversion.

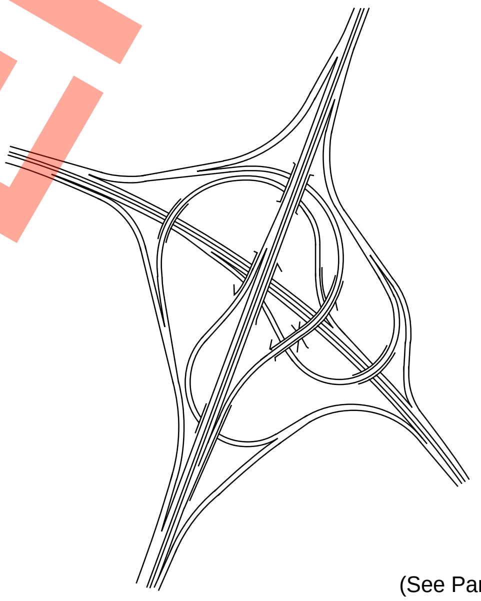
5.13 Merges can occur within an interchange where there is a flow imbalance, ie the merging left hand link traffic can be greater or equal to the mainline right hand link traffic. Experience has shown that nonetheless priority should continue to be given to traffic on the mainline. If the merging flow is over a lane capacity, there will obviously need to be a lane gain. Whatever is done, there is a need to ensure that HGVs can reach their normal positions on the continuing mainline safely and expeditiously. Other operational problems have occurred where the left hand link has been on a long downhill section and the right hand link uphill, with consequential disparity in vehicle speeds at the merge, and this particular layout is not recommended.

5.14 Loops and certain links may require advisory speed limits to warn the driver of the safe negotiating speed. This speed limit should be used in conjunction with a bend warning sign and chevron boards to reinforce the hazard warning. Only one level of speed limit should be used within an interchange as steps down in speed limits will only confuse the driver.

5.15 Single lane interchange links can have considerable advantages in cost over 2 lane interchange links for interchanges which contain structures of substantial length. They also have operational advantages if a merge imbalance occurs (Para 5.13) which needs only a single lane entry at the mainline merge. This has advantages of reduced taper length at congested sites. However, where the predicted flows are near the top of the range (TD 22 (DMRB 6.2.1), Table 3/1) the uncertainty of the prediction should be recognised (Para 3.1) as the cost of being wrong is particularly significant and may prohibit later conversion to a two lane interchange link. A disadvantage is that single lane interchange links require closure during maintenance activities.

5.16 Some forms of interchange do not provide a U turn facility for maintenance traffic such as gritters, consequently where there is no other grade separated junction within an acceptable distance, consideration may need to be given to including a "short cut opening" within the interchange for maintenance and emergency vehicles. Figure 5.3 shows an example at a cyclic interchange. The layout and design of any such facility must be approved by the Overseeing Department.

Figure 5/3 Maintenance Connection at X to Provide Southbound U Turn



(See Paragraph 5.16)

5.17 For motorway interchanges emergency telephones should not be sited in an exposed position on the inside of left hand interchange links with radii below Desirable Minimum, as some vehicles have been observed to cut across the hardshoulder at this point. They should be located on straight or right hand curve sections.

Slip Roads

5.18 Slip roads are part of grade separated junctions and are normally one way. Two way slip roads only occur at half-cloverleaf and trumpet junctions where traffic separation is achieved either by a physical central reserve with safety fences, safety barriers, or a solid double white line road marking. Study into the safety of tight loops (Para 4.4) showed an increased accident risk for 2 way slip roads as compared to one way. Within the sample both forms of separation were included and the results indicated that a physical barrier will improve safety and reduce cross-over accidents. This is therefore now the standard for such layouts.

5.19 Diverge slip roads can be of a relatively short length if the mainline is on a steep down gradient and in any case they need not be the same length as merge slip roads. If persistent peak hour queuing develops at the slip road exit, backing up on to the mainline will become a problem because of the lack of stacking space, and remedial measures such as part time traffic signals may be required.

5.20 The accident risk for slip roads at junctions is similar whether the mainline is carried over or under. In order to match mainline vehicle speeds on merging and reduce them on diverging at the approach to the side road junction the preferred treatment is to design off-slips uphill and on-slips downhill, with the side road over the mainline.

