Chapter 38 Priority Junctions

38.1 Introduction

The majority of junctions in urban areas take the form of some type of priority junction, which is normally appropriate where traffic flows, particularly to and from minor roads, are relatively light. Where flows are heavier or layouts are complex, other types of layout or control, such as roundabouts or traffic signals, are required to reduce accident risks and to balance or improve capacity. The primary advantage of priority junctions is that the main road flow does not normally experience any delay. Movements from the minor road, and right turns into it, are dependent on gaps in the major traffic stream and this influences both safety and capacity. The problem is that, as main road traffic flows increase, gaps between vehicles get smaller and accidents increase as gap–acceptance gets shorter. As in all junction design, the needs of pedestrians and cyclists should be considered from the outset and not added as an afterthought.

The three basic types of priority junction are:

- 'T' junctions;
- staggered junctions; and
- crossroads.

Each of these types can be divided into four forms of layout, which are derived from the characteristics of the major road. These are:

- simple layouts;
- 'ghost island' layouts;
- localised single–lane dualling; and
- dual carriageways.

Photograph 38.1: A typical major/minor priority junction.

The main source of advice on the choice and design of priority junctions is contained in the publication TD42/95 Geometric Design of Major/Minor Priority Junctions (HMG, 1995) [Sa]. This relates specifically to new and improved trunk roads but it is often applied to other categories of road.

38.2 Choice of Major/Minor Priority Junction

Table 38.1 gives guidance on the major/minor priority junction forms considered suitable for various major road carriageway types in urban situations. This represents the starting point when choosing the most appropriate type of major/minor priority junction to use at any particular site (see Photograph 38.1).

Simple Junctions

TD 42/95 states that new simple junctions are not suitable when design flows exceed about 300 vehicles two–way average annual daily traffic (AADT) on the minor road and 13,000 vehicles two–way AADT on the major road. However, this advice relates specifically to rural junctions. The only advice relating to urban junctions is that consideration should be given to upgrading existing simple junctions, where the minor road flow exceeds 500 vehicles two–way AADT. Minor road flows of 300 and 500 vehicles per day are low for an urban situation, particularly as no reference is made to the major road flow or to the pattern of turning movements.

Where the occurrence of accidents involving right–turning vehicles is evident, or expected, simple layouts may not be appropriate. This is equally the case where major road traffic would be inhibited by right turns into the minor road. Capacity analysis will help determine if this is likely.

Ghost Islands

The provision of a dedicated lane for traffic slowing and waiting to turn right from the major road has significant road safety and capacity benefits. However, problems can arise if overtaking manoeuvres are thereby encouraged. Consequently, ghost islands should not be used where overtaking opportunities on the upstream and downstream links are very restricted. As an alternative, a nearside passing lane or a left–hand diverging lane loop (see

Carriageway Type		Junction Type								
		Simple			Ghost Island			Dualling		
Standard	Location	T junction	Staggered crossroads	Straight crossroads	T junction	Staggered access roads	Straight crossroads	T junction	Staggered crossroads	Straight crossroads
S2	Urban	Yes	Yes	Maybe	Yes	Yes	No	Yes (D1)	Yes (D1)	No
WS2	Urban	No	No	No	Yes	Yes	No	Yes (D1)	Yes (D1)	No
D2	Urban	No	No	No	No	No	No	Yes (D2)	Yes (D2)	No
D3		No	No	No	No	No	No	No	No	No

Table 38.1: Choice of junction type. Source: TD42/95.

Key:

S2	Single 2–lane carriageway
WS2	Wide single 2–lane carriageway
D1	Dual single–lane carriageway
D2	Dual 2–lane carriageway
D3	Dual 3–lane carriageway

Figures 38.1 and 38.2) can be beneficial, where a normal ghost island layout cannot be achieved.

