The field observations can be significantly simplified by providing observers with an electronic watch and bleeper. The watch should show time to the nearest second and should sound bleeps every 15 seconds. One bleep is sounded at 0 seconds, two at 15 seconds, three at 30 seconds and four at 45 seconds.

Observers should be carefully trained. It is recommended that a video recording of a queue at a junction or crossing be used during the training. Each observer should be tested carefully to determine whether he or she understands the procedure of counting queue lengths exactly. Some observers who are used to counting traffic volumes, find it difficult to adjust to queue length counts since queue lengths are counted at the end of an interval, while traffic volumes are counted during the interval.

2.4.6 Traffic modelling of queue lengths

1. It is not always possible to undertake field observations of queue lengths, and traffic modelling will then have to be resorted to. Field observations of queue lengths, for instance, are not possible at new junctions that have not yet been constructed. This would typically occur when a new development is planned. During the Traffic Impact Study required to establish the impact of such development, the need for additional traffic signals at new accesses or junctions must be established based on traffic modelling and using the traffic signal warrants.

2. Traffic modelling will also be required where changes to the road network, or the installation of a new traffic signal, would result in a redistribution of traffic in an area. A newly signalised road junction may attract drivers from nearby priority controlled junctions who may find that by diverting to the signalised junction, they experience less delay. These scenarios would entail a more rigorous traffic planning analysis with the purpose of estimating the likely traffic volumes at the junction or crossing being evaluated.
A variety of computer traffic models are available, although some manual methods are also used. The estimation of queue lengths by means of a traffic model is a complex exercise and should be undertaken with circumspect. All traffic models are based on some idealised representation of reality, which may, or may not, be representative of actual traffic operations. Some models are more accurate than others, but all models have limitations. The results of such models should therefore be used with caution.

Some models can calculate average queue lengths directly. Some models calculate 90th or 95th percentile queue lengths. These should not be used, as it is the average queue length that is required. Where queue lengths are only provided per approach and not by lane, such queue lengths should be divided by the number of lanes on the approach to establish the average queue length per lane.

Some models only provide average delay as output and not queue length. The average queue length can then be calculated by means of the following formula:

\[
N_i = \frac{D_i \cdot Q_i}{3600}
\]

in which:

- \(N_i\) = Average queue length in lane i.
- \(D_i\) = Average delay of vehicles in lane i in units of seconds/vehicle, excluding acceleration and deceleration delay.
- \(Q_i\) = Arrival flow rate in lane i in units of vehicles/hour/lane.

2.4.7 Normal days

1. An important consideration in establishing queue lengths, is that such queues should be established for a normal day rather than for an exceptional day.

2. A normal day is one on which traffic flow is relatively stable, unaffected by events such as traffic accidents, road closure, construction, inclement weather, special sporting events and during school terms. Exceptional days include public and school holidays, as well as days on which traffic patterns are abnormal due to the conditions as mentioned above. More information on normal and exceptional days is given in Chapter 29 of this manual.

3. Traffic counts and queue length observations should be discontinued or discarded when an exceptional event has occurred that may have affected the observations.
CHAPTER 3: TRAFFIC SIGNAL FACES

3.1 INTRODUCTION

1 The traffic light signal is the means by which a traffic signal communicates with the driver. This communication is of fundamental importance for the efficient and safe operation of a traffic signal installation.

2 Due to the importance of the traffic light signal and signal faces in the communication with drivers, light signals and faces are regulated by the National Road Traffic Regulations, while minimum requirements are given in Chapter 6 of Volume 1 of the Road Traffic Signs Manual. It is important that these regulations and standards shall be strictly adhered to in order to ensure uniform and safe traffic signalling.

3.2 LIGHT SIGNALS AND FACES

1 The light signal is the basic element of communication with the road user. A light signal consists of a single illuminated signal aspect and can be coloured green, yellow or red. A signal aspect is the lamp unit that displays a light signal when illuminated.

2 A vehicular light signal can be either a disc or an arrow light signal. Special light signals are also available for the control of buses, trams, pedestrians and pedal cyclists (as well as reversible lanes).

3 The vehicular disc light signal applies to ALL traffic movements, while the arrow (or a disc light signal combined with the Traffic Signal Arrow Sign ST1 to ST5) applies only to a particular turning movement or movements.

4 A light signal can also be either steady or flashing.

5 At traffic signals where no pedestrian signals are provided, the vehicular light signals will also apply to pedestrians.

6 The traffic signal face contains a number of signal aspects in particular arrangements. Standard traffic signal faces are prescribed and only those signal faces SHALL be used in traffic signal installations.

3.3 AREA OF CONTROL

1 Traffic signals, as defined by the National Road Traffic Regulations, shall control traffic only at a junction or a pedestrian or pedal cyclist crossing. The signals shall control ALL approaches to the junction or crossing.

2 A JUNCTION is defined by the National Road Traffic Regulations as "as that portion of an intersection contained within the prolongation of the lateral limits of the intersecting roadways and include any portion of the roadway between such lateral limits, and any stop or yield line marking which is painted at such intersection".

3 An INTERSECTION is defined by the regulations as the "the area embraced within the prolongation of the lateral boundary lines of two or more public roads, open to vehicular traffic, that join one another at any angle, whether or not one such public road crosses the other".

4 The above definition of a junction allows for the provision of slipways adjacent to the junction that can be controlled independently of the main junction. A SLIPWAY is a roadway that passes to the left (or in the instance of one-way systems, to the right) of the main junction without intersecting the main junction. The regulations, however, require that "a slipway for traffic turning left or right at a junction which is traffic signal controlled, shall be separated from the lane to the right or left of such slipway by a constructed island."

5 A slipway that is signal controlled would normally only have signals controlling the slipway, and any potential conflicts must be prevented at the main junction. All conflicting movements at the main junction, including the right turn movement from the opposite direction, must face a RED LIGHT SIGNAL while the slipway receives a GREEN SIGNAL.

6 A PEDESTRIAN CROSSING is defined by the National Road Traffic Regulations as "a) any portion of a public road designated as a pedestrian crossing by appropriate road traffic signs or b) that portion of a public road at an intersection included within the prolongation or connection of the kerb line and adjacent boundary line of such road, when no pedestrian crossing has been designated by appropriate road traffic signs".

7 The above definitions are illustrated in Figure 3.1. The figure shows an intersection defined by the boundary lines of the two intersecting roads. Two junctions are also shown in the figure, the main junction as well as a slipway junction. A number of marked pedestrian crossings as well as one unmarked pedestrian crossing are also shown. Pedestrian crossings are always defined at junctions (whether they are marked or not), except when pedestrians are specifically prohibited from crossing the junction.

3.4 CONTROL PRECEDENCE

1 According to the National Road Traffic Regulations, "the traffic control at a junction or pedestrian or pedal cyclist crossing may include the use of road signs, road markings and road signals and the control precedence SHALL be as follows:

(a) A road sign which prohibits or prescribes directional movement of traffic at a junction or pedestrian or pedal cyclist crossing which is controlled by a traffic signal, shall have precedence over any light signal which permits right of way.

(b) A light signal that permits right of way shall have precedence over the stop line RTM1;"
3.2 TRAFFIC SIGNAL FACES

Figure 3.1: Definition of intersections, junctions, slipways and pedestrian crossings

(c) A light signal that has the significance that traffic shall stop, has precedence over any other road traffic sign or another light signal that permits right of way, EXCEPT when such other light signal (permitting right of way) has a higher precedence level. The precedence levels for light signals are as follows, given from the highest to lowest precedence level:

(i) steady or flashing pedestrian and pedal cyclist light signals;
(ii) steady or flashing bus or tram light signals;
(iii) steady or flashing arrow signals, or steady disc signals with traffic signal arrow signs ST1 to ST5; and
(iv) steady disc light signals”.

2 The National Road Traffic Regulations require that "NO road sign except –
(a) a street name sign;
(b) a direction route marker sign;
(c) information signs IN14, IN15 and pedestrian and pedal cyclist signs relating to the function of the traffic signal;
(d) a one-way roadway sign;
(e) a no-entry sign;
(f) a left-turn prohibited, right-turn prohibited or a U-turn prohibited sign;
(g) a proceed straight through only, proceed left only, or proceed right only sign;
(h) a pedestrian prohibited sign R218; or
(i) a traffic signal arrow sign ST1 to ST5;
SHALL be used in conjunction with a traffic signal, and such signs may be mounted on the same post or overhead cantilever or gantry as that of the traffic signal”. Examples of such signs are shown in Figure 3.2.
Figure 3.2: Examples of road signs used in conjunction with traffic signals

3 The following signs, in particular, may NOT be used in conjunction with a traffic signal, even if the signal is out of order (however, the signs may be used when the traffic signal has been masked out):
   (a) STOP sign R1 or any of its derivatives.
   (b) YIELD sign R2.
   (c) RIGHT-OF-WAY sign IN7.
   (d) Any sign that conflicts with or gives right of way over the traffic signal.

4 According to the definition of a junction, a slipway at a signalised junction is defined as a separate junction, operating independently of the main junction. A slipway therefore can be STOP or YIELD controlled as it is regarded as a separate junction.

5 The PEDESTRIAN PROHIBITED SIGN R218 is used to prohibit pedestrians from proceeding beyond the sign. The sign must be posted on the near side of the junction, in the direction to which it is applicable (and in both directions of the crossing).

6 TRAFFIC SIGNAL ARROW SIGNS ST1 to ST5 may be used in conjunction with traffic signals. According to the National Road Traffic regulations, the signs "indicate to the driver of a vehicle, when displayed vertically above a traffic signal face, that any light signal installed in such face only applies to the direction of movement indicated by the arrow".
3.5 VEHICULAR LIGHT SIGNALS

3.5.1 General requirements

1 Vehicular light signals are described in the following sections. Appropriate combinations of the light signal may be used at a signalised road junction or pedestrian or pedal cyclist crossing.

2 The following basic sequence of vehicular light signals shall be used on each approach road to a signalised junction or pedestrian or pedal cyclist crossing, and on each traffic signal face:

   (a) a FLASHING or STEADY GREEN LIGHT SIGNAL, followed by:
   (b) a STEADY YELLOW LIGHT SIGNAL followed by:
   (c) a STEADY RED LIGHT SIGNAL, where it is provided on a signal face (not provided on S10L, S10R, S10B and S10T signal faces).

3 On the S9 and S10L traffic signal faces, the STEADY YELLOW ARROW LIGHT SIGNAL may be omitted from the signal sequence subject to the conditions that:

   (a) the FLASHING GREEN ARROW LIGHT SIGNAL must immediately be followed by a STEADY GREEN LIGHT SIGNAL which allows the left-turn movement to turn; and
   (b) when pedestrian or pedal cyclist signals are provided, no GREEN PEDESTRIAN or PEDESTRIAN CYCLIST LIGHT SIGNAL may be displayed following the flashing green arrow light signal.

The yellow arrow light signal shall NOT be omitted when such green pedestrian or pedal cyclist light signal is displayed.

4 Light signals of different colours shall NOT be displayed at the same time to the same turning movement. A driver may, for example, not receive a red signal at the same time as a yellow or green signal (even at a staggered or very wide junction).

5 Under no circumstances SHALL a GREEN LIGHT SIGNAL be used at some times in a STEADY mode and other times in a FLASHING mode. A RED LIGHT SIGNAL, however, may be used in both flashing and steady modes. The YELLOW LIGHT SIGNAL may under no circumstances be used in flashing mode on a traffic signal face.

6 When traffic signals are not in operation, such as during installation, all traffic signal faces SHALL be suitably masked so as to obscure them from the sight of drivers, pedestrians or pedal cyclists. Advance information signs relating to the signal shall also be masked. While the traffic signal is not operational, each non-priority side road approach to the junction shall be controlled by a STOP sign R1, or a YIELD sign R2, or all approaches shall be controlled by all-way STOP signs R1.3 or R1.4. These signs shall be removed immediately once the traffic signal has come into operation.

7 The meanings assigned to vehicular light signals given in the following subsections are quoted directly from the National Road Traffic Regulations.

3.5.2 Red vehicular light signals

1 A STEADY RED DISC LIGHT SIGNAL (without a traffic signal arrow sign ST1 to ST5) indicates “to the driver of a vehicle that he or she shall stop his or her vehicle behind the stop line RTM1 and that he or she shall remain stationary until a green light signal is displayed, and it is safe to proceed, and in the event that a pedestrian light signal is not provided, indicates to a pedestrian that he or she shall not cross the roadway until a green light signal is displayed and it is safe to do so”.

2 A STEADY RED BUS LIGHT SIGNAL indicates “to the driver of a vehicle allowed in an exclusive bus lane that he or she shall stop his or her vehicle behind the stop line RTM1 and that he or she shall remain stationary until a green bus light signal is displayed, and it is safe to proceed.”

3 A STEADY RED TRAM LIGHT SIGNAL indicates “to the driver of a vehicle allowed in an exclusive tram lane that he or she shall stop his or her vehicle behind the stop line RTM1 and that he or she shall remain stationary until a green tram light signal is displayed, and it is safe to proceed”.

4 A STEADY RED DISC LIGHT SIGNAL WITH A TRAFFIC SIGNAL ARROW SIGN ST1 to ST5 INSTALLED ABOVE THE SIGNAL indicates “to the driver of a vehicle that he or she shall stop his or her vehicle behind the stop line RTM1 if he or she intends turning in the direction indicated by” … the traffic signal arrow sign and that he or she shall remain stationary until a green light signal is displayed that allows movement in the direction of the arrow and it is safe to proceed”.

5 A FLASHING RED DISC, BUS OR TRAM LIGHT SIGNAL indicates “to the driver of a vehicle that he or she shall act as for a 3-way stop sign R1.3 or 4-way stop sign R1.4 and shall yield right of way to all pedestrians crossing his or her path, and the signal indicates to a pedestrian that he or she may cross the roadway if it is safe to do so”. This use of this signal shall be SUBJECT TO THE FOLLOWING CONDITIONS:

   (a) It shall NOT be displayed at the same time as ANY other light signal on any approach road, and the pedestrian and pedal cyclist signals shall be switched off (except when a pelican phase is provided).
   (b) At a pedestrian crossing it may be used during a “Pelican” phase to indicate to drivers of vehicles that pedestrians may be clearing the road and have right of way. During this phase, the FLASHING RED LIGHT SIGNAL may be displayed only at the same time as the FLASHING RED MAN or PEDESTRIAN CYCLIST RED LIGHT SIGNAL. Pedestrians or pedal cyclists may not enter the crossing on the flashing red signal, and the duration of this interval should therefore NOT exceed the time required to clear the crossing. Information on the timing of pedestrian and pedal cyclist signals is given in Chapter 4 of this manual.
3.5.3 Yellow vehicular light signals

1 A STEADY YELLOW DISC LIGHT SIGNAL indicates "to the driver of a vehicle that he or she shall stop his or her vehicle behind the stop line RTM1 and that he or she shall remain stationary until a green light signal is displayed, and it is safe to proceed; provided that if he or she is so close to a stop line RTM1 when the steady yellow disc light signal is displayed that he or she cannot stop safely, he or she may proceed with caution against such yellow light signal, and in the event that a pedestrian light signal is not provided, indicates to a pedestrian that he or she shall not cross a roadway until a green light signal is displayed and it is safe to do so". The use of this signal shall be SUBJECT TO THE FOLLOWING CONDITIONS:

(a) It shall NOT be displayed to right-turning traffic at the same time as a GREEN LIGHT SIGNAL is displayed to traffic on the conflicting opposing approach. This means that a phase allowing traffic to turn right may not be terminated while a green light signal is still being displayed on the conflicting opposing approach (Right-turning traffic receiving yellow may not know that the opposing traffic is still receiving green and may turn right into the face of oncoming traffic).