5.21 Side road access on to slip roads may be required in urban areas for junction improvement schemes. The layout should be such that drivers on the access are made fully aware of their emergence on to a one way slip road by clear signing. The access should not include a merging lane but terminate at a normal give way road marking.

Merging and Diverging Lanes

5.22 Mainline lane drops within a junction (3 lanes prior to the diverge, 2 lanes between diverge and merge and then back to 3 lanes) are not generally recommended on operational and safety grounds (see Para 4.4). They severely impair future maintenance, especially at interchanges where no reasonable diversion route is available.

5.23 A lane drop or addition at a junction diverge or merge is the only recommended layout when changing carriageway standards from 3 lanes to 2 or 2 to 3 and 4 to 3 or 3 to 4 lanes. The actual layout of the diverge or merge should be selected corresponding to the leaving or joining flow but under light conditions could be Figure 2/4d or Figure 2/6c in TD 22 (DMRB 6.2.1). Lane drops should remove only the left hand lane and (excluding climbing lanes) should not take place on the link between junctions.

5.24 If the proportion of HGVs is greater than 10% at a merge on an uphill mainline gradient in excess of 2% and within 0.5km of the crest, consideration should be given to the extension of a parallel merging lane (TD 22 (DMRB 6.2.1.4.18) to the crest. This will enable merging drivers to match their speed with those on the mainline.

5.25 Parallel diverging lanes are not recommended for entry into loops (except TD 22 (DMRB 6.2.1.4.18) as this has been observed to encourage high speed and loss of control at the commencement of the loop.

5.26 Urban junction improvements may incorporate safety fences or safety barriers between the mainline and slip road if there is a speed limit of 50 mph or under on the mainline (TD 19 (DMRB 2.2)). This may have the effect of reducing the inter carriageway sideways visibility and can create operational problems in the merge area. To alleviate this, it is recommended that the full range of safety fences and safety barriers is considered to see if better visibility can be achieved with particular systems. Otherwise the merge nose and taper may be increased in length by 50%.

Weaving Area

5.27 In calculating the number of traffic lanes required (TD 22 (DMRB 6.2.1.2.26)) a fractional part will inevitably require a decision to round up or down. If it is possible to vary the position of the junctions and thus increase or decrease the weaving length, the fractional part will converge approximately to a whole number of lanes and the decision is simplified. However, if this is not possible the decision becomes more difficult and it should be reflected in the assessment procedure. Where the fractional part is small and is combined with a low weaving flow rounding down is suggested, whereas a high fractional part with a high weaving volume suggests rounding up. For example the addition of a fourth lane would have operational advantages in releasing the two middle lanes for weaving traffic. Other factors which may influence the decision are:

i. the number of lanes required for merging and diverging (TD 22 (DMRB 6.2.1.2.21 and DMRB 6.2.1.2.23));

ii. when the fractional part is about 0.5 the uncertainty of the predicted flows (Para 3.1) suggests always rounding up from 2-3 lanes;

iii. on recreational routes there can be a high proportion of drivers who are not local and therefore behave less efficiently than commuters would at the same flow levels;

iv. in urban areas extra land take is difficult to acquire and is very costly;

v. fully grade separated rural all purpose roads have operational characteristics approaching those of motorways and should be treated as such (TD 22 (DMRB 6.2.1.4.23)).

5.28 Where possible on all purpose roads, the weaving length between junctions and layby/service area tapers should be the minimum weaving length as defined in TD 22 (DMRB 6.2.1), para 4.23 for rural roads and para 4.24 for urban roads.

Signing and Lighting

5.29 The signing and lighting proposals should be considered at the earliest stage of design to ensure the satisfactory operation of a grade separated junction for all users, including cyclists and pedestrians.

6. CYCLISTS AND PEDESTRIANS FACILITIES

6.1 On motorways, where cyclists and pedestrians are prohibited, they only have to negotiate the at grade part of the grade separated junction. However, on all purpose roads, detailed attention to the needs of cyclists and pedestrians is required throughout the junction.