Single–Lane Dualling

Dualling of single lane roads is normally used on unrestricted rural single carriageway roads and, therefore, its application in urban areas is not commonplace. However, its use can be beneficial in particular cases, for example, where a pedestrian crossing needs to be located on the major road, near to a priority junction, for which a divided crossing is appropriate.

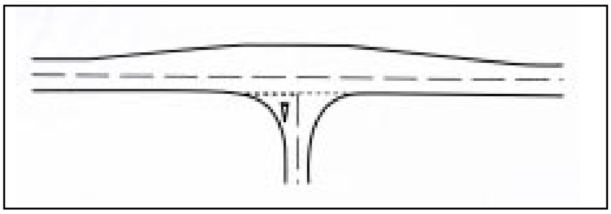

Figure 38.1: A nearside passing lane.

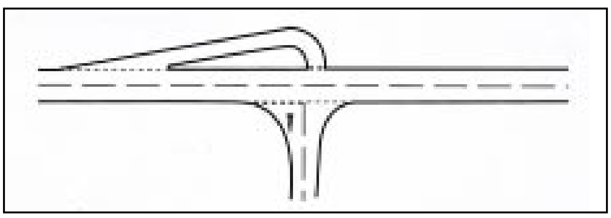

Figure 38.2: A left–hand diverging lane loop.

Dual Carriageways

Major/minor priority junctions may be used on new dual two–lane carriageways but never on new dual–3 all–purpose (D3AP) roads. Such junctions should include the widening of the central reserve to provide an offside diverging lane and waiting space for vehicles turning right from the major road. TD42/95 recommends an upper limit for minor road flows of 3000 vehicles 2–way AADT for D2AP roads in rural areas.

No advice exists specifically for urban roads but capacity analysis will assist in this respect. There may be no preferable alternative to retaining a priority junction on an existing urban D3AP roads but consideration should be given to restricting right–turn movements into and out of the side–road.

Crossroads

It is best to avoid straight crossroads because of their generally poor safety performance. Staggered junctions are better but roundabouts or traffic signal–control may be better still. If crossroads are unavoidable, they should be provided only on single carriageway roads and measures should be introduced to make the priorities clear and to slow traffic down on the minor roads approaches.

Staggered Junctions

Right–left staggers are preferred because, with this layout, traffic moving between the minor roads is less likely to have to wait in the centre of the major road. Also, right–turning movements from the major road will not 'hook' and thereby interfere with each other.

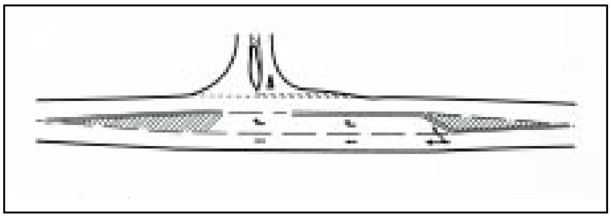

Figure 38.3: Road markings for a protected turning bay.

38.3 Siting of Priority Junctions

If overtaking on single carriageways is likely to be a road safety problem, measures should be included to prevent or discourage it. These may include:

- ❑ reduction of the carriageway width, by hatched markings;
- ❑ the use of different coloured surfacing materials; and
- ❑ the use of double white lines, where the visibility criteria can be met (see Figure 38.3).

In terms of horizontal alignment, priority junctions should not be sited on sharp curves, particularly on the inside of a bend. At skew junctions, careful consideration should be given to measures to ensure that priority is not mistaken.

Priority junctions are best located on level ground or where approach gradients do not exceed plus or minus two percent. Significant downhill major road gradients encourage excessive speed, whilst uphill gradients reduce drivers' appreciation of the junction layout, as they approach it.

On minor roads, downhill approaches can result in over–running at the give–way lines and uphill approaches can reduce both drivers' appreciation and gap–acceptance. The profile of a junction should be such as to enable a driver to see the full width of a junction. This is particularly important at junctions on dual carriageways.