(b) It should be followed by a clearance or all-red interval to allow vehicles to clear the junction before green light signals are displayed to conflicting traffic movements.

(c) The duration of the yellow and clearance or all-red intervals is calculated using procedures given in Chapter 6 of this manual (Volume 3).

(d) An enforcement tolerance should be provided during the all-red interval to accommodate drivers who are unable to stop during the yellow interval. Law enforcement should only commence during the last one second of the all-red interval.

2 A STEADY YELLOW BUS LIGHT SIGNAL indicates "to the driver of a vehicle allowed in an exclusive bus lane that he or she shall stop his or her vehicle behind the stop line RTM1 and that he or she shall remain stationary until a green light signal is displayed, and it is safe to proceed; provided that if he or she is so close to a stop line RTM1 when the steady yellow bus light signal is displayed that he or she cannot stop safely, he or she may proceed with caution against such yellow light signal". The use of this light signal is SUBJECT TO THE CONDITIONS given for the STEADY YELLOW DISC LIGHT SIGNAL.

3 A STEADY YELLOW TRAM LIGHT SIGNAL indicates "to the driver of a vehicle allowed in an exclusive tram lane that he or she shall stop his or her vehicle behind the stop line RTM1 and that he or she shall remain stationary until a green light signal is displayed, and it is safe to proceed; provided that if he or she is so close to a stop line RTM1 when the steady yellow tram light signal is displayed that he or she cannot stop safely, he or she may proceed with caution against such yellow light signal". The use of this light signal is SUBJECT TO THE CONDITIONS given for the STEADY YELLOW DISC LIGHT SIGNAL, except that the duration of the yellow and clearance intervals must be adjusted to accommodate the operational characteristics of the tram.

4 A STEADY YELLOW ARROW LIGHT SIGNAL indicates "to the driver of a vehicle that he or she shall stop his or her vehicle behind the stop line RTM1 if he or she intends turning in the direction indicated by the yellow arrow light signal and that he or she shall remain stationary until a green light signal, allowing the movement is displayed, and it is safe to proceed; provided that if he or she is so close to stop line RTM1 when a steady yellow arrow light signal is displayed that he or she cannot stop safely then he or she may proceed with caution against such yellow arrow light signal". The use of this light signal is SUBJECT TO THE CONDITIONS given for the STEADY YELLOW DISC LIGHT SIGNAL.

3.5.4 Green vehicular light signals

1 A STEADY GREEN DISC LIGHT SIGNAL indicates "to the driver of a vehicle that he or she may proceed through a junction or crossing, or turn to the left or right, subject to any restricting road traffic sign or light signal, but shall yield right of way to other vehicular traffic and to pedestrians lawfully within the junction or crossing, at the time a steady green disc light signal is displayed, and in the event that a pedestrian light signal is not provided, to indicate to a pedestrian that he or she may cross the junction within the pedestrian crossing markings RTM3 or RTM4 as appropriate, provided that a conflicting flashing green arrow, bus or tram light signal is not displayed at the same time". The use of this signal is SUBJECT TO THE FOLLOWING CONDITIONS:

(a) It shall NOT be displayed at the same time on the same approach as a STEADY GREEN ARROW LIGHT SIGNAL.

(b) With the exception of the S12 traffic signal face, it shall NOT be displayed for a duration less than 7 seconds (preferably not less than 11 seconds).
2 A STEADY GREEN BUS LIGHT SIGNAL indicates “to the driver of a vehicle allowed in an exclusive bus lane that he or she may proceed through a junction or crossing, or turn to the left or right, subject to any restricting road traffic sign or light signal, but shall yield right of way to other vehicular traffic and to pedestrians lawfully within the junction or crossing, at the time such steady green bus light signal is displayed”. The use of this signal is SUBJECT TO THE CONDITION that it shall NOT be used to indicate a FLASHING GREEN BUS LIGHT SIGNAL at another time.

3 A STEADY GREEN TRAM LIGHT SIGNAL indicates “to the driver of a vehicle allowed in an exclusive tram lane that he or she may proceed through a junction or crossing, or turn to the left or right, subject to any restricting road traffic sign or light signal, but shall yield right of way to other vehicular traffic and to pedestrians lawfully within the junction or crossing, at the time such steady green tram light signal is displayed”. The use of this signal is SUBJECT TO THE CONDITION that it shall NOT be used to indicate a FLASHING GREEN TRAM LIGHT SIGNAL at another time.

4 A STEADY GREEN ARROW LIGHT SIGNAL indicates “to the driver of a vehicle that he or she may proceed in the direction indicated by the steady green arrow light signal, subject to any restricting road traffic sign or light signal, but shall yield right of way to other vehicular traffic and to pedestrians lawfully within the junction or crossing, at the time such green light signal is displayed and in the event that a pedestrian signal is not provided, indicates to a pedestrian that he or she may cross the junction within the pedestrian crossing markings RTM3 or RTM4 as appropriate, provided that a conflicting flashing green arrow, bus or tram light signal is not displayed at the same time”. The use of this signal is SUBJECT TO THE FOLLOWING CONDITIONS:
   (a) It should preferably only be used to indicate the direction of ONE-WAY roads or streets.
   (b) It shall NOT be used when there is a conflicting traffic movement from the opposite direction (the movement is opposed). The STEADY GREEN RIGHT ARROW LIGHT SIGNAL, in particular, may NOT be used when there is an opposing traffic movement (e.g. on two-way roads).
   (c) It shall NOT be displayed at the same time on the same approach as a STEADY GREEN DISC LIGHT SIGNAL.
   (d) A maximum of two STEADY GREEN ARROW LIGHT SIGNALS, showing in different directions, may be located in one signal face.
   (e) It shall NOT be used to indicate a FLASHING GREEN ARROW LIGHT SIGNAL at another time.
   (f) It shall not be displayed for a duration less than 7 seconds (preferably not less than 11 seconds).

5 A FLASHING GREEN BUS LIGHT SIGNAL indicates “to the driver of a vehicle allowed in an exclusive bus lane that he or she may proceed and that his or her movements are unopposed by other traffic”. The use of this light signal is SUBJECT TO THE CONDITIONS given for the FLASHING GREEN ARROW LIGHT SIGNAL except that it shall NOT be used to indicate a STEADY GREEN BUS LIGHT SIGNAL at another time.

6 A FLASHING GREEN TRAM LIGHT SIGNAL indicates “to the driver of a vehicle allowed in an exclusive tram lane that he or she may proceed and that his or her movements are unopposed by other traffic”. The use of this light signal is SUBJECT TO THE CONDITIONS given for the FLASHING GREEN ARROW LIGHT SIGNAL except that it shall NOT be used to indicate a STEADY GREEN TRAM LIGHT SIGNAL at another time.

7 A FLASHING GREEN ARROW LIGHT SIGNAL indicates “to the driver of a vehicle that he or she may proceed in the direction indicated by the flashing green arrow light signal and that his or her movement is unopposed by other traffic”. The use of this signal is SUBJECT TO THE FOLLOWING CONDITIONS:
   (a) It shall NOT be used to indicate a STEADY GREEN ARROW LIGHT SIGNAL at another time.
   (b) It SHALL be displayed only when the indicated movement is protected and no opposing or conflicting vehicular, pedestrian or pedal cyclist movement has explicit or priority right of way. Conflicting movements through the junction shall face RED LIGHT SIGNALS.
   (c) When no pedestrian signal is provided, pedestrians do not have right of way when the FLASHING GREEN ARROW LIGHT SIGNAL is displayed. However, separate pedestrian signals for the control of pedestrians are recommended at junctions where such signals are displayed. Alternatively, pedestrian movements may be prohibited by means of PEDESTRIAN PROHIBITED SIGNS R218.
   (d) It shall NOT be displayed for a duration less than 4 seconds (preferably not less than 7 seconds).
3.6 FLAShING AND OTHER mODES OF OPERATIONS

1 Flashing and other modes of operations include:
   (a) FLASHING RED LIGHT SIGNALS on all approaches.
   (b) No light signal illuminated (signals switched off).
   (c) Manual signal advance, whereby the timing of green light signals can be changed manually.

2 The operations at the signal when light signals are flashing red or when the light signals are not illuminated, are similar to that of a 3- or 4-way STOP controlled junction. According to the National Road Traffic Regulations, "when no light signal is illuminated on an approach to a signalised junction, the driver of a vehicle shall act as for a 3-way stop sign R1.3 or a 4-way stop sign R1.4".

3 According to the National Road Traffic Regulations, "a traffic signal may be placed in a mode of operation indicating that it is out of order, and this mode of operation shall be that either all the light signals shall not be illuminated, or that all vehicular red light signals shall be flashing and pedestrian and pedal cyclist light signals shall be switched off".

4 At no time SHALL an operational traffic signal be intentionally switched off, other than for maintenance or repairs or when controlled by a traffic officer or an authorised pointsman (part-time operation of traffic signals is NOT allowed).

5 A traffic officer or an authorised pointsman may intervene with the operation of a traffic signal. The traffic signal may then be placed in any one of the above modes of operation.

6 The planned operation of traffic signals in flashing mode for part of the day or night, in place of normal traffic signal operations, is not recommended. Under conditions of low traffic flow, the following alternatives should first be considered:
   (a) Reduce cycle length, but with pedestrian phases still available on demand (in which case the cycle length may have to be increased to accommodate pedestrian crossing times).
   (b) Vehicle-actuated control.

7 It is recommended that, where and when possible, a traffic signal should be placed in a flashing mode of operation or switched off by first introducing STEADY RED LIGHT SIGNALS on all traffic signal faces for a duration of at least 3 to 5 seconds.

8 The traffic signal should again be returned to the normal mode of operation, or switched on, by using one of the following methods:
   (a) A FLASHING RED LIGHT SIGNAL should be followed by a STEADY RED LIGHT SIGNAL for a duration of between 3 and 5 seconds. This steady red light signal in turn, should, be followed by a GREEN LIGHT SIGNAL on the main road (where possible).
   (b) A switched-off traffic signal should be switched on again by first displaying FLASHING RED LIGHT SIGNALS for a duration of not less than 5 seconds, followed by STEADY RED LIGHT SIGNALS for a duration of between 3 and 5 seconds, followed by a GREEN LIGHT SIGNAL on the main road (where possible).

3.7 ARRANGEMENT OF LIGHT SIGNALS ON A SIGNAL FACE

1 The number and positioning of light signals on a traffic signal face SHALL conform to one of the standard traffic signal face arrangements shown in Figure 3.3. The relative position of each light signal relative to the others on a particular traffic signal face is of significance in the interpretation of the meaning of light signals.

2 The RED, YELLOW and GREEN LIGHT SIGNALS on a traffic signal face that contains three or more light signals, shall be positioned in line vertically with the RED LIGHT SIGNAL at the top, the YELLOW LIGHT SIGNAL immediately below the red and the GREEN LIGHT SIGNAL immediately below the yellow signal. If there is a second GREEN ARROW LIGHT SIGNAL it shall be located in line vertically below the first green arrow signal. A straight-ahead arrow shall be located above a right or left arrow and a right arrow shall be located above a left.

3 The YELLOW and GREEN LIGHT SIGNALS on a traffic signal face that contains two light signals, shall be positioned in line vertically with the YELLOW LIGHT SIGNAL at the top and the GREEN LIGHT SIGNAL immediately below the yellow signal.

4 When vehicular signal faces are mounted adjacent to each other in a horizontal group, all light signals of the same colour must be located on the same horizontal level (as shown in Figure 3.7), except that for S5, S6, S7 traffic signal faces, the second green arrow light signal may be located immediately below the level of the green light signals.

5 No light signal shall be located at the same level as a light signal of a different colour (except for pedestrian or pedal cyclist light signals).

6 DUPLICATE light signals shall NOT be provided in a traffic signal face. Providing such light signals would mean that the signal face no longer conform to one of the standard traffic signal faces of Figure 3.3. Where increased conspicuity is required, additional standard traffic signal faces may be provided.

3.8 STANDARD SIGNAL faces

1 Standard traffic signal faces are prescribed by the National Road Traffic Regulations. The standard faces are shown in Figure 3.3 and in the colour plate provided at the beginning of this manual (Volume 3). All traffic signal faces SHALL conform to one of the standards, and no other faces may be used.

2 The standard traffic signal faces have been developed to ensure uniformity and adequate comprehension by road users. They will meet all practical signal requirements and applications. The use of any other signal face arrangements is not necessary and is NOT allowed.

3 TRAFFIC SIGNAL FACES S16 to S19 are used for individual lane control and are discussed in Chapter 13 of this manual (Volume 3). The faces are included in Figure 3.3 to indicate that they form part of the numbering system.

4 Dimensions for the standard traffic signal faces are given in Volume 4 of the Road Traffic Signs Manual and in the standard specifications SANS 1459: Traffic lights.
Figure 3.3: Standard traffic signal faces and traffic signal arrow signs
TRAFFIC SIGNAL ARROW SIGNS ST1 to ST5 may be used to indicate the directions in which light signals are applicable. The use of the signs is subject to the following conditions:

(a) The signs shall ONLY be used when it is necessary to assign to traffic signal faces S1L and S1R a higher precedence level (using signs ST3 and ST2 respectively).

(b) When the arrow signs are used with the S1L and S1R signal faces, arrow signs may optionally also be used with signal faces S1, S2, S3, S4, S5, S6 and S7. However, when these signal faces are erected immediately adjacent to the S1L and S1R signal faces (typically on the same post), the use of arrow signs with the signal faces is recommended as shown in Figures 3.4a and 3.4b.

The standard TRAFFIC SIGNAL FACE S1 is used when traffic is permitted to proceed in any direction that is allowed at the junction. The signal face is also used at signalised pedestrian and pedal cyclist crossings, as well as for the control of two-way traffic on a single lane. The signal face may NOT be used on the same approach as signal faces S2, S3, S4, S5, S6 and S7 (because of the conflicting meanings of the green light signals).