Cyclists

6.2 Advice is available on the provision of facilities for cyclists in the following documents

- Local Transport Note (1/86) published by the Department of Transport
- Traffic Advisory Unit Leaflet (1/88) published by the Department of Transport
- Cycling Advice Note 1/89 and 2/89 published by the Scottish Office Industry Department Roads Directorate

Consideration should also be given to combined pedestrian/cyclists subways as outlined in TD 3 (DMRB 6.3) and in TA 42 (DMRB 6.2).

Pedestrians

6.3 A grade separated crossing either by subway or footbridge, can be included to remove conflict between pedestrians and vehicles. Advice is contained in TA 42 (DMRB 6.2) on the facilities for pedestrians at roundabouts.

7. REFERENCES

1. Introduction

a. TD 22 (DMRB 6.2.1) - Layout of Grade Separated Junctions

b. TA 30 (DMRB 5.1) - Choice between options for Trunk Road Schemes

c. The Traffic Signs Manual - Chapters 1,3,4,5 and 14 - HMSO

d. TD 18 (DMRB 5.1) - Criteria for the use of Gantries for Traffic Signs and Matrix Traffic Signals on Trunk Roads and Trunk Road Motorways

2. General Principles

a. TD 22 as Chapter 1

b. TD 9 (DMRB 6.1) - Highway Link Design: Amendment No 1: 1985 and Amendment No 2: 1991

c. The Traffic Signs Manual as Chapter 1

d. TA 23 (DMRB 6.2) - Determination of Size of Roundabouts and Major/Minor Junctions

e. TD 16 (DMRB 6.2) - The Geometric Design of Roundabouts

f. TA 42 (DMRB 6.2) - The Geometric Design of Roundabouts

g. TA 20 (DMRB 6.2) - The Layout of Major/Minor Junctions

h. Traffic Signs Regulations and General Directions 1981 - SI 1981 No 859: HMSO: 1981; The Traffic Signs (Amendment) Regulations 1982 - SI 1982 No 1879: HMSO: 1982; and The Traffic Signs General (Amendment) Directions 1982 - SI 1982 No 1880: HMSO: 1982

i. TA 30 as Chapter 1

3. Flow Standards

a. TA 23 as Chapter 2

b. Traffic Appraisal Manual - (TAM): DTp: 1982

c. Scottish Traffic and Environmental Appraisal Manual (STEAM). Scottish Office 1986

d. TD 22 as Chapter 1

e. LR679 - The Capacity of Motorway Merges; TRRL: 1976

4. Geometric Standards

a. TD 22 as Chapter 1

b. TD 9 as Chapter 2

c. TA 20 as Chapter 2.

5. Layout Options

a. TD 19 (DMRB 2.2) - Safety Fences and Barriers: Amendment No 1: 1986

b. TD 32 (DMRB 2.2) - Departmental Standard - Wire Rope Safety Fence

c. "Highway Construction Details" - HMSO (MCHW 3)

d. TA 20 as Chapter 2

e. TA 42 as Chapter 2

f. TD 22 as Chapter 1

6. Cyclists and Pedestrians Facilities

a. TD 3 (DMRB 6.3) - Departmental Standard - Combined Pedestrian and Cycle Subways - Layouts and Dimensions: DTp: 1979

b. TA 42 as Chapter 2

8. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:-

Head of Highways Engineering Division The Department of Transport St Christopher House Southwark Street London SE1 0TE	N S ORGAN Head of Highways Engineering Division

The Deputy Chief Engineer Roads Directorate The Scottish Office Industry Department New St Andrew's House Edinburgh EH1 3TG	J INNES Deputy Chief Engineer

Head of Roads Engineering (Construction) Division Welsh Office Y Swyddfa Gymreig Government Buildings Ty Glas Road Llanishen Cardiff CF4 5PL	B H HAWKER Head of Roads Engineering (Construction) Division

Superintending Engineer Works Department of the Environment for Northern Ireland Commonwealth House Castle Street Belfast BT1 1GU	D O'HAGAN Superintending Engineer Works

Orders for further copies should be addressed to: DOE/DTp Publications Sales Unit Government Building Block 3, Spur 2 Lime Grove Eastcote HA4 8SE	Telephone No: 081 429 5170