38.4 Road Safety

In urban areas, over half of all personal injury accidents occur at or near major/minor junctions. For the same level and pattern of traffic flow, major/minor priority junctions will usually have more accidents per year than other types of junction. Right turn manoeuvres, both from the major road and from the minor road, are particularly vulnerable and the safety implications of these movements should receive special consideration in junction design.

Road safety at priority junctions can be improved in several ways:

- ❑ by protecting pedestrians and making special provision for cyclists;
- ❑ by preventing overtaking on the approaches;
- ❑ by making crossroads more conspicuous or replacing them with staggered junctions;
- ❑ by improving visibility; and
- ❑ by preventing right turning, particularly on high speed carriageways.

Road safety audits will provide an overview to ensure a safe combination of design parameters and features for all users (see Chapter 16).

38.5 Road–User Requirements

Cyclists

Major/minor junctions should be designed from the outset with the interests of cyclists (as well as pedestrians) in mind, as 73% of cyclist accidents occur at such junctions.

On the busiest roads, there will be value in providing for cyclists away from the junction, where space permits. This could involve:

- ❑ provision of a cycle track away from the carriageway;
- ❑ Toucan crossings for shared use by pedestrians and cyclists;
- ❑ signposting an alternative cycle route; and
- ❑ grade–separation

If cyclists are expected to use the main carriageway then facilities along the length of the carriageway can improve conditions for cyclists generally and raise drivers' awareness of the presence of cyclists, as they approach junctions. The specific facilities to incorporate at a junction are best considered on a site by site basis, according to the dominant turning movements for cyclists at that junction. Every design should emphasise to drivers where they can expect to encounter cyclists at a junction. If the volume of cyclists is significant, or is expected to increase at a particular location, consideration should be given to signalising the whole junction and to providing advanced stop–lines for cyclists. Measures to improve facilities for cyclists are considered in more detail in Chapter 23.

Pedestrians

The needs of pedestrians should be considered throughout the design process. Pedestrian facilities are normally provided in the form of refuge islands, Zebra or signal–controlled crossings. The type of treatment will depend on the anticipated vehicular and pedestrian flows. Chapter 22 deals with pedestrian facilities in more detail.

Defined at–grade Zebra, or signal–controlled, pedestrian crossings on minor roads should normally be a minimum of 15m back from the give–way line and should be sited to minimise crossing widths.

Separation islands are normally situated at the mouth of the side road. Dropped kerbs and tactile surfaces should be used at all pedestrian crossing points for the blind and the partially sighted.

Guardrails should be used only where significant pedestrian activity makes it necessary to channel pedestrians to the appropriate crossing points. Care should be taken to ensure that guardrails do not interrupt visibility for drivers and consideration should be given to the use of types of barrier designed especially for that purpose.

Landscaping

Landscaping can help to define the outline of junctions, to provide reference points and to establish a background for signs. Sensitive use of textured surfaces, choice of street furniture and planting should be used to enhance the general appearance. However, landscaping should not compromise visibility and good maintenance must be provided.

38.6 Geometric Design

Design Speed

Geometric standards are related to the traffic speed of the major road and, for new roads, to the design speed as defined in TD9/93 'Highway Link Design' (DOT, 1993). Advice on measurement of the 85th percentile wet weather speeds on existing roads is contained in TA22/81 (DOT, 1981) (see also Chapter 31) [Sa].

Corner Radii

Where no provision is made specifically for large goods vehicles, the minimum circular corner radius should be six metres. Where provision for heavy vehicles is to be made, a 10m circular corner radius, followed by a taper of 1.5m over a distance of 30m, is recommended. Where a significant number of heavy vehicles is likely to use the minor road, corners should be designed using a three–centred compound curve (HMG, 1995).

Carriageway Widths

Through lanes should normally be a maximum of 3.65m and a minimum of 3.0m wide. A ghost island turning lane should be 3.5m, although relaxation to 3.0m is permissible. In very restricted situations, a minimum width of 2.5m may be used. If it is considered desirable to encourage vehicles turning right from the minor road to execute the turn in two separate manoeuvres, the right–turn lane should be widened to provide a five metre refuge. Carriageway widening is required on tight radii to take account of the overhang and cut–in associated with articulated lorries.