The sign faces S1B and S1T are only applicable to vehicles allowed in exclusive bus and tram lanes respectively. The faces may NOT be used to control buses or trams travelling in non-exclusive lanes.

The standard TRAFFIC SIGNAL FACES S1A, S1AR and S1AL are used ONLY in the Alternative System. The faces are used to signal protected turning phases, and may only be used if the turning movement indicated by the direction of the arrows is unopposed by any conflicting movements.

The standard TRAFFIC SIGNAL FACES S1R and S1L are used to signal protected-only turning phases. The flashing green signals indicate that the turning movement is unopposed by any conflicting movements during the turning phase. During other phases, turning is prohibited by the red light signal. The use of the signals faces is subject to the following conditions:

(a) The signal faces may be used without TRAFFIC SIGNAL ARROW SIGNS ST2 and ST3 on approaches to junctions serving only one turning movement or on signalised slipways that are separated from other turning movements by a constructed island.

(b) The signal faces must be used in combination with TRAFFIC SIGNAL ARROW SIGNS ST2 and ST3 on approaches to junctions from which more than one direction of movement is allowed. Examples of the combined use of the traffic signal faces and arrow signs are shown in Figures 3.4a and 3.4b.

(c) The signal faces may only be used when the conditions for the use of red, yellow and green light signals given in Sections 3.5.2 to 3.5.4 of this chapter are met.

Standard TRAFFIC SIGNAL FACES S2, S3, S4, S5, S6 and S7 may be used where traffic is permitted to proceed only in particular directions. The use of the signal faces is subject to the following conditions:

(a) The signal faces should preferably only be used to indicate the direction of ONE-WAY roads or streets.

(b) Traffic signal faces S2, S6 and S7 may ONLY be used if there are no vehicular movements from the opposite direction conflicting with the right-turn movement.

(c) The signal faces shall NOT be used on the same approach as signal face S1 (because of the conflicting meanings of the green light signals).

(d) The green arrow light signals on signal faces S5, S6 and S7 shall be indicated concurrently.

Traffic signal faces S2, S6 and S7 may ONLY be used on signalised slipways that are separated from other turning movements by a constructed island.

Traffic signal faces S2, S6 and S7 may ONLY be used if there are no vehicular movements from the opposite direction conflicting with the right-turn movement.

Traffic signal faces S8, S8B, S8T, S9, S9B and S9T may be applied in a similar way than traffic signal faces S2, S1B and S1T, except that provision is made for signalling of a protected/permitted turning phase. During the turning phase, the movement is protected and unopposed by any conflicting traffic movement. During other phases of the signal, the turning movement is permitted (e.g. by means of gap acceptance). The use of the signal faces is subject to the following conditions:

(a) The signal faces may only be used when the conditions for the use of red, yellow and green light signals given in Sections 3.5.2 to 3.5.4 of this chapter are met.

(b) The traffic signal faces can also be provided as two separate but adjacent traffic signal faces (e.g. faces S1 and S10R instead of face S8).

Traffic signal faces S10R, S10L, S10B and S10T may be used to signal protected/permitted right-turn or left-turn phases. The use of the signal faces is subject to the following conditions:

(a) The light signals shall only be displayed during the protected turning phase and shall NOT be displayed at any other time.

(b) The signal faces may only be used when the conditions for the use of yellow and green signal faces given in Sections 3.5.2 to 3.5.4 of this chapter are met.

(c) The signal faces can be used as stand-alone signal faces or in combination with other signal faces. The stand-alone configuration, however, is not recommended (since no red light signal is available in these faces).
Figure 3.4a: Signalling for protected-only right turn at a T-junction

Figure 3.4b: Signalling for protected-only right turn at a 4-way junction (road divided by a median)
3.9 NUMBER AND LOCATION OF TRAFFIC SIGNAL FACES

3.9.1 General requirements

1 Traffic signal faces for use at junctions and pedestrian or pedal cyclist crossings are classified as follows:
   (a) Principal traffic signal faces are faces provided to meet the minimum legal requirements of the National Road Traffic Regulations.
   (b) Supplementary traffic signal faces are additional traffic signal faces, not being principal traffic signal faces, provided to meet requirements in respect of visibility and conspicuity or improved traffic operations.

2 According to the National Road Traffic Regulations, the following PRINCIPAL traffic signal faces SHALL be provided at a signalised junction, signalised slipway or signalised pedestrian or pedal cyclist crossing for the control of vehicular traffic for each direction from which vehicular traffic may approach the junction, slipway or crossing (these requirements shall not necessarily apply to traffic signals used at other locations):
   (a) FAR-SIDE PRINCIPAL SIGNAL FACES. “At least two traffic signal faces shall be provided on the far side of the stop line RTM1 at locations:
      (i) that are NOT on the near side of a junction or slipway;
      (ii) that are not less than 6 metres (but preferably not less than 10 metres) from the stop line RTM1;
      (iii) such that the two traffic signal faces shall not be less than 3 metres and not more than 20 metres apart; Provided that where it is unavoidable that the traffic signals are more than 20 metres apart, additional PRINCIPAL traffic signals shall be provided in such a manner that no traffic signals are more than 20 metres apart (signals should preferably not be more than 16 metres apart);
      (iv) at a signalised junction, but not a pedestrian or pedal cyclist crossing, where a straight-through movement is permitted from an approach to the junction, and where the roadway continues straight through the junction, a traffic signal face for the control of straight-through movements shall be provided subject to the requirements of subparagraphs a) (i) to (iii), on either side of the roadway on the far side of the junction; Provided that when the roadway is divided at the junction by a constructed median island of adequate width to accommodate a signal, the right-hand traffic signal face shall be situated on the median island;”
   (b) NEAR-SIDE PRINCIPAL SIGNAL FACES. “At a signalised junction or slipway, but not a pedestrian or pedal cyclist crossing, at least one signal face containing a red light signal shall be provided on the near side of the junction or slipway, on the left- or right-hand side of the roadway at a position not further than 3 metres from the prolongation of the stop line RTM1”. Although not prescribed, the near-side signal face is also recommended at pedestrian and pedal cyclist crossings.
   (c) PRINCIPAL SIGNAL FACES FOR TURNING PHASES. “When a separate left- or right-turn signal is required, at least two traffic signal faces that incorporate a flashing green arrow light signal, flashing green bus light signal or a flashing green tram light signal, shall be provided, one on the far side of the stop line RTM1 subject to subparagraphs a) (i) and (ii), and the other on the far or near side;”

3 According to the National Road Traffic Regulations “additional traffic signal faces may be provided at the junction or crossing at any suitable location”, even if the minimum requirements for principal traffic signal faces have been met. Supplementary signal faces must be provided where the minimum visibility requirements cannot be achieved by means of the principal faces alone.

4 With the exception of Traffic Signals S16 to S19, the position of a signal face on an approach, including an overhead mounted signal face, in relation to any lane on the approach, is generally not significant in the interpretation of the light signal by the road user (although positions of traffic signals may be prescribed).

5 A number of examples of traffic signal layouts showing the minimum required principal traffic signal faces are given in Appendix B of this manual.

3.9.2 Two-way traffic on a single lane

1 Traffic signals may be installed to successively give right of way to traffic from opposite directions on a single traffic lane, such as a narrow bridge and tunnel, or at roadworks when only one lane of the road is open.

2 At least two traffic signal faces of type S1 shall be provided on a two-way single lane road, one on each side of the road, at a position not less than 6 m (but preferably not less than 10 m) beyond the stop line RTM1. However, where the traffic signal is manually operated (such as at roadworks), only one such signal face may be provided.

3 The stop line should be suitably located on the wider part of the road so that opposing traffic can pass any vehicles waiting at the stop line.
4 An all-red interval of sufficient duration is necessary that would allow slow moving traffic to clear the single lane section before the onset of the opposing green. For fixed time operation, this may be established based on the 15th percentile free-flow speed on the lane (judgement may be required to establish whether this would be adequate). When vehicle-actuated control is provided, the all-red period can be determined by the controller from vehicle detector inputs.

5 When sufficient sight distance is provided, the vehicular red light signal may be followed by a flashing red light signal to indicate that drivers can proceed if no vehicles are present in the opposite direction on the single lane section.

3.9.3 Left- and right-turn signal phases

1 Turning movements at traffic signals can be permitted, prohibited or protected. The different modes of operation are as follows:
   (a) Permitted-only mode in which a turning movement is permitted but no exclusive turning phase is provided.
   (b) Protected/permitted mode in which an exclusive protected turning phase is provided, but the turning movement is also permitted during the main phase.
   (c) Protected-only mode in which vehicles are only allowed to turn during a protected phase.
   (d) Prohibited mode in which no turning movement is allowed.

2 Protected signal phases can be provided as follows:
   (a) Protected/Permitted mode – traffic signal faces S10R, S10L, S10B or S10T used singly or in combination with another suitable signal face that contains a red light signal (preferably not singly). Signal faces S8, S8B, S8T, S9, S9B and S9T can also be used for this purpose.
   (b) Protected-only mode on an approach other than a signalised slipway – traffic signal faces S1R and S1L with TRAFFIC SIGNAL ARROW SIGNS ST2 and ST3 respectively.
   (c) Protected-only mode on a signalised slipway – traffic signal faces S1R and S1L without TRAFFIC SIGNAL ARROW SIGNS ST2 or ST3.

3 When one of the traffic signal faces S1R and S1L is used to control a turning movement, the straight-through and other turning movement must be controlled using another suitable traffic signal face. When used on an approach other than a signalised slipway, separate lanes must be provided for the turning movements controlled by the S1R and S1L signal faces. Such lanes should preferably be separated from other lanes by a WM2 CONTINUITY LINE, a RMS PAINTED ISLAND or a constructed island.

4 Figures 3.5a and 3.5b illustrate a number of traffic signal operating sequences for right-turn phases. Details are shown for leading as well as lagging right-turn phases, for situations where the phases start or end with the main phase or where they run before or after the main phase. Figure 3.5a shows the details for protected/permitted right-turn phases and Figure 3.5b the details for protected-only phases.

3.10 SIGNALS ON HIGH-SPEED ROADS

1 The speed limit on any approach to a signalised junction or pedestrian or pedal cyclist crossing shall NOT exceed 80 km/h.

2 At traffic signals where the speed limit is 70 km/h or higher, the following measures can be considered to improve the visibility of the signals:
   (a) High intensity traffic light signals; or
   (b) Overhead mounted traffic signal faces;

3 At traffic signals where accidents occur due to high speed, or transgression of posted speed limits occurs, consideration may be given to the measures given above as well as the following corrective measures:
   (a) Law enforcement of the speed limit;
   (b) High visibility warning signs in advance of the signals;
   (c) Skid resistant road surface, particularly on downhill approaches to the signals;
   (d) Speed calming measures (e.g. rumble strips), but only if they are not distracting to drivers (such measures should preferably be introduced in advance of the traffic signal and not at the traffic signal); or
   (e) Converting the traffic signal to a traffic circle.

4 Speed discrimination equipment may be used to continually vary the intergreen period depending on vehicle approach speeds. The cost of the equipment may, however, mitigate against the use of such equipment. Where operating speeds are higher than the speed limit, it would be advisable to enforce the speed limit.

3.11 VISIBILITY REQUIREMENTS

1 Under normal atmospheric conditions, traffic signal faces should be clearly visible and recognisable on approaches to a signal. Where the principal signal faces alone cannot provide the required visibility, additional traffic signal faces must be provided to supplement the principal signal faces.

2 The overriding objective in deciding the number and location of supplementary traffic signal faces is that light signals should be clearly visible to the approaching vehicles for which they are intended, taking into account:
   (a) The position of the vehicle on the approach;
   (b) The alignment of the approach;
   (c) Obstructions to visibility (including other vehicles that may be queued on an approach);
   (d) Distracting lights and signs; and
   (e) Required sight distances.

3 Street lights, illuminated signs and distracting advertising signs close to, or behind traffic signals may be confusing and distracting to drivers. Such distracting features should not be permitted.
Figure 3.5a: Traffic signal sequence for protected/permited right-turn phases using a S8 signal face.

Figure 3.5b: Traffic signal sequence for protected-only right-turn phases using the S1 and S1R signal faces in conjunction with ST5 and ST2 traffic signal arrow signs.
Signal faces should be visible over the minimum distances described below. In each case, all light signals in a face must be visible from a reference point 1.05 m above the centre line of each lane of traffic for which the signal face is intended.

At least two traffic signal faces - principal or supplementary - should be visible at any one time over the minimum sight distances from the stop line given in Table 3.1. The sight distances given in the table allow for driver recognition, reaction and stopping times from the speed limit or posted advisory speed.

(a) Minimum and preferable sight distances are given for urban roads. The minimum sight distances given for rural roads are the preferred distances for urban roads. The minimum sight distances are based on a shorter reaction time, and should only be used at junctions were drivers would expect a traffic signal. The longer sight distances should be used when traffic signals are not expected and a longer reaction time is required to respond to the signals.

(b) The sight distances also vary according to the approach grade to a junction or crossing. Note that sight distances for speeds lower than 60 km/h should be permitted only in circumstances where the geometry of the approach ensures that vehicles reduce speed, and an appropriate advisory speed and warning sign is posted.

At least two traffic signal faces on the far side of the stop line should be visible from a distance of 50 m or more, up to the stop line.

At least one traffic signal face should lie within the average driver's "cone of vision" as shown in Figure 3.6. The cone of vision is measured from the stop line position, 20 degrees on either side of the continuation of the centre line of each approach lane.

At least one traffic signal face on the far side should be visible for right-turning vehicles waiting inside the junction to turn right. This traffic signal should preferably be located on the far right-hand corner of the junction.

Additional supplementary signal faces may (and preferably should) be provided to ensure consistency and uniformity along a road or street. For instance, if an overhead mounted signal face is provided at one location, then such signals should be provided at other junctions and pedestrian and cyclist crossings on the road or street (but only while roadway and other characteristics remain the same along the road or street and when signals are spaced at distances closer than 1 km apart).

The optical axis of each light signal should be positioned and aligned so that it is at the greatest effectiveness to the approaching traffic for which it is intended. The optical axis of each light signal should be aligned on the reference point in the centre of the approach lane or lanes midway over the distance that it is intended to control.

CARE SHOULD BE TAKEN TO ENSURE THAT NO TRAFFIC SIGNAL FACE INTENDED FOR TRAFFIC ON ONE APPROACH IS ALIGNED SO THAT IT COULD BE WRONGLY TAKEN TO APPLY TO ANOTHER APPROACH AT THE SAME JUNCTION.

3.12 MOUNTING OF VEHICULAR TRAFFIC SIGNALS

3.12.1 General

1. Traffic signal faces may be mounted on one of the following supports:
   (a) standard post;
   (b) extended (longer) post; or
   (c) overhead cantilever or gantry; Supporting traffic signal faces by means of catenary wires or cables, is NOT allowed.

2. A lateral clearance of at least 0.5 m should generally be provided from the edge of a roadway and any post or any part of a signal face, including the backboard. If there is a significant tipping of vehicles to one side due to camber or crossfall on the road, or where vehicles tend to cut corners, it is preferable to increase the clearance to 1.0 m or more.

3. On medians, where insistence on the 0.5 m lateral clearance would mean that signal faces cannot be provided on the median, the lateral clearance can be reduced to an absolute minimum of 0.1 m, but only if the camber or crossfall of the roadway falls away from the median.

3.12.2 Post-mounted traffic signals

1. Principal traffic signal faces should preferably be post-mounted at the side of the road. Supplementary traffic signal faces may be either post-mounted or mounted above the road surface on a gantry or cantilever.

2. Traffic signal faces on the left-hand side of the road, should generally be located not more than 2 m to the left of the continuation of the left-hand edge of the approach roadway, measured parallel to the road centre line and excluding any approach splay.

3. Traffic signal faces that are mounted on posts at the side of the road, should be not less than 2.3 m and not more than 3 m above the level of a point on the road surface nearest to the post, measured to the centre of the lowest (green) signal aspect, as shown in Figure 3.7. A minimum clearance of not less than 2.1 m above the sidewalk should also be provided.

4. Where it is necessary to achieve the minimum visibility requirements (e.g. on a vertical curve), supplementary traffic signal faces may be mounted on posts at the side of the road at a height exceeding 3 m. These supplementary traffic signal faces may be mounted on the same post, provided that the two traffic signal faces shall be not less than 1 m apart, measured from the centres of the two nearest light signals on the two signal faces, as shown in Figure 3.8. There is no maximum limit, but line-of-sight and stability factors should be taken into consideration and a practical limit would be 5 m (between centres of two closest light signals).
### Table 3.1: RECOMMENDED SIGHT DISTANCES FOR TRAFFIC SIGNALS

<table>
<thead>
<tr>
<th>Speed limit or advisory speed (km/h)</th>
<th>Minimum for urban conditions (where signals are expected)</th>
<th>Preferable for urban conditions and minimum for rural conditions</th>
<th>Adjustments for grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(km/h)</td>
<td></td>
<td>-5%</td>
</tr>
<tr>
<td>40 km/h (*)</td>
<td>55 m</td>
<td>130 m</td>
<td>0 m</td>
</tr>
<tr>
<td>50 km/h (*)</td>
<td>80 m</td>
<td>160 m</td>
<td>5 m</td>
</tr>
<tr>
<td>60 km/h</td>
<td>110 m</td>
<td>190 m</td>
<td>10 m</td>
</tr>
<tr>
<td>70 km/h</td>
<td>140 m</td>
<td>215 m</td>
<td>10 m</td>
</tr>
<tr>
<td>80 km/h</td>
<td>170 m</td>
<td>240 m</td>
<td>15 m</td>
</tr>
<tr>
<td>90 km/h</td>
<td>210 m</td>
<td>270 m</td>
<td>20 m</td>
</tr>
</tbody>
</table>

(*) To be used only in conjunction with an advisory speed sign, e.g. at a horizontal curve

![Figure 3.6: Cone of vision in horizontal plane](image)

Figure 3.6: Cone of vision in horizontal plane
3.12.3 Overhead traffic signals

1 Overhead mounting may be used for any principal or supplementary traffic signal face (principal signal faces should preferably be post-mounted). Overhead mounting will also be required when it is not possible to comply with the requirement that principal signal faces may not be further than 20 m apart (preferably not further than 16 m apart).

2 Consideration should be given to providing overhead mounted signal faces as supplementary signal faces at junctions or crossings where accidents occur due to high speed, or to ensure consistency and uniformity along a road or street.

3 Any traffic signal face that is mounted on a gantry or cantilever above the roadway SHALL have a minimum clearance above the road of not less than 5.2 m. The height to the lowest light signal should not exceed 6.2 m on a level road, as shown in Figure 3.9.

4 The vertical part of the gantry or cantilever structure may be used to mount a signal face at the side of the road.

5 The position of the traffic signal face mounted on a gantry or cantilever, relative to the traffic lane over which it is located, is NOT of significance in the meaning of the signal. The light signals displayed by such signal face apply to the approach and NOT just the lane over which it is located (does not apply to signals S16 to S19). The cantilever should, however, preferably be located on the left-hand side of the road.

6 The cantilever may be of any horizontal reach, although in practice a reach that exceeds 5 m will present stability problems. Alternatively, an overhead gantry can be used when a longer reach is required.

3.13 TRAFFIC SIGNAL LAYOUT PLANS

1 Traffic signal layout plans are used to show the numbers, types and location of traffic signal faces, as well as other elements of the traffic signal.

2 The National Road Traffic Regulations require that the layout plans SHALL be approved by a “responsible registered professional engineer or registered professional technologist (engineering) of the road authority concerned”; and that the signal plan shall be kept by the road authority in control of the traffic signal.”

3 According to the regulations, the plan must at least contain the following information:

(a) scaled drawing of the layout of the junction, indicating lane markings and road layout;
(b) number, type and location of traffic signal faces;
(c) number, type and location of pedestrian and pedal cyclist facilities, including pedestrian push buttons; and
(d) name, signature and registration number of the engineer or technologist who approved the signal, and date of signature.

4 An example of a traffic signal plan is given in Figure 3.10. The example shows a scaled drawing of the layout of the junction, lane markings, traffic signal faces, vehicle detection loops, pedestrian facilities and other data as required above. The plan also shows the signal groups that display exactly the same sequence of light signals at the same time (more information on signal groups is given in Chapter 6 of this manual).

5 The example traffic signal plan in Figure 3.10 utilises text to indicate types of traffic signal faces. This method is used throughout this manual. Symbols may also be used to indicate traffic signal faces as shown in Figure 3.11. The symbols used in this figure are pictorial and can be readily interpreted without reference to a legend.
Figure 3.7: Standard post mounting  

Figure 3.8: Extended post mounting

Figure 3.9: Overhead (cantilever) mounting of traffic signal faces
NOTE: Pedestrian signal faces may also be installed perpendicular to vehicular faces if visibility will not be obstructed by vehicles queuing at stop line.

Signal face types shown together with signal groups (between parentheses)

Legend
- Vehicular signal faces
- Pedestrian signal faces
- Extended (Totem)
- Push Button
- Existing signal faces
- Controller
- Overhead mounting

Scale: 1:500

DESIGNED BY
Consulting Engineer

APPROVED BY
Responsible Authority

N/S Street & E/W Street

Figure 3.10: Example traffic signal layout plan
Figure 3.11: Alternative traffic signal layout plan using graphic symbols for signal faces
CHAPTER 4: PEDESTRIAN AND PEDAL CYCLIST SIGNALS

4.1 INTRODUCTION

1 Pedestrian and pedal cyclist traffic is subject to control by any traffic signal that is intended for vehicular traffic. Separate signals, however, can be provided for the control of pedestrians and pedal cyclists.

2 Pedestrian and pedal cyclist signals SHALL be operated only in conjunction with vehicular traffic signals. They will normally be provided where a significant number of pedestrians or pedal cyclists experience difficulty and/or delay in crossing a road at certain times during the day. Situations in which pedestrian or pedal cyclist signals may be used are:
   (a) at signalised road junctions; and
   (b) at signalised mid-block pedestrian and pedal cyclist crossings.

3 Warrants for the provision of signals at pedestrian and pedal cyclist mid-block crossings are given in Chapter 2 of this manual (Volume 3).

4 The general provisions for vehicular traffic signals given in Chapter 3 of this manual (Volume 3) shall also apply to pedestrian and pedal cyclist signals and to vehicular traffic signals used in conjunction with such signals, except where otherwise noted in this chapter.

5 Where pedestrian signals are not provided at a junction, vehicular traffic shall yield right of way to pedestrians lawfully in the junction. Pedal cyclists, however, do not have the same right of way and are treated similar to vehicular traffic when pedal cyclist signals are not provided.

4.2 PEDESTRIAN AND PEDAL CYCLIST SIGNALS

1 Pedestrian light signals shall comprise:
   (a) a STEADY GREEN MAN LIGHT SIGNAL, followed by:
   (b) a FLASHING RED MAN LIGHT SIGNAL, followed by:
   (c) a STEADY RED MAN LIGHT SIGNAL.

2 Pedal cyclist signal installations shall comprise:
   (a) a STEADY GREEN PEDAL CYCLIST LIGHT SIGNAL, followed by:
   (b) a FLASHING RED PEDAL CYCLIST LIGHT SIGNAL, followed by:
   (c) a STEADY RED PEDAL CYCLIST LIGHT SIGNAL.

3 Pedestrian and pedal cyclist light signals shall have the significance assigned to them in the National Road Traffic Regulations. The meanings assigned to the different light signals below are quoted directly from the regulations.

4 A STEADY GREEN MAN LIGHT SIGNAL indicates “to a pedestrian that he or she may cross the roadway within the pedestrian crossing markings RTM3 or RTM4 as appropriate, and that the driver of a vehicle shall yield right of way to a pedestrian crossing such roadway”.

5 A STEADY GREEN PEDAL CYCLIST LIGHT SIGNAL indicates “to a pedestrian that he or she may cross the roadway within the pedal cyclist crossing, and that the driver of a vehicle shall yield right of way to a pedal cyclist crossing such roadway”.

6 A FLASHING RED MAN LIGHT SIGNAL indicates “to a pedestrian (a) who has not yet commenced crossing the roadway that he or she shall not cross the roadway until the steady green man light signal is displayed, or (b) who is within a pedestrian crossing that the steady red man light signal will follow shortly”.

7 A FLASHING RED PEDAL CYCLIST LIGHT SIGNAL indicates “to a pedestrian (a) who has not yet commenced crossing the roadway that he or she shall not cross the roadway until the steady green pedal cyclist light signal is displayed, or (b) who is within a crossing that the steady red pedal cyclist light signal will follow shortly”.

8 A STEADY RED MAN LIGHT SIGNAL indicates “to a pedestrian that he or she shall not cross the roadway until the steady green man light signal is displayed”.

9 A STEADY RED PEDAL CYCLIST LIGHT SIGNAL indicates “to a pedal cyclist that he or she shall not cross the roadway until the steady green pedal cyclist light signal is displayed”.

10 A GREEN MAN or PEDAL CYCLIST LIGHT SIGNAL shall not be displayed at the same time as a FLASHING or STEADY RED MAN or PEDAL CYCLIST LIGHT SIGNAL on the same crossing.

11 A pedestrian signal face shall comprise two light signals, one depicting a red standing man and the other depicting a green walking man. The standard signal face Type S11P shall be used. The red man shall be located in line directly above the green man signal aspect.

12 A pedal cyclist signal shall comprise two light signals, displaying a green and red bicycle symbol respectively when illuminated. The standard pedal cyclist signal face Type S11C shall be used. The red pedal cyclist shall be located in line directly above the green pedal cyclist aspect.
4.3 OPERATION OF PEDESTRIAN AND PEDAL CYCLIST SIGNALS

1 The function of the steady GREEN MAN and GREEN PEDAL CYCLIST LIGHT SIGNAL is to provide a limited initial "step off" or "launching" interval for pedestrians and pedal cyclists. It SHALL always be followed immediately by a FLASHING RED MAN or PEDAL CYCLIST LIGHT SIGNAL.

2 The STEADY GREEN MAN or PEDAL CYCLIST LIGHT SIGNAL shall be displayed for an interval appropriate for the particular traffic conditions and shall be not less than a minimum of 4 seconds. A longer interval of 5 to 7 seconds, however, is more desirable. Longer intervals may be required when pedestrian volumes are high, but volumes requiring an interval longer than 7 seconds do not occur often. Where vehicular capacity is important, the green interval should not be made longer than necessary. However, where capacity is not important, the maximum possible pedestrian green may be given.

3 Sufficient time must be provided after the green man or pedal cyclist light signal for a pedestrian to walk or pedal cyclist to push his or her bicycle across the roadway to the other side of the road, or up to the median island where such median is provided. Where the median is set back from the pedestrian crossing, sufficient time must be provided to allow crossing of the junction in one stage.

4 A design walking speed of 1.2 m/s should be used for calculating the pedestrian or pedal cyclist clearance time under normal operating conditions. A slower speed of 1.0 m/s may be used for elderly or infirm pedestrians. The pedestrian or pedal cyclist must be able to clear the roadway by the time the parallel vehicular intergreen ends (end of the all-red interval).

5 The FLASHING MAN or PEDAL CYCLIST LIGHT SIGNAL should not be displayed for a period longer than the duration of the pedestrian or pedal cyclist clearance time. The flashing signal can, however, be displayed for a shorter period if a STEADY RED MAN or PEDAL CYCLIST LIGHT SIGNAL is displayed for the remainder of the clearance time. The flashing signal should not be displayed for a period shorter than the minimum of the following two values:
   (a) 75% of the clearance time; or
   (b) the clearance time less the parallel vehicular intergreen period.

6 At road junctions, the pedestrian or pedal cyclist phase may run concurrently with a parallel vehicular phase. The vehicle phase, however, SHALL not include any exclusive turning phase in conflict with the pedestrian or pedal cyclist green phase.

7 The green man (and pedal cyclist) signal normally starts at the same time as the vehicular green. The vehicular green light signal, however, may be delayed to allow pedestrians to enter the roadway ahead of vehicles. Care should be taken in using delays longer than 3 seconds as such delays can lead to undesirable behaviour. Such behaviour may include illegal turning manoeuvres by drivers and pedestrians (or pedal cyclists) utilising the delay to cross the junction in the wrong direction.

8 At a mid-block pedestrian or pedal cyclist crossing, other than where a "Pelican" phase has been provided, a vehicular red light signal SHALL be displayed for at least the full duration of the green and flashing red man or pedal cyclist intervals. It may also be necessary to introduce an "all-red" interval.

9 At a mid-block pedestrian or pedal cyclist crossing, a "Pelican" phase may be provided to indicate to drivers of vehicles that pedestrians may be clearing the road and have right of way. During the "Pelican" phase, vehicular FLASHING RED DISC LIGHT SIGNALS are displayed at the same time as the FLASHING RED MAN or PEDAL CYCLIST LIGHT SIGNAL. Pedestrians may not enter the crossing on the flashing red man, and the duration of this interval should therefore NOT exceed the time required by pedestrians to clear the crossing.

10 Pedestrian phases should generally be demand dependent (using push buttons), even when used at fixed time signals. This is because the vehicular green interval is often made longer to meet pedestrian requirements. When no demand is registered for a signal phase, a shorter vehicular green phase can be provided which could reduce overall vehicular delay.

11 When vehicular signals are in flashing mode, pedestrian and pedal cyclist signals must be switched off, giving no pedestrian or pedal cyclist indications (except when the signal is operating in pelican mode).