Where significant cycle flows are anticipated, the inside lane should be widened to 4.25m to provide space for lorries to overtake cyclists. Alternatively, additional width, in the form of a 1.5m wide cycle lane, could be provided (see Chapter 23).

Right–Turn Lanes

The layout at right–turn lanes comprises the taper, the deceleration length and the turning/queueing length [see Figures 7/4 and 7/6 in TD 42/95 (HMG, 1995)]. It should be noted that the turning length should be long enough to accommodate predicted peak period queues.

Diverging and Merging Lanes

Diverging and merging lanes are recommended only on roads with design speeds of 85 km/h (53 miles/h) or above. In cases where such lanes are potentially suitable, TD42/95 (HMG, 1995) provides general numerical criteria. Diverging and merging lanes create hazards for cyclists and provision for cyclists should follow the guidelines for grade–separated junctions (DOT, 1988).

Channelisation

Traffic islands can serve several useful purposes:

- ❑ to direct or guide vehicles to take a specific path and to segregate opposing traffic streams;
- ❑ to provide a refuge for pedestrians and waiting traffic;
- ❑ to provide segregated lanes for buses or cyclists in appropriate circumstances; and
- ❑ to provide convenient locations for essential street furniture, such as traffic signs, street lighting, manholes and inspection chambers.

They should be of sufficient size to be clearly visible, otherwise they will be potential accident hazards.

Traffic Signs and Road Markings

The choice and positioning of traffic signs and road markings should be an integral part of the design process. Advance direction and warning signs should be provided and care must be taken with the positioning and the size of these signs. Policy and detailed guidance on these aspects are given in the Traffic Signs Manual (DOT, 1982–86) [Sb].

38.7 Visibility

Drivers emerging from the minor road of a priority junction must have adequate visibility to left and right along a single carriageway major road. Where the major road is a dual carriageway, with a central reserve of adequate width to shelter turning traffic, the standard visibility splay to the left is not required for the minor road but visibility to the left is needed in central reserves. If the major road is a one–way street then, clearly, visibility is only required towards oncoming traffic.

Major Road Distance ('y' distance)

The 'y' distance (see Figure 38.4) is determined by the speed of main road traffic. It must be sufficient to allow side–road traffic to emerge safely and to provide forward visibility to allow major road traffic to stop, if required.

The 'y' distance is determined by the 85th percentile wet weather speed or, if this is not known, by the speed–limit of the road. Tables 38.2 and 38.3 should be used, as appropriate

Minor Road Distance ('x' distance)

The 'x' distance (see Figure 38.4) gives a good field of view for a driver approaching, or stationary at, the give–way line. It also allows oncoming traffic to see emerging side–road traffic. TD 42/95 advises a desirable 'x' distance of nine metres but acknowledges that, in difficult circumstances, this may be relaxed to 4.5m for lightly trafficked simple junctions and, exceptionally, to 2.4m. Annex D of PPG13 Transport (DOE/DOT,1994) [Sc] [Wa] states that a 4.5m 'x' distance will normally be acceptable for less busy simple junctions and busy private accesses. For single dwellings and small culs–de–sac, a minimum of 2.0m is given.

In some circumstances, it is not possible to achieve the above requirements and authorities take a more relaxed view, particularly regarding 'x' distances. A pragmatic and balanced view is sometimes necessary. The following advice from PPG13 highlights this but needs to be used with caution [Sc].

'It is not always practicable to comply fully with visibility standards. Such standards, like all other material considerations in development control, need to be assessed in the light of all the circumstances of each case. However, visibility should not be reduced to such a level that danger is likely to be caused.'