4.4 PROVISION OF PEDESTRIAN SIGNALS AT JUNCTIONS

1 Pedestrian signals at junctions have the advantage that safety is improved by restricting the pedestrian movement to a shorter period of time during a signal cycle. It also has the advantage that the capacity of the left-turn vehicular movement is increased.

2 Pedestrian signals can be considered when exclusive vehicular left- or right-turn phases are provided that conflict with pedestrian movements (alternatively, PEDESTRIAN PROHIBITED SIGNS R218 may be posted). However, pedestrians do not have right of way when no pedestrian signals are provided and flashing green signals are displayed.

3 Pedestrian signals may also be provided on one-way roads where vehicular signals are provided only in the one direction and no signals are available in the other direction.

4 Pedestrian signals should be considered when large numbers of pedestrians cross the road and pedestrians can impede turning traffic. A capacity analysis can be undertaken to establish whether pedestrian signals would improve the traffic flow.

5 Pedestrian signals may be considered on an approach when the pedestrian volume crossing the particular approach multiplied by the volume of conflicting turning traffic exceeds 10 000 in any one hour, or 5 000 for each of any four hours of a day.

6 Pedestrian movements across slipways at junctions may be signalised where warranted by pedestrian queues or delays, or when pedestrians require additional protection due to special conditions such as high vehicle speeds, poor sight distance and pedestrian disabilities.
4.5 PEDESTRIAN SCRAMBLE PHASE

The pedestrian scramble phase is also known as an exclusive or serial pedestrian phase. Such a phase allows only pedestrians to walk across the junction while all vehicles receive RED LIGHT SIGNALS and are not allowed to enter the junction from any approach. Provision can also be made for the diagonal crossing of the junction by pedestrians.

The main advantage of the scramble phase is that it can eliminate pedestrian-vehicle conflict, thus improving the level of safety. This, however, will only be achieved if full pedestrian compliance of the light signals can be obtained. In practice, pedestrians may utilise the scramble phase as well as the vehicular phases to cross the junction.

The capacity of turning movements at junctions can be improved by the provision of scramble phases (but only when pedestrians do not violate the light signals). The capacity of straight-through movements, however, is significantly reduced by scramble phases.

Scramble phases can be effectively utilised in pedestrian precincts where vehicular capacity is of less importance. Such phases can create an environment in which priority is given to pedestrians and vehicular traffic flow is of less concern.

4.6 LAYOUT OF PEDESTRIAN AND PEDAL CYCLIST SIGNALS

A pedestrian signal face Type S11P or a pedal cyclist signal face Type S11C is provided for each direction of movement at a junction or mid-block crossing (both sides of the roadway).

The signal faces may be mounted on the same posts as vehicular signal faces, either parallel or perpendicular to the vehicular faces as shown in Figure 4.1. The following criteria should be used in selecting posts for the mounting of pedestrian signal faces:

(a) The signals should be in line with the pedestrian crossing, at a position where pedestrians can readily see the signals.

(b) The signals should not be located at a position where vehicles stopping at, or slightly beyond, the stop line may obstruct the visibility of the signals. Attention must particularly be given to the possible obstruction of the signal face by buses and heavy vehicles.

(c) The signal posts should not impede the flow of pedestrian traffic.

(d) The number of signal posts should be restricted to avoid clutter on the sidewalk and to reduce installation and maintenance costs.

Where no vehicular light signals are provided, consideration can be given to providing a second pedestrian or pedal cyclist signal face as a backup should one of the signals fail.

4.7 MOUNTING OF PEDESTRIAN AND PEDAL CYCLIST SIGNALS

Pedestrian and pedal cyclist signal mounting details are shown in Figure 4.6. The signals should preferably be post-mounted. The signals should have a minimum clearance above the sidewalk of not less than 2.1 m. The signal face should be not more than 3.0 m above the level of a point on the road surface nearest to the post, measured to the centre of the lowest (green) light signal.

Where the pedestrian or pedal cyclist signal face is mounted adjacent to a vehicular signal face, the red man or pedal cyclist signal aspect SHALL not be mounted higher than the level of the lowest vehicular green signal aspect. The pedestrian or pedal cyclist signal faces should not be located in a line vertically with any vehicular signal aspect facing the same direction and should be offset to the left or right of such signal aspect.

The pedestrian or pedal cyclist push button should be mounted approximately 1.1 m above the sidewalk surface. A pedestrian or pedal cyclist sign should preferably be placed immediately above or below the push button. Preferred locations and directions of push buttons are shown by the hand symbols in Figures 4.1 to 4.4.
Figure 4.1: Alternative positions for pedestrian and pedal cyclist signals at signalised junctions

Figure 4.2: Pedestrian (and pedal cyclist) signal faces at a mid-block crossing
Figure 4.3: Staggered mid-block pedestrian crossing

Figure 4.4: Staggered pedestrian crossing on a wide junction
Figure 4.5: Pedestrian crossing road markings at a junction

Figure 4.6: Mounting pedestrian and pedal cyclist signals
CHAPTER 5: JUNCTION LAYOUT

5.1 INTRODUCTION

1 The layout of a road junction or pedestrian crossing and its approaches should be carefully designed to allow the safe and efficient operation of traffic signals. Geometric and other improvements are often required at a junction before signals can be installed.

2 The objectives of improving road geometry at a signalised junction include the following:
   (a) to reduce conflict and thus improve safety;
   (b) to promote efficient traffic flow; and
   (c) to reduce construction and maintenance cost.

3 Installation of traffic signals without due regard to the above requirements may result in an inefficient or unsafe situation, associated with high user cost. It is therefore imperative that appropriate geometric improvements should be carried out as a part of the traffic signal installation project, and be included in the implementation programme and budget.

5.2 GEOMETRIC DESIGN OF SIGNALISED JUNCTIONS

5.2.1 General

1 Geometric design standards of signalised junctions are given in a variety of design manuals. These include the TRH17 and UTG manuals of the Committee of State Road and Urban Transport Authorities (see bibliography). These manuals can be supplemented by manuals from other countries, such as the AUSTROADS (1988) and AASHTO (1995) manuals.

2 The geometric design manuals address general road and junction geometric design standards. The intention of this chapter is not to repeat these standards, but to provide supplementary guidelines applicable to signal controlled junctions.

3 The geometric design of signal controlled junctions differs in a number of important aspects from the design used at priority controlled junctions. It is therefore important that even at locations where signals are not currently warranted, a decision must be made on the possibility of future signalisation. The main differences are:
   (a) Operations at priority controlled junctions can be improved by increasing corner radii and by providing tapers, but this creates difficulty in positioning traffic signals and providing for pedestrians. At signalised junctions, smaller corner radii may be required.
   (b) At priority controlled junctions, shoulder widths and through lanes are normally maintained through the junction. At signalised junctions, the number of lanes is commonly increased to improve capacity, and the shoulders eliminated to improve signal positioning.

5.2.2 Factors influencing geometric design

1 The geometric design of a signalised junction is influenced by a number of factors, such as traffic volumes, human factors, vehicle factors, topography, and economic considerations.

2 A junction must be able to accommodate peak-hour traffic volumes efficiently and safely. This is particularly important at signalised junctions that carry large volumes of traffic, and where additional lanes may be needed to provide the required capacity to accommodate the traffic.

3 The human factor is a particular important element in the design of signalised junctions. Humans are inclined to act according to habit, and they may become confused when surprised, and tend to be inattentive at times. These factors make it essential that uniform and proper design standards should be utilised at junctions.

4 The design of a junction should make provision for the type of vehicle anticipated to use a particular junction. Use can be made of turning templates to establish “swept paths” through a junction.

5 The topography as well as the environment are important factors often restricting the geometric design of a signalised junction. Compromises in design are often required due to topographical and environmental restrictions.

6 The cost of providing high design standards at signalised junctions is often a restricting factor. However, significant improvements can often be achieved by relatively minor low-cost improvements.

5.2.3 Spacing of signalised junctions

1 The spacing of signalised junctions (and pedestrian crossings) on two-way roads is one of the most important factors affecting efficiency and road safety in signalised networks.

2 Optimal co-ordination on two-way roads depends on a large number of factors, and while it is not possible to provide detailed recommendations regarding junction spacing that would optimise co-ordination, a minimum distance of 500 m is generally required. Factors influencing co-ordination include traffic patterns, speeds, cycle length, signal phasing, queue lengths, etc. In general, however, longer cycles and higher speeds require signals to be spaced further apart. Each situation should be investigated depending on particular circumstances.

3 On one-way arterials (not in networks), co-ordination can be achieved relatively easy for any spacing of junctions. The spacing of traffic signals on one-way roads is therefore less of an important factor, except that minimum requirements should be met.

4 The distance at which signals can be spaced apart depends on maximum expected queue lengths. Short block lengths often lead to the blocking of upstream junctions, which have an adverse effect on network operations.
5.2.4 Conflicting manoeuvres at junctions

1 In the design of junctions, consideration must be given to the different types of conflicting traffic manoeuvres that can occur in a junction. These are:
   (a) Diverging manoeuvres that occur when a traffic stream splits into two separate streams.
   (b) Merging manoeuvres that occur when two traffic streams merge into one.
   (c) Weaving manoeuvres that occur when traffic streams cross each other by lane changing.
   (d) Crossing manoeuvres that occur when one traffic stream crosses another at near right angles.

2 Where possible, junction design should eliminate or reduce conflicts, or at least avoid multiple manoeuvres, which combines two or more of the above manoeuvres. Multiple manoeuvres should where possible, be replaced with a series of elemental ones. Such manoeuvres should preferably be separated by at least two or three seconds of travel time.

3 Diverging, merging and weaving manoeuvres should be designed for low RELATIVE speeds between conflicting traffic streams. This means that the angle of intersection of the streams should be relatively small, and vehicles should preferably be travelling at about the same speeds when the manoeuvres are made. This could mean that acceleration or deceleration lanes may be required to achieve desired operating speeds.

4 Crossing manoeuvres should be made at approximately right angles to minimise driver estimation errors. To achieve this, the angle of intersection between approach roads should preferably be 90 degrees. Angles of down to 70 degrees, however, would also be acceptable. Where possible, geometric improvements should be introduced to achieve such angles.

5.2.5 Sight distance requirements

1 Good junction design requires that proper attention should be given to sight distance requirements. The provision of adequate sight distance is fundamental to safe signal operations.

2 The following sight distances are of importance at traffic signals:
   (a) Stopping sight distance required by vehicles to stop for hazardous objects on the roadway or in the junction. Minimum stopping sight-distances are given in the various geometric design manuals.
   (b) Sight distance required for traffic signal faces as given in Chapter 3 of this manual (Volume 3).
   (c) Sight distance required by right-turning traffic when seeking gaps in an opposing conflicting stream. This sight distance can be established using Figure 2.7: Shoulder sight distance for stop condition” given in Volume 1 of the Road Traffic Signs Manual.

3 It is not necessary to provide shoulder sight distance on the approaches to signals that may be out of order since drivers must treat such signals as 3-way or 4-way stop controlled junctions.

5.2.6 Design vehicles

1 The design of a junction should make provision for the types of vehicles expected to use the junction, to carry out turning movements with adequate space for their swept paths.

2 Turning templates are used for the design of junctions. These templates indicate the “swept path envelope” for various angles for turn. Provision should be made to accommodate such swept paths plus a minimum clearance of 600 mm on each side of the path.

3 Some turning templates have been developed for vehicles travelling at crawl speeds to establish absolute minimum design standards. Vehicles turning at such speeds, however, would lead to a deterioration of operations at traffic signals. Templates that provide for vehicles turning at higher speeds should therefore preferably be used.

4 Where provision must be made for particularly difficult turning movements through a junction, care should be taken to check turning paths from all likely positions the junction can be approached from by the design vehicle, and not only one ideal position. This is particularly important where wide approach lanes are provided, but the vehicle must negotiate a narrow path through the junction.

5.2.7 Lane widths

1 Lane widths for straight-through movements at a traffic signal should preferably not be narrower than 3,3 m, although a width of 3,0 m can be resorted to where insistence on the 3,3 m would mean that a right-turn lane cannot be provided. Where there are significant volumes of heavy vehicles, lane widths can be increased to about 3,5 m.

2 Lane widths for left- and right-turn lanes should preferably not be narrower than 3,0 m, although a width of 2,7 m (and even 2,5 m) can be accepted if it would otherwise again mean that a right-turn lane cannot be provided. Where significant volumes of heavy vehicles utilise the turning lanes, the turn lane may be increased to 3,3 m or more.

3 Double and triple turning lanes should be at least 3,3 m and preferably 3,5 m wide on the approach to the junction. Wider widths will be required on the exit side of the junction to accommodate the paths of the turning vehicles. If a median is provided on the exit side, a wider exit width can be achieved by either reducing the width of the median or by setting the median back from the junction.

4 An offset of 0,3 m should preferably be provided between the kerb face and the edge of the roadway.

5 The widths of exit lanes at junctions should be sufficient to accommodate the swept paths of turning vehicles, particularly when double or triple turning lanes are provided, or where only one exit lane is available. Such exit lanes should preferably be at least 3,5 m wide, but a width of between 4,0 m and 4,5 m may be required. Where significant volumes of heavy vehicles turn right, the required widening should be established by means of turning templates.
Figure 5.1: Vehicle swept paths through a signalised junction

Figure 5.2: Auxiliary through lanes at signalised junctions
6 Where a right-turn movement turns into a two-way road, the stop line on the exit side of the junction can be set back to provide space for the movement. Where a median is provided, the exit lane can be widened by either setting the median back from the junction or by reducing the width of the median locally. The different options are shown in Figure 5.1.

5.2.8 Median widths

1 The width of a median should generally not be less than 1.2 m. This is the minimum requirement to accommodate road traffic signs such as the “keep left” sign.

2 At signalised junctions, however, a width of 1.2 m would not be sufficient to accommodate a traffic signal because of the recommended clearance distance of 0.5 m. Assuming a backboard width of 0.5 m and a clearance distance of 0.5 m on both sides of the backboard, a median width of 1.5 m is required to accommodate a single signal face, while a width of 2.0 m is required to accommodate two signal faces side by side. A minimum median width of 2.0 m is therefore generally recommended near signalised junctions.

3 On narrow medians, where insistence on the 0.5 m clearance would mean that signal faces cannot be provided on the median, the lateral clearance can be reduced to an absolute minimum of 0.1 m, but only if the camber or crossfall of the roadway falls away from the median. In such a case, it would be possible to install two signal faces on a 1.2 m wide median.

4 A minimum median width of 2.0 m is desirable where it is necessary to accommodate pedestrians or pedal cyclists. Wider medians may be required where large volumes of pedestrians must be accommodated.