Drivers' Eye–Height

The splay of visibility should be uninterrupted at the typical drivers' eye–height of 1.05m. At junctions near the crests of hills and adjacent to bridges, the effect of vertical alignment on visibility will need careful consideration. Problems are particularly likely when a priority junction occurs near the crest of a hill.

Other Visibility Considerations

As well as visibility between drivers, the visibility of, and between, pedestrians and cyclists using the junction should be considered in the design process. Drivers approaching on the minor road should have an unobstructed view of the junction. TD 42/95 has introduced two requirements in this respect and these are illustrated in Figure 38.4. This ensures that drivers slow down sufficiently to see the junction form clearly. On curved alignments, splays should be made tangential to the nearside edge of the road (see Figure 7/2 in TD 42/95).

Vehicles turning right from the major road need good visibility towards oncoming traffic and this should never be less than the desirable minimum stopping sight distance (DMSSD). TD 9/93 Highway Link Design (DOT, 1993) [Sd] states that DMSSD must be achieved on the immediate approach to a junction. The immediate approach is defined as:

Major road speed (85%ile)	miles/h (km/h)	75 (120)	62.50 (100)	53 (85)	44 (70)	37.5 (60)	31 (50)	25 (40)	19 (30)
Major road (y) distance	m	295	215	160	120	90	70	45	33

Table 38.2: Visibility distance based upon 85th percentile wet weather speed.

Speed Limit on Major Road	miles/h (km/h)	70 (113)	60 (96)	50 (80)	40 (64)	30 (48)	20 (32)
Major road (y) distance	m	295	215	160	120	90*	45*

* includes an allowance for vehicles travelling 10 km/h above the speed limit.

Table 38.3: Visibility distance based upon prevailing speed–limit.