5.2.9 Junction corners

1 Corner kerb turn radii at signal controlled junctions of between 8 and 10 m are normally desirable, but radii as small as 6 m and as large as 12 m can be used. Corner radii below 8 m lead to left-turning vehicles making wider turns, and encroachment onto adjacent lanes. Radii above 10 m, on the other hand, lead to an increase in turning speeds that could affect the safety of pedestrians. The larger radii also create problems with the positioning of traffic signals.

2 At locations where significant volumes of heavy vehicles use the junction, the above corner turn radii could be inadequate. In such cases, slipways may be required to accommodate left-turn movements.

3 Where parking is provided, it is preferable to widen the sidewalk area at the corner of the junction, as shown in Figure 5.1. Such widening serves to protect the parking area and it allows for the closer positioning of traffic signal faces to the roadway. Another advantage is that it reduces the clearance time required by pedestrians to cross the junction.

4 Barrier or semi-mountable kerbs should be used on the corners of signalised junctions to prevent parking on the corners. Provision should also be made for recessed pedestrian ramps at the corners.

5.3 AUXILIARY LANES

5.3.1 Auxiliary through lanes

1 Auxiliary through lanes are sometimes provided at signalised junctions to improve capacity. An example of a junction with such lanes is shown in Figure 5.2.

2 The length of the auxiliary through lane on the approach to a junction depends on the amount of storage required to accommodate the queue length waiting at the traffic signal. The auxiliary through lanes should be terminated well clear of the junction, desirably 100 m minimum beyond the junction (excluding the taper).

3 Adequate active and passive taper rates should be provided in accordance with standards provided in design manuals. Care must be exercised with the location of the merging (active) taper to ensure that there is sufficient sight distance for the approaching driver to perceive the merge and have adequate time for relative speed adjustment and gap selection for merging.

5.3.2 Left-turn auxiliary lanes

1 The left-turn does not have the same impact on the safe and efficient operation of a signalise junction as the right-turn movement (except where left-turning movements are hampered by high volumes of pedestrians). This, however, does not mean that left-turn auxiliary lanes are not required. In many instances, it may be possible to improve signal operations and safety significantly by introducing left-turn lanes.

2 Left-turn lanes have the advantage that decelerating turning traffic is removed from the through lanes, thus improving operations on such lanes. It could also be more cost effective to add a left-turn lane than to increase the number of through lanes.

3 A left-turn lane can be of particular advantage when a left-turn phase can be provided when the right-turn movement from the left is given a separate phase. At many T-junctions, there is an opportunity to provide such a left-turn phase, and the provision of a left-turn lane can often be more readily justified at such junctions (except when pedestrian signals are required to accommodate pedestrians).

4 Left-turning lanes are most effective when significant volumes of traffic turn left, the traffic signal has insufficient capacity to handle peak-hour traffic (due to pedestrians), and the provision of a left-turn lane would be the most cost-effective solution to increase the capacity of the junction.
5.3.3 Right-turn auxiliary lanes

1 The right-turn movement is of particular importance at signalised (and also other) junctions. Even one vehicle wanting to turn right at a junction, and having to wait because of limited gaps in the opposing flow, will impede other traffic and could create unsafe operating conditions. Exclusive right-turn lanes at a traffic signal will be warranted at most locations where signals are warranted.

2 Right-turn lanes not only contribute to improved capacity, but also have a significant safety benefit. In many cases, right turn lanes can be warranted based on their safety benefits alone, rather than the capacity improvements that can be achieved. Relatively few right-turn vehicles can cause severe disruptions that could lead to accidents, although sufficient capacity may be available at a junction.

3 The need for right-turn lanes to improve safety depends on the speed on a road as well as the probability of conflicts between the right-turn and other traffic travelling in the same direction. On high-speed roads, a right-turn lane will be justified, even if very low volumes of traffic turn right. On roads with low operating speeds, a higher degree of conflict can be accepted.

4 In general, right-turn lanes should be provided at all traffic signals, except where operating speeds are low (50 km/h or less) or where very few conflicts occur between right-turn and other traffic movements (either because of low volumes of right-turners or low volumes of opposing traffic movements). A cost-benefit analysis can be undertaken in which the benefits accruing from the provision of a right-turn lane can be compared with the cost of providing such a lane.

5 Right-turn lanes can also be justified on capacity grounds. A capacity analysis would indicate whether such lanes are required. Where right-turn traffic volumes exceed 300 vehicles in the peak hour, provision of a double right-turn lane may be considered. Triple right-turn lanes can also be considered, but normally only on one-way streets and on the side approaches of T-junctions.

5.3.4 Design of right-turn lanes

1 Right-turn lanes can be introduced by utilising a number of different methods, as shown in Figure 5.3. In the north-south direction, the approach lanes are narrowed to accommodate the right-turn lanes, and the lanes delineated by using road markings. The turning lanes in the east-west direction are provided inside a constructed median.

2 Two methods of delineating right-turn lanes by means of road markings are shown in Figure 5.3. From the north, a painted island is utilised to provide greater protection to right-turn movements. From the south, no such island is provided and WM2 CONTINUITY LINES are used to demarcate the turning lane.

3 The painted island design has the advantage that it is significantly more visible than the second design, particularly at night. However, in urban areas where street lighting is provided and speeds are relatively low, the design without the island is adequate. This design has the advantage that the S-type of manoeuvre required to make a right-turn associated with a painted island is eliminated.

4 When traffic signal face S1R is used (in combination with traffic signal arrow sign ST2) to control a right-turn movement, separate right-turn lanes must be provided. Such lanes should be separated from other lanes by a WM2 CONTINUITY LINE, a RM5 PAINTED ISLAND or a constructed island.

5 In the design of right-turn lanes, it is important that sufficient sight distance should be provided to avoid the possibility of head-on conflict. The sight-distance of right-turning vehicles is often obstructed by a queue of right-turning vehicles in the opposite direction. Two examples of this problem are shown in Figures 5.4 and 5.5. Possible methods of addressing these problems are discussed.

5.3.5 Double and triple right-turn lanes

1 Double or triple left and right-turn lanes can be provided at junctions provided that there is adequate space on both the approach to, and exit from, the junction. The capacity for turning traffic can be significantly improved by providing such lanes (triple right-turn lanes would normally only be considered on one-way streets and on the side legs of T-junctions).

2 For the right-turn movement, the provision of double or triple turn lanes can impair lines of sight. Protected-only right-turn phases should therefore be considered when such lanes are used.

3 It is strongly recommended that use should be made of guide lines through the junction when double or triple lanes are provided. Such lines are needed to discourage encroachment between the turning lanes and to reduce the possibility of sideswipe accidents between vehicles.

4 The guide lines should allow for the largest type of vehicle anticipated to make the right-turn movement. Turning templates are used to establish the turning paths of two or three heavy vehicles turning right at the same time.

5.3.6 Length of right-turn lanes

1 Standards for the lengths of right-turn lanes are given in the design manuals. These lengths are normally determined based on the expected 95th percentile queue length in the peak hour. The lengths should be checked against the queue in the adjacent through lane and the longer queue used to ensure that turning vehicles are not blocked from entering the turn lane.

2 On high-speed roads where expressway type conditions are required, an appropriate deceleration length may be added to the storage length requirement to ensure optimum and safe traffic flow. At traffic signals, it is generally more important to provide the storage space than a deceleration length.
Figure 5.3: Provision of right-turn lanes at a signalised junction
In this figure, sight distance is obstructed due to the provision of a very wide median and the queue of right-turning vehicles forming in the opposite direction. A possible geometric improvement that can be considered at such a junction is to provide the right-turn lane in the median, as indicated in the figure.

Figure 5.4: Restricted sight distance for right-turning traffic due to a very wide median

In this figure, sight distance is obstructed due to the horizontal curve on the road and the queue of right-turning vehicles forming in the opposite direction. A possible remedy for this problem is to provide a protected-only right-turn phase. Note that this problem only occurs in the one direction (bottom-to-top) and not in both directions.

Figure 5.5: Restricted sight distance for right-turning traffic due to a horizontal curve (bottom-to-top direction)
3 In establishing the required right-turn storage lengths, it is important that attention be given to future requirements. This means that traffic volumes and patterns must be predicted for the design year. As with the geometric design of other elements of a junction, the length of the turning lane should be designed to accommodate such design year traffic volumes.

4 As a minimum, provision should be made for storage space for at least two vehicles in the right-turn lane (about 12m). However, it is more desirable to provide a storage space for at least five vehicles (about 30 m). Typically, storage spaces vary between 30 to 60 m, depending on right-turn volumes.

5.3.7 Slipways

1 A slipway is a roadway that passes to the left (or in the case of one-way systems, to the right) of the main junction without intersecting the main junction. Slipways can be controlled or free-flow as shown in Figure 5.6.

2 Slipways at signalised junctions, may be required under the following circumstances:
   (a) When provision has to be made for large turning vehicles, and the corner turn radius cannot be increased to accommodate such vehicles.
   (b) At skew junctions where the normal treatment would lead to a large junction.
   (c) Where improved operations and capacity are required for the turning movement.

3 Controlled slipways are controlled by a traffic signal or a yield or stop sign. The following are a number of considerations that should be taken into account:
   (a) YIELD control should only be used when adequate shoulder sight distance is available. STOP control is otherwise used. Such sight distance is required to allow drivers to view straight-through vehicles from the right as well as vehicles turning right from the opposite approach.
   (b) The angle of entry of a controlled slipway should not be less than 70 degrees relative to the crossroad (with the stop line angled at a maximum of 20 degrees). A sharper angle not only increases driver discomfort, but also leads to speeding, which could result in unsafe operating conditions.
   (c) The controlled slipway is treated as a separate junction operating independently of the main signalised junction. This creates no problem when a slipway is yield or stop controlled. Signalised slipways, however, have the problem that signals are normally not provided on the main road and that potential conflicts must therefore be prevented at the main junction. All conflicting movements at the main junction, including the right-turn movement from the opposite direction, must face a red light signal while the slipway receives a green signal. This would require the provision of a protected-only right-turn phase for right-turning traffic from the opposite approach.

4 Free-flow slipways allow for free-flow turning movements at relatively high speed. The following are a number of important considerations in the design of such slipways:
   (a) The radius adopted for the slipway should preferably allow for a relatively high operating speed.
   (b) Due to the high operating speeds, free-flow slipways are only appropriate when there are very low volumes of pedestrians.
   (c) An acceleration lane of sufficient length should be provided on the exit side of the slipway.
   (d) The slipway design should prevent vehicles making wide turns directly onto the crossing road. A short median can be provided on the exit side of the slipway to direct vehicles onto the acceleration lane.

5 Free-flow slipways can improve operations significantly when they are properly designed using appropriate design standards (and there are no or few pedestrians).

6 Yield (or stop) sign-controlled slipways have the advantage that turning traffic movements do not have to stop at the traffic signal.

7 Signal controlled slipways have the following disadvantages:
   (a) The opportunity for gap acceptance is not available.
   (b) Right-turning movements on the main junction must be prohibited when the slipway receives a green light signal.
   (c) Although the saturation flow of the left-turn movement at a traffic signal can be slightly increased by providing a signalised slipway, it does not mean that the capacity of the junction can be increased. In many instances, capacity could in fact be reduced, particularly if additional signal phases must be introduced to accommodate opposing right-turn movements.

8 Signalisation of slipways may be required on double or triple lane slipways due to possible sight distance problems. It is, however, important to reiterate that such signalisation should only be provided when a permanent protected-only right-turn phase is provided on the opposite approach at the main junction.
Figure 5.6: Free-flow and controlled slipways at a signalised junction
5.4 ROAD SIGNS

1 The National Road Traffic Regulations allow for the use of various road signs at traffic signals. There are, however, a limited number of road signs that may be used in conjunction with a traffic signal. These signs are the following (these signs have also been listed in Chapter 3 of this manual):

(a) a street name sign;
(b) a direction route marker sign;
(c) information signs IN14, IN15 and pedestrian and pedal cyclist signs relating to the function of the traffic signal;
(d) a one-way roadway sign;
(e) a no-entry sign;
(f) a left-turn prohibited, right-turn prohibited or a U-turn prohibited sign;
(g) a proceed straight through only, proceed left only, or proceed right only sign;
(h) a pedestrian prohibited sign R218; or
(i) a traffic signal arrow sign ST1 to ST5; The above signs may be mounted on the same post, cantilever or gantry as that of the traffic signal.

2 Other signs may not be used in conjunction with a traffic signal, even if the signal is out of order (except where the signals have been masked out). These include the STOP sign R1, YIELD sign R2 and the RIGHT-OF-WAY sign IN7. A slipway at a signalised junction, however, may be STOP or YIELD sign controlled.

3 The PEDESTRIAN PROHIBITED SIGN R218 is used to prohibit pedestrians from proceeding beyond the sign. The sign must be posted on the near side of the junction, in the direction to which it is applicable (and in both directions of the crossing).

4 The following information signs related to the operation of traffic signals, may be used at signals:

(a) Where signal timings are co-ordinated for a fixed speed, information sign IN14 may be displayed on the relevant exit from a junction.
(b) Where a traffic signal has three or more vehicular signal phases, information sign IN15 may be located directly below a signal face.
(c) Pedestrian and pedal cyclist information signs.

5 The TRAFFIC SIGNAL AHEAD SIGN W301 may be used to warn a road user of the presence of a mid-block pedestrian crossing ahead. This sign should be displayed not less than 90 m or not more than 180 m in advance of the crossing.

8 The PEDESTRIAN CROSSING SIGN W306 may be used to warn a road user of the presence of a mid-block pedestrian crossing ahead. The sign should be displayed not less than 90 m or not more than 180 m in advance of the crossing.

5.5 ROAD MARKINGS

5.5.1 Range of road markings

1 Signalisation is applied to a wide range of road junctions. As the traffic handling characteristics of a junction become more complex, so the need for clear and unambiguous road markings becomes greater. Road safety, and the efficiency of, a junction can be greatly affected by the way in which the approaches to it, and the areas shared by conflicting traffic movements are marked.

2 Details related to road markings are given in Chapter 7 of Volume 1 of the Road Traffic Signs Manual. The various types of road markings and their dimensions are summarised in Table 5.1.

3 The minimum road markings required at a signalised junction or crossing includes the stop line (RTM1), pedestrian crossing lines (RTM3) and the no-overtaking line (RM1). Additional road markings will be required at more complex junctions.

4 Figure 5.7 shows road markings for typical signalised approaches to junctions. Figure 5.8 shows typical guide lines through a junction.

5.5.2 Pedestrian crossing lines

Pedestrian crossing lines (RTM2) are used to indicate the position where pedestrians (or pedal cyclists) may cross at a junction or a mid-block crossing. Block pedestrian crossing markings (RTM4) may also be used instead of the crossing lines at both junctions and mid-block crossings, particularly in locations where pedestrian volumes are high.

2 Pedestrian crossing lines (or block pedestrian crossing markings):

(a) SHOULD as a general rule be provided at all traffic signal controlled junctions, even if the junction is used by no pedestrians (except where pedestrians are specifically prohibited);
(b) MAY be provided without pedestrian or pedal cyclist signals being installed at a junction;
(c) SHALL be provided where pedestrian signals are installed at junctions or crossings; and
(d) SHALL NOT be provided when PEDESTRIAN PROHIBITED R218 signs have been posted.

3 Pedestrian crossing lines not only mark crossing positions for pedestrians, but can serve to improve the visibility of the junction and to assist drivers in recognising and identifying a junction as being signal controlled.
5.5.3 Regulatory road markings

1. The RTM1 STOP LINE imposes a mandatory requirement upon drivers of vehicles, when combined with a red light signal, that they shall stop their vehicles immediately behind such line.

2. The RTM2 YIELD LINE imposes a mandatory requirement upon drivers of vehicles that they shall yield right of way at the point marked by the line to all traffic, including pedestrians.

3. The RTM3 PEDESTRIAN CROSSING LINE imposes a mandatory requirement that drivers of vehicles shall yield right of way to a pedestrian who is crossing the roadway (or to a pedestrian waiting to cross the roadway), provided that pedestrians are crossing in accordance with the traffic light signals. It also imposes a mandatory requirement that pedestrians shall only cross the roadway within the area demarcated by the markings.

4. The RTM4 BLOCK PEDESTRIAN CROSSING imposes a mandatory requirement similar to that of the RTM3 pedestrian crossing line.

5. The RM1 NO-OVERTAKING LINE imposes a mandatory requirement that drivers of vehicles shall not drive on the right side of the line, or that any part of a vehicle crosses the line (except when the vehicle must gain direct access to any adjacent property, or to pass a stationary obstruction). At a junction or crossing, no-overtaking lines are used between two opposing directions of travel.

6. The RM3 CHANNELISING (STACKING) LINE imposes the mandatory requirement that drivers shall not drive a vehicle in such a manner that it, or any part of it, crosses such a marking. These lines are used between lanes of vehicles travelling in the same direction. The channelising line should be preceded by EXTRA DENSITY GM1 LANE LINES.

7. The RM4.1 LEFT EDGE LINE (YELLOW) is used to demarcate the left-hand edge of the travel way.

8. The RM4.2 RIGHT EDGE LINE (WHITE) is used to demarcate the right-hand edge of a travel way.

9. The RM5 PAINTED ISLAND MARKING imposes the mandatory requirement that drivers shall not drive a vehicle in such a manner that it, or any part of it, crosses such a marking.

10. The RM8 MANDATORY DIRECTION ARROWS (YELLOW) impose a mandatory requirement that drivers of vehicles may proceed only in the direction indicated by the arrows. The arrows SHALL be preceded by at least one and preferably two direction arrow ahead WM7 markings. The arrows may NOT be used to indicate an increase in the number of lanes ahead – BIFURCATION ARROWS GM3 must be used for this purpose.

11. The RM10 BOX JUNCTION marking imposes a mandatory requirement that drivers of vehicles shall not enter the box marked area within a junction if they are not able to leave such area due to stationary vehicles ahead of them.

12. The RM11 ZI ZONE LINE imposes a mandatory requirement that drivers shall not park or stop in the area marked by the line except to yield right of way to pedestrians on a pedestrian crossing.

13. The RM12 NO-STOPPING LINE (RED) imposes a mandatory requirement that drivers of vehicles shall not stop their vehicles adjacent to such line (except in compliance to a regulatory sign or traffic signal).

5.5.4 Warning road markings

1. The WM2 CONTINUITY LINE is used to warn drivers that if they drive to the left (or right) of such line that they will shortly deviate from the through roadway.

2. The WM3 DIVIDING LINE is used to warn drivers that vehicles travelling on the other side of the line are travelling in the opposite direction (and if they wish to cross such line, they must wait until it is safe to do so).

3. The WM5 YIELD CONTROL AHEAD is a triangular shaped road marking used to warn drivers of a YIELD sign R2 ahead.

4. The WM6 LANE REDUCTION ARROWS are used to warn drivers that a lane on a multi-lane road ends some distance ahead, either from the left or the right, or from both left and right. The markings should be repeated at least once, but preferably three times, as shown in Figure 5.2.

5. The WM7 MANDATORY DIRECTION ARROW AHEAD warning markings are used to warn drivers that a MANDATORY DIRECTION ARROW marking RM8 is ahead which will require the driver to proceed only in the direction indicated by the arrow. At least one WM7 arrow shall precede an RM8 arrow marking (except when the RM8 arrow is in a recessed turn lane that is less than 25 m in length). The arrows MAY NOT be used to indicate an increase in the number of lanes ahead – BIFURCATION ARROWS GM3 must be used for this purpose.

5.5.5 Guidance road markings

1. The GM1 LANE LINES are used to demarcate traffic lanes for vehicles travelling in the SAME direction. STANDARD DENSITY LANE LINES are normally used on road links. At junctions, EXTRA DENSITY LANE lines should precede CHANNELISING (STACKING) LINES over a distance of at least 18 m (24 m in rural areas).

2. The GM2 GUIDE LINES are used to provide guidance through a junction. The lines may also be used to provide guidance to pedestrians when a formal pedestrian crossing is not warranted. YIELD LINES RTM2 may be incorporated to advise drivers of the likely need to yield within a turning movement.

3. The GM3 BIFURCATION ARROWS are used to indicate an increase in the number of lanes ahead. Mandatory direction arrows WM7 may not be used for this purpose.

4. The GM4 INFORMATION ARROWS are used to indicate the direction of travel permitted in a particular lane. The arrows can be useful at very wide junctions to indicate exit paths. The arrows can also be useful to indicate the exit direction of one-way streets at junctions.
### Table 5.1: SUMMARY OF ROAD MARKINGS FOR SIGNALISED JUNCTIONS AND CROSSINGS

<table>
<thead>
<tr>
<th>Marking number</th>
<th>Description</th>
<th>Width</th>
<th>Length</th>
<th>Urban areas</th>
<th>Rural areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Regulatory road markings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTM1 (white) [1,2]</td>
<td>STOP Line</td>
<td>300 mm Min</td>
<td>Full approach</td>
<td>500 mm Min</td>
<td>Full approach</td>
</tr>
<tr>
<td>RTM2 (white) [1,3]</td>
<td>YIELD line</td>
<td>300 mm Min</td>
<td>600 mm Line</td>
<td>500 mm Min</td>
<td>1000 mm Line</td>
</tr>
<tr>
<td>RTM3 (white) [2,3]</td>
<td>Pedestrian crossing line</td>
<td>100 mm Min</td>
<td>Full roadway</td>
<td>100 mm Min</td>
<td>Full roadway</td>
</tr>
<tr>
<td>RTM4 (white)</td>
<td>Block pedestrian crossing</td>
<td>[4]</td>
<td>600 mm Block</td>
<td>[4]</td>
<td>600 mm Block</td>
</tr>
<tr>
<td>RM1 (white)</td>
<td>No-overtaking line</td>
<td>100 mm Min</td>
<td>9 m Minimum</td>
<td>12 m Minimum</td>
<td>24 to 60 m</td>
</tr>
<tr>
<td>RM3 (white)</td>
<td>Channelising/Stacking line</td>
<td>100 mm Min</td>
<td>Same as GM1 or WM2</td>
<td>12 m Minimum</td>
<td>24 Preferred</td>
</tr>
<tr>
<td>RM4.1 (yellow)</td>
<td>Left edge line</td>
<td>100 mm Min</td>
<td>100 mm Min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM4.2 (white)</td>
<td>Right edge line</td>
<td>100 mm Min</td>
<td>100 mm Min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM5 (yellow with white borders)</td>
<td>Painted island marking</td>
<td>100 mm White boundary lines</td>
<td>150 mm to 1 000 mm Yellow lines sloped at 30/60 degrees or 200 mm to 600 mm Continuous yellow line between two white lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM8 (yellow)</td>
<td>Mandatory direction arrows</td>
<td>Approximately 1 m in advance of stop line.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM10 (yellow)</td>
<td>Box junction</td>
<td>100 mm Min</td>
<td>100 mm Min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM11 (white)</td>
<td>Zig Zag Zone</td>
<td>100 mm Min</td>
<td>2.0 m Line</td>
<td>100 mm Min</td>
<td>2.0 m Line</td>
</tr>
<tr>
<td>RM12 (red)</td>
<td>No-stopping line</td>
<td>100/150 mm Min</td>
<td>100/150 mm Min</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Warning road markings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WM2 (white) [5]</td>
<td>Continuity line</td>
<td>200 mm Min</td>
<td>1,5 m Line</td>
<td>200 mm Min</td>
<td>2 m Line</td>
</tr>
<tr>
<td>WM3 (white)</td>
<td>Dividing line</td>
<td>100 mm Min</td>
<td>3,0 m Line</td>
<td>100 mm Min</td>
<td>4,0 m Line</td>
</tr>
<tr>
<td>WM5 (white)</td>
<td>Yield control ahead</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WM6 (white)</td>
<td>Lane reduction arrows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WM7 (white)</td>
<td>Mandatory direction arrow ahead</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Guidance road markings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM1 (white) [5]</td>
<td>Lane lines</td>
<td>100 mm Min</td>
<td>1,5 m Line</td>
<td>100 mm Min</td>
<td>2 m Line</td>
</tr>
<tr>
<td>GM2 (white)</td>
<td>Guide lines</td>
<td>100 mm Min</td>
<td>0,5 m Line</td>
<td>100 mm Min</td>
<td>0,5 m Line</td>
</tr>
<tr>
<td>GM3 (white)</td>
<td>Bifurcation arrows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM4 (white)</td>
<td>Information arrows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES**

[1] Stop line not less than 1.2 m and not more than 15 m in advance of continuation of edge of the crossing roadway.
[2] Stop line minimum 1.0 m in advance of pedestrian crossing lines (3.0 m at pedestrian crossings).
[3] Yield line minimum 3.0 m in advance of pedestrian crossing lines minimum (preferably 6.0 m).
[4] Pedestrian crossing width – 2.4 m Minimum; 3.0 m Preferred minimum; 5.0 m Preferred maximum.
[5] Continuity and Lane lines available as extra, standard and reduced density lines, depending on gap size.
Figure 5.7: Road junction with pedestrian crossing markings

Figure 5.8: Guide lines through a junction
5.6 ROAD LIGHTING

1. The provision of road lighting at signalised junctions and mid-block pedestrian crossings will promote safe operations at night. Adequate lighting will contribute to increased visibility, thereby increasing driver awareness of the signals as well as possible conflicts within the junction. Lighting enhances traffic safety by illuminating hazardous objects or situations so that the driver can respond readily and safely.

2. Lighting can reduce the number of accidents at night by about a third of that occurring during the day. Reduction factors such as this can be used in cost-benefit analyses in which the benefits accruing from lighting can be compared with the cost of providing such lighting.

3. In addition to its safety benefits, the provision of road lighting can also contribute to reducing crime levels.

4. At junctions, road lighting is particularly justified when a significant number of pedestrians cross the junction or crossing at night. Such junctions would normally be located near developments that have a large component of recreational land use. This includes sporting venues, cinemas, popular restaurants, resorts, etc.

5. Lighting is also required at complex junctions with islands and other obstructions, or where significant volumes of vehicles turn right at night.

6. An important principle in the provision of road lighting is that a uniform level of brightness should be provided over the full junction or crossing. Drivers may not discern objects when brightness is allowed to vary. Care should also be taken to ensure that all important features are illuminated, including kerbs and pedestrian crossings.

7. A further important aspect related to the introduction of lighting at remotely located junctions is the time required by drivers to visually adapt to changes in lighting levels. The problem mainly occurs when drivers leave the illuminated area. To address this problem, the level of lighting at the junction should be kept relatively low. Alternatively, the level of lighting can be gradually reduced.

8. High mast lighting is often used at remotely located junctions. This method of lighting has several advantages. These include the following:
   (a) High mast lighting covers a greater area of the junction, including areas adjacent to the roadway. Drivers can therefore relate to the entire junction complex.
   (b) Fewer poles located farther away from the edge of the pavement reduce the probability of collisions with the poles.
   (c) Transition lighting is more easily achieved because of the gradual reduction of light levels at higher mounting heights.

The disadvantage of high mast lighting is that additional energy is required to illuminate areas other than the roadway itself.

5.7 BIBLIOGRAPHY

1. AUSTROADS, 1988, Part 5- Intersections at Grade, Australia.
7. Committee of State Road Authorities, 1988, TRH 17, Geometric design of rural roads, Pretoria.
6.1 INTRODUCTION

1 Correct timing and phasing are fundamental to the proper functioning of traffic signals. Wrong signal settings can lead to wastage of time and fuel by road users and drivers taking risks, leading to a greater risk of collisions. Managing the effective operation of signals depends upon careful planning and the implementation of an effective programme of data collection and analysis/calculation.

2 The timing methods described herein apply to signals operating in fixed time mode, but some of these methods can be extended to other modes of control, perhaps with some modification. These other modes of control include vehicle-actuated and traffic responsive control. Additional information on these modes of control is given in other chapters of this manual.

3 In fixed time control, the sequence and duration of each light signal is predetermined and can only be changed by changing the controller settings. Different timing plans, however, can be operated at different times of the day, and days of the week, with suitable controllers.

6.2 TIMING PARAMETERS

1 The establishment of traffic signal settings involves the setting of signal phases and the timing of parameters such as the cycle length, green splits, yellow and all-red intervals and co-ordination offsets.

2 The concept of signal timing is best thought of as intervals of a cycle time during which different light signals are given to the different streams of traffic. An example of such signal intervals is shown in Figure 6.1. This figure shows the intervals during which green, yellow and red light signals are displayed on two intersecting roads.

3 A number of important timing parameters are shown in Figure 6.1. The following are definitions of these parameters:

(a) Cycle: The time required for one complete sequence of light signals.

(b) Intergreen: The yellow signal interval plus the all-red interval. This is the safety period between the end of one green light signal and the start of another green light signal that gives right of way to a conflicting traffic stream. This period is also called the interstage interval.

(c) Offset: The time difference between the start of a signal stage at one traffic signal relative to the start of a stage at another signal, or relative to some system time base. Offsets are sometimes also measured at the start of an interstage interval.

(d) Phase: An interval of the signal cycle during which a particular green signal is displayed. The phase starts when the particular green signal is first displayed and ends as soon as this same green signal is terminated.

(e) Stage: An interval of the signal cycle during which any combination of vehicular green signals is displayed (pedestrian or pedal cyclist green signals excluded). A stage starts when any vehicular green signal is first displayed and ends as soon as any of the vehicular green signals being displayed are terminated.

(f) Signal group: A group of traffic signal faces that always display exactly the same sequence of light signals at the same time. These signal faces are electrically interconnected and can therefore not display different signals at any time.