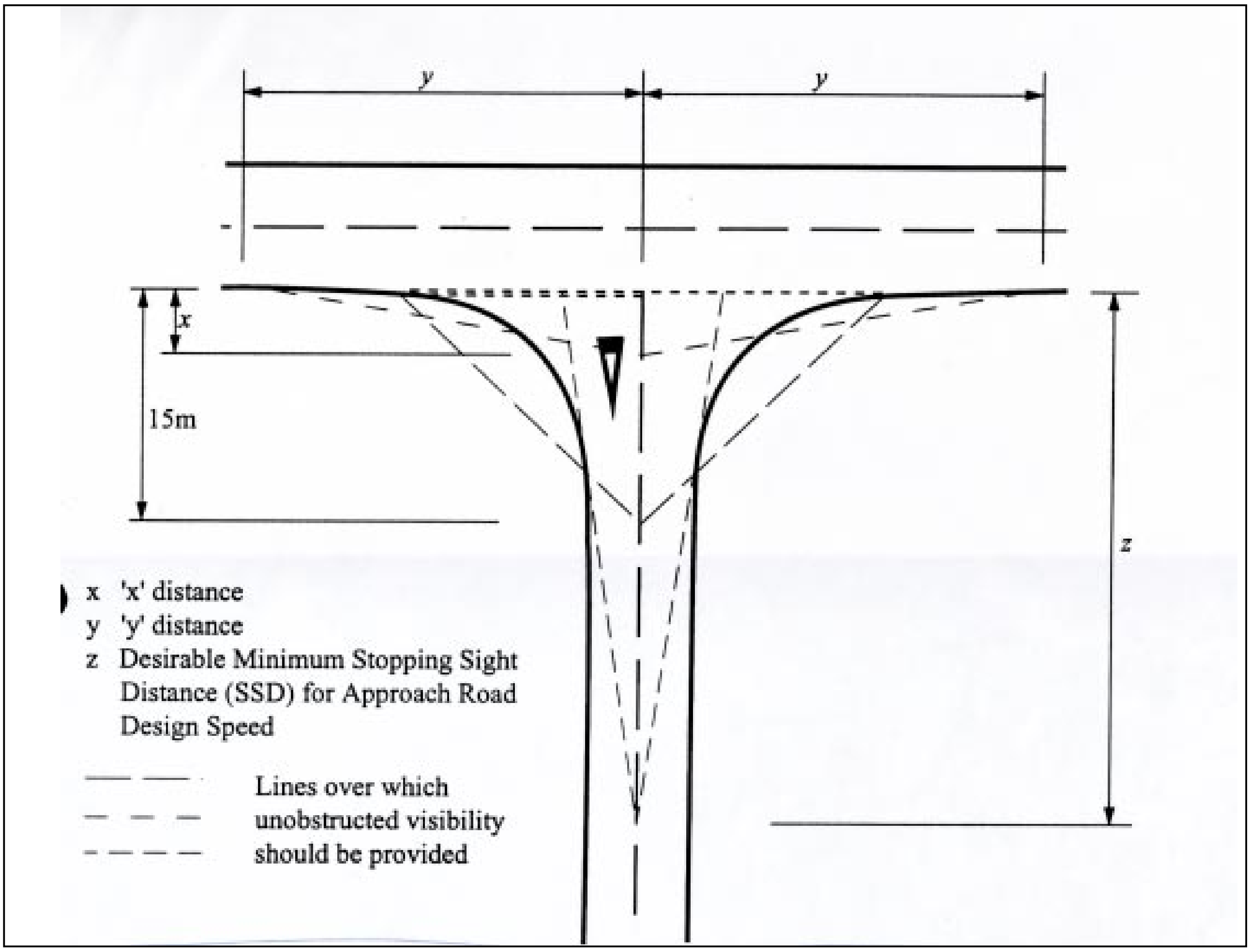

Figure 38.4: Visibility distances on major road and side–road.

- ❑ minor road – 1.5 times the DMSSD upstream of the give–way line; and
- ❑ major road – 1.5 times the DMSSD from the centre line of the minor road

Visibility splays should preferably lie within the curtilage of the highway to ensure that they are not obstructed. Planning controls can be used to prevent any future obstructions and section 79 of the Highways Act 1980 (HMG, 1980) [Se] provides highway authorities with the powers to pursue measures to improve or safeguard visibility.

As outlined earlier, 'x' and 'y' distances are measured respectively along the centre line of the minor road and along the kerbline of the major road. In reality, these are not the points from which drivers observe oncoming traffic or the positions of approaching vehicles. In some circumstances, where decisions on visibility standards are marginal, it may be beneficial to consider the visibility distances that are achieved in reality. Such an approach can assist pragmatic decision–making.

38.8 Traffic Throughput and Delay

Maximum Throughput

Prior to determining whether a design for a priority junction is a satisfactory solution, it is necessary to test the proposed layout using the relevant 'design reference' flows. The maximum throughput of the non–priority movements can be determined by two factors, which are:

- ❑ the number and length of gaps, occurring in the major traffic streams, that can be used by traffic entering or leaving the minor road(s); and
- ❑ the characteristics of the junction layout, such as lane widths, flare lengths and visibility distances.

A quick and simple assessment of the throughput of a particular traffic stream can be obtained by using the following formula:

$$C = 700 - 0.33M$$

where C is the throughput (veh/h) of the non–priority stream(s) and M is the total flow (veh/h) opposing priority movement(s).

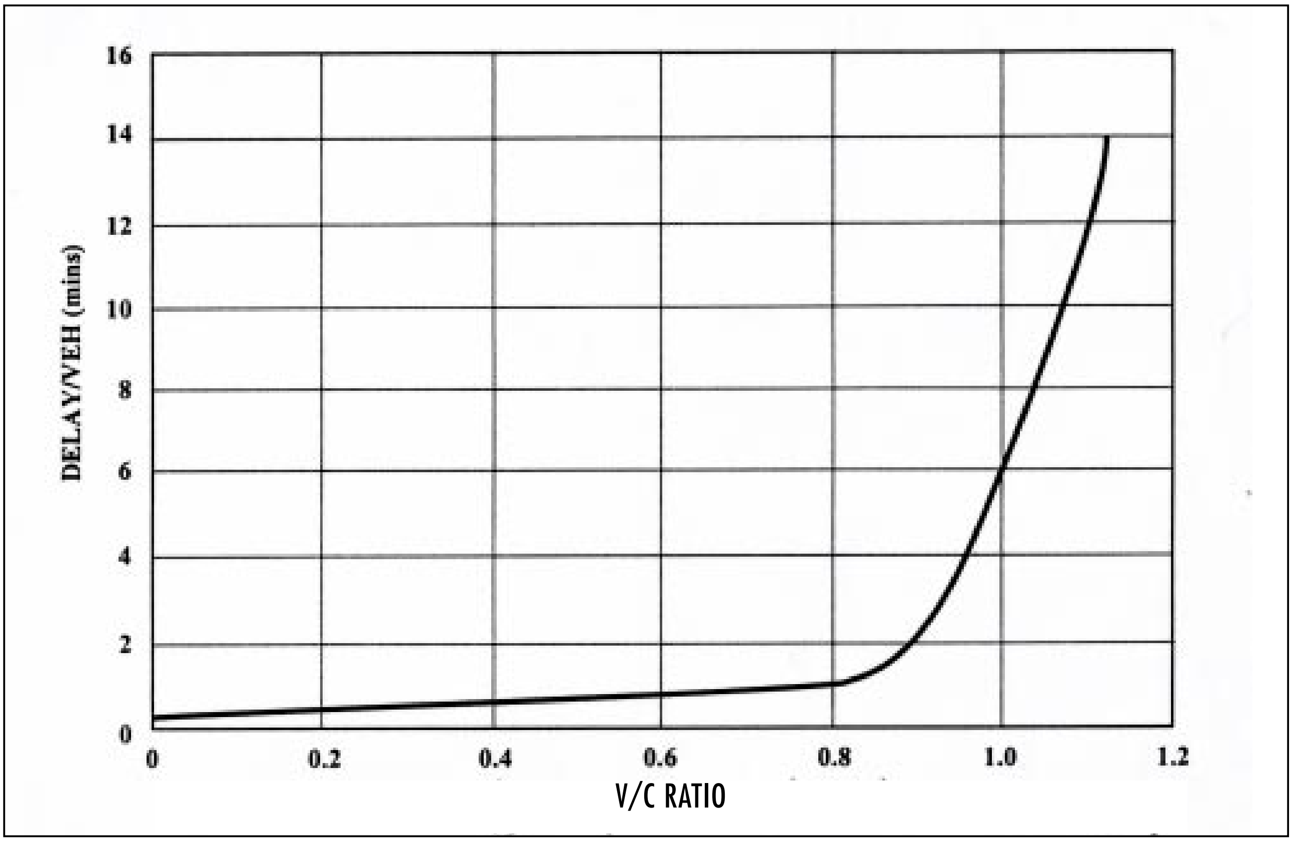

Figure 38.5: Increase in traffic delays with increase in the volume ratio to capacity (V/C).

The most critical traffic streams are usually the right–turn movements into, and out of, the minor road. More detailed equations for turning–stream capacities are given in Annex 1 of TD 42/95 (HMG, 1995).

The computer program PICADY 3 (TRL, 1993) has been developed to calculate the queues and delays that are likely with any particular junction layout and design flows. The program is commonly used to determine the capacity of all types of priority junction and it can also predict accident–rates for some types of junction.

Performance Indicators

The acceptability of any junction design depends upon the performance indicator used. TD 42/95 suggests the use of the ratio of volume to capacity (V/C) as an indicator of likely junction performance and it suggests that a design with a V/C ratio of about 85% is likely to result in a level of provision which will be economically justified in urban areas. Beyond a V/C ratio of around 0.85, in any stream of traffic, delays to that traffic tend to increase disproportionately, as illustrated in Figure 38.5.

Such an approach is simple to apply but should be tempered by examination of the actual demand flows and the significance of delays. Queue–lengths are only of major significance, if blocking back to adjacent junctions or accesses threatens to impair the performance of the network.

Commonly, junction analysis concentrates on conditions during peak periods, but it may be necessary to assess performance over the range of conditions occurring over a typical week. Trade–offs between what happens in a few peak hours and what happens in the many more off–peak hours can be important in the choice of layout, or even the type of junction control, adopted.

The Use of PICADY 3 (TRL, 1993).

The PICADY 3 User Manual details the use of this program. The following observations relate to some of the complexities that may not be self–evident.

Blocking of Major Road Traffic by Right–Turners

The program can predict the delays to straight–ahead traffic caused by waiting right–turning traffic. However, this is not the case where there are two lanes on the major road and only one is blocked or where blocking occurs only sometimes.

Flaring on Minor Roads

If a minor road has a single–lane approach but is flared close to the junction entry, the traffic on this arm is considered as two streams; one containing the left–turning traffic and the other containing the right–turning traffic. The queues and delays for the two streams take account not only of the traffic capacity at the give–way line but also of the effect of vehicles being trapped upstream in the single–lane approach.

Pedestrian Crossings
The effect of Zebra crossings close to junctions can be modelled using PICADY 3. This takes into account pedestrian flows at a crossing and the location of the crossing.

However, Zebra crossings cannot be modelled, if they occur at any of the following locations:

- ❑ across a major road between the two minor arms of a staggered junction; or
- ❑ on a flared minor road within the flared two–lane section; or
- ❑ on a major road arm where right–turning traffic blocks the straight–ahead stream.

Furthermore, it is not possible to model the effect of Pelican or Puffin crossings close to junctions.

Site–Specific Corrections
PICADY 3 will not always model a junction with sufficient accuracy. Observations should therefore be made to identify if this is the case. At three–arm junctions, entry capacity can be determined when there is continuous queueing, with corrections then being made to the program. The application of this calibration technique will not be appropriate, if large scale changes in junction layout are planned.

'Marginal effects analysis' predicts the effects of small discrete changes in junction geometry.

The measurement of visibility distances differs from the standards used in TD 42/95 and relates more closely to the distances that are actually achieved.

Prediction of Accident Rates
The prediction of likely accident rates is an important issue. PICADY 3 has the facility to predict accident rates for some types of junction. The increasing range of junctions for which this is possible makes it easier to consider road safety issues, consistently, when evaluating junction design.

38.9 References

DOE/DOT (1994) PPG13 Planning Policy Guidance 'Transport', DOE/DOT [Sa] [Wa].

DOT (1981) TA22/81 (DMRB 5.1) 'Vehicle Speed Measurement on all–purpose Roads', Stationery Office [Sa].

DOT (1982–1986) 'The Traffic Signs Manual', Stationery Office [Sb].

DOT (1988) TA1/88 'Provision for Cyclists at Grade–Separated Junctions', DOT, [Sa].

DOT (1993) TD9/93 (DMRB 6.1.1) 'Highway Link Design', Stationery Office [Sa]

HMG (1980) 'Highways Act 1980', Stationery Office [Sf].

HMG (1995) TD42/95 (DMRB 6.2.6) 'Geometric Design of Major/Minor Priority Junctions', Stationery Office [Sa].

TRL (1993) 'PICADY 3 User Manual', TRL.

38.10 Further Information

DOT (1981) TA23/81 (DMRB 6.2) 'Junctions and Accesses : Determination of the Size of Roundabouts and Major/Minor Junctions', Stationery Office [Sa].

DOT (1995) TD41/95 (DMRB 6.2.7) 'Vehicular Access to All Purpose Trunk Roads', Stationery Office.

TRL (1980) Report SR582 'The Traffic Capacity of Major/Minor Priority Junctions', TRL.

TRL (1982) Report SR724 'The Effect of Zebra Crossings on Junction Entry Capacity', TRL.