4 Figure 6.1 shows an example of a three-stage traffic signal with six signal groups. The following signal groups are provided:

(a) North/South street – all turning movements.
(b) East approach – protected-only right-turn.
(c) East approach – left-turn and straight-through movements.
(d) West approach – all turning movements.
(e) North/South pedestrian signal.
(f) East/West pedestrian signal.

5 The three stages in Figure 6.1 are as follows:

(a) Stage 1 during which green is given to the N/S street and N/S pedestrians.
(b) Stage 2 during which green is given for the protected-only right-turn phase on the east approach.
(c) Stage 3 during which green is given for the E/W street and E/W pedestrians.

6 A number of signal phases are also shown in the figure:

(a) The North/South main phase.
(b) The East approach right-turn phase.
(c) The North/South pedestrian phase.
(d) The East/West pedestrian phase.

6.3 DEFINITION OF PHASES

1 The definition of the term phase used in this manual differs from that used in most other publications. Professionals involved with traffic signal design should be aware that, in addition to the definition used in this manual, there are (at least) two other definitions for the term. These definitions are as follows:

(a) In the one definition, a phase is defined as the sequence of light signals applicable to one or more streams of traffic that always receive identical indications (equivalent to the above definition of a signal group or a SABS phase).

(b) In the second definition, a phase is defined as an interval of time during which one or more traffic streams simultaneously receive right of way (equivalent to the above definition of a stage).
### Signal Timing and Phasing

#### Signal Group | Light signals
---|---
N/S Street | N/S Main phase
| Green | Yellow | Red
| East Right-turn | East right-turn phase
| Red | Green | Yellow | Red
| East Approach | Red | Green | Yellow | Red
| West Approach | Red | Green | Yellow | Red
| N/S Pedestrians | N/S Pedestrian phase
| Green | Flash red | Red
| E/W Pedestrians | Red | Green | Flash red | Red

**Figure 6.1:** Example of signal intervals for a three-stage traffic signal with six signal groups

2 The first definition is used in South African standard specification SANS 1547: Traffic signal controllers as well as most, if not all, traffic signal configuration programs used in South Africa. The second definition, on the other hand, is used in many international traffic engineering manuals and handbooks. This has lead to considerable confusion in South Africa.

3 To address the above problem, the use of the term “phase” in this manual is restricted to situations where the meaning of the term is generally well understood. The term is generally used as a replacement for the term “green light signal”, as shown in Figure 6.1.

4 In this manual, the term “signal group” is used as an equivalent for the first definition for phase given above, and the term “stage” is used instead of the second definition. This corresponds with the approach followed in the SABS specifications, except that the term “signal group” is used instead of “phase”. In a number of situations, the term “signal group” will be augmented by the phrase [SABS phase] to ensure that there is no misunderstanding of terms.

### 6.4 Managing Signal Settings

1 Signal settings need to be reviewed periodically in the light of possible changes in traffic demand or changes to the road network. In situations where the road network does not change and traffic patterns do not vary significantly (such as in a busy central business district), frequent updating of signal timings will not be necessary. On the other hand, in situations where traffic is growing or the road network is changing, new settings may have to be revised at intervals as short as 12 months. This requires an awareness of what is happening on the roads in an area.

2 It is important to realise that traffic flow patterns may change after the commissioning of a new traffic signal. It will often be necessary to adapt traffic signal timings, and even phasing, after the system has settled down.

3 Data collection plays a particularly important part in the management of fixed time signal settings. Signal phasing and timing should be based upon the best available data at any given time. There should therefore be a structured programme for data collection, from the planning and design stage, through implementation, to the subsequent on-going maintenance and support.

4 It is important to note that traffic counts at existing traffic signals under congested or saturated conditions should be treated with care since they will not give a true indication of demand due to overflow queuing. Stop line traffic counts in such circumstances could indicate that the current settings are adequate, while this might not be the case. Traffic counts must then be adjusted to account for queues that form on the road network.

5 Updating may involve changes to the signal timings as well as signal phases. Most often, it is the signal timings that will need updating. Phasing requirements – such as the need for new right-turn phases - will change less often. Physical changes to the road network may have a marked impact on phasing requirements.
6.5 SIGNAL TIMING PLANS

1 Traffic signals often require the use of multiple timing plans to cope with the variation in traffic demand throughout the day, and on different days of the week. This is particularly important when fixed time traffic signal systems are used.

2 A timing plan determines the cycle time, the sequence of phases and stages, and the timing characteristics of each stage. It may also determine the mode of operation at a particular time, where the controller is capable of operating under different control modes.

3 Any given plan may be brought into operation during any selected period of the day, or day of the week, according to a predetermined timetable, or "programme". By changing the plan, the signal settings can thus be changed to suit the traffic conditions at a particular time.

4 A single timing plan may be adequate when traffic volumes are generally low, but then the signals are probably not warranted in the first place (or traffic volumes may fluctuate equally on each approach at the same time). Most signals would usually require more than one signal timing plan.

5 The following traffic signal plans would typically be provided at a typical signal location:
   (a) Weekday morning (AM) peak period plan, typically operated for a period of 30 minutes before and 30 minutes after the morning peak period.
   (b) Off-peak (midday) period, operating between the morning and afternoon peak plans.
   (c) Weekday afternoon (PM) peak period plan, typically operated for a period of 30 minutes before and 30 minutes after the afternoon peak period.
   (d) Evening period (following the PM peak period).
   (e) Night (low-flow) period.
   (f) Weekend and holiday periods.

6 Near shopping centres, high traffic volumes may be experienced on weekends. It may then also be required to implement the following additional timing plans:
   (a) Friday afternoon (PM) peak period plan.
   (b) Saturday peak period plan.

7 A special Sunday peak period plan may also be required near holiday resorts and at shopping centres which are open on Sundays.

8 At schools, a midday plan may be required to accommodate a local peak in traffic volumes.

9 In large cities, there may also be a need to subdivide peak periods into smaller sub-periods to cope with different demand patterns that may occur due to different trip purposes.

10 At some locations, a development (e.g. a hospital or a factory) that generates large volumes of traffic may also create a specific peak period associated with the opening and closing times (or visiting hours) of the development.

11 Traffic operations can be improved by providing a variety of timing plans that can cope with variations in traffic demand. Care should, however, be taken not to change plans too often, since plan changes involve transitions which are often inefficient and which could seriously disrupt traffic flow and signal operations.

6.6 TRAFFIC COUNTS

6.6.1 General

1 Traffic counts are required for establishing optimal settings and phasing of a traffic signal. Each timing plan would require a set of traffic counts taken over a specific design period.

2 Design periods may be known for a particular area or can be determined based on a general knowledge of traffic flow patterns in the area. Where such information is not available, design periods can be identified by means of automatic 24-hour traffic counts taken on a few representative roads or streets over a period of seven days or longer. In order to establish traffic patterns, it is not necessary to count traffic on each approach to each signal, or to count each individual turning movement. The selected roads or streets must, however, be representative of the traffic patterns in the network.

3 Detailed traffic counts are required for each design period for which traffic signal settings and phases are to be established. These counts are taken manually, and each turning movement is counted separately. If there are significant numbers of heavy vehicles and/or buses (more than 5 or 10% of the traffic), classified counts may be taken. The counts are enumerated in 15-minute intervals.

4 A lane utilisation study may also be required at locations where drivers tend to avoid using particular lanes. Such a study will establish the proportion of vehicles using the heaviest loaded lane. This study will generally be undertaken for straight-through movements, but where more than one lane is provided for a left- or right-turn movement, the study may also be required for the turning movements.

6.6.2 Congested conditions

1 It is important to realise that a traffic count is not necessarily an indication of traffic demand. A low traffic volume could indicate congested conditions rather than a low demand. If this occurs, queues of vehicles at the traffic signal(s) can be observed and the traffic counts adjusted for changes in the queue lengths. These queues may be forming at the signal(s) being investigated or at other upstream bottlenecks in the system. In such cases, the traffic demand is estimated at such bottlenecks and projected through the road network.

2 A procedure for adjusting traffic counts by means of queue length observations is described in Chapter 29. It should be noted that the adjustments could still probably under- or overestimate actual traffic demand due to traffic diverting to other routes in the network.
6.6.3 Normal and exceptional days

1 An important consideration when traffic is counted, is the concept of normal and exceptional days. Fixed time traffic signal timings are established for the normal days of the week in a year, and not those days on which traffic volumes are either exceptionally high or low. Normal days occur more often than exceptional days, and signal timings established for such days would generally result in more efficient operations compared to timings established for days that occur less often in a year.

2 It is important that care should be taken to ensure that traffic is counted only on normal days and not on exceptional days. More details on normal and exceptional days are given in Chapter 29.

6.6.4 Predicting traffic volumes

1 It is obviously not possible to count traffic on a road that is still being planned and that has not yet been constructed. The installation of new traffic signals at a junction could also attract additional traffic to the junction because of the greater accessibility provided by the signals. In such cases, future traffic volumes must be estimated.

2 Specialised techniques are used to predict changes in traffic volumes, and these are not covered. Such techniques may involve the utilisation of computer models, or it may involve a simple consideration of traffic patterns in an area.

3 It is often difficult to predict changes in traffic volumes sufficiently accurate to set traffic signals, and it is therefore preferable to recount traffic volumes once the changes have been implemented and traffic patterns have settled. Traffic signal settings can be changed relatively easily, and it is therefore not necessary to predict traffic too far ahead into the future.

6.7 SIGNAL PHASES

1 Determining the phasing requirements of a traffic signal is an important aspect of establishing traffic signal settings.

2 Examples of signal phases that can be provided at a traffic signal are shown in Figure 6.2. The following phases are shown in the figure:

(a) The main phase, which provides for straight-through and permitted left and right-turn movements, and which is signalised by a steady green light signal. A parallel pedestrian or pedal cyclist phase is also provided.

(b) Single right-turn phase which provides for a movement to the right, with or without a parallel left-turn phase which provides for a movement to the left. Both phases are signalised by flashing green arrow light signals. A parallel pedestrian or pedal cyclist phase is also provided, but only on the one side of the road.

(c) Double right-turn phase which provides for right-turn movements from two approaches, with or without left-turn phases from two adjacent directions. All phases are signalised by flashing left green arrow light signals.

3 A protected turning phase that allows one movement direction to turn while another movement on the same approach is stopped, should preferably only be used if separate exclusive lanes are provided for each of the movements. For instance, a right-turn phase, which allows right-turn vehicles to turn while straight-vehicles are stopped, should only be used when a separate right-turn lane is provided.

6.8 MAIN SIGNAL PHASES

1 The main signal phase can be provided for straight-through and permitted left and right-turn movements. Such a phase is signalled by a S1 traffic signal face.

2 Particular care must be taken when terminating a main phase during which a right-turn movement was permitted. The following are of importance:

(a) A phase during which right-turn traffic is permitted to turn shall NOT be terminated early while a green light signal is displayed to traffic on the conflicting opposing approach. The right-turn traffic may not be aware that the opposing traffic is still receiving green, and may then turn into the face of oncoming traffic, which could be dangerous.

(b) When a protected left-turn phase is introduced on the opposing approach immediately following a main signal phase, an all-red period of sufficient duration should be given to allow right-turning vehicles to clear the junction before the onset of the protected left-turn phase.

6.9 LEFT-TURN SIGNAL PHASES

1 The left-turn signal phase is provided for left-turning vehicles only, and is allowed by a flashing green left arrow light signal (or the flashing tram and bus light signals).

2 The basic sequence of green, yellow and red (where provided) light signals shall normally be displayed when a left-turn phase is provided. However, on the S9 and S10L signal faces, the yellow arrow light signal may be omitted from the sequence subject to the conditions that (as stated in Chapter 3):

(a) the flashing green arrow light signal must immediately be followed by a steady green light signal which allows the left-turn movement to turn; and

(b) when pedestrian or pedal cyclist signals are provided, no green pedestrian or pedal cyclist light signal may be displayed following the flashing green arrow light signal. The yellow arrow light signal shall NOT be omitted when such green pedestrian or pedal cyclist light signal is displayed.
Main signal phase with pedestrian/pedal cyclist phase.
Right-turning movements can either be permitted or prohibited.

Single right-turn phase with/without left-turn phase
Can be provided as either a leading or lagging phase.
Lagging phases shall only be provided when no vehicles turning right from the opposite direction can be trapped (such as at T-junctions or on one-way streets).
Pedestrian phase can optionally be provided on the one side of the junction.

Double right-turn phase with/without left-turn phases
Can be provided as either a leading or lagging phase.
No vehicles turning right can be trapped, and the phase can be provided as a lagging phase at all types of junctions.

Figure 6.2: Various types of traffic signal phases at a signalised junction

3 The left-turn phase is used to indicate to drivers of vehicles that their turning movements are unopposed by any conflicting vehicular, pedestrian and pedal cyclist traffic movements. The phase may therefore not be provided when there are any such conflicting movements. The following are particularly important examples of such movements:
(a) Pedestrians movements (the left-turn phase may not be provided at the same time as a parallel pedestrian phase).
(b) Right-turning traffic from the opposite approach.
4 A left-turn phase will usually be a parallel phase, i.e. it runs at the same time as another non-conflicting phase. It often runs parallel with a right-turn phase on the crossing approach from the left of the junction (or the side road at a T-junction).
5 When a protected left-turn phase is introduced immediately following a main phase, an all-red period of sufficient duration is required to allow opposing right-turning traffic from the opposite direction to clear the junction. The onset of the left-turn phase can be delayed by a short period of time to provide the additional clearance time.

6.10 RIGHT-TURN SIGNAL PHASES

6.10.1 Signalling right-turn phases
1 The right-turn signal phase is provided for right-turn vehicles only, and is allowed by a flashing green right arrow light signal (as well as the flashing tram and bus light signals).
2 The right-turn phase is used to indicate to drivers of vehicles that their turning movements are unopposed by any conflicting traffic movements. This phase may therefore not be provided when there are any conflicting traffic movements. An important example of such conflicting traffic movements is pedestrians.
3 The pedestrian phase may be provided in parallel with the main or other suitable phase that serves the same approach as the right-turn phase. There is, however, an exception to this, worth considering: the pedestrian crossing in question can be eliminated altogether and a pedestrian prohibited sign R218 posted. In this case, pedestrians would cross the other approaches to get to the other side of the right-turn exit - this would entail an extra road crossing and may not be acceptable to pedestrians.
4 A right-turn phase can be provided in one of two modes of operation, namely protected/permitted and protected-only modes:
   (a) In protected/permitted mode, a leading or lagging protected turn phase is provided, but the turning movement is also permitted during the main phase.
   (b) In protected-only mode, vehicles are only allowed to turn during a leading or lagging protected phase.

6.10.2 Single and double right-turn phases

1 Leading and lagging right-turn phases can be provided as single or double right-turn phases.
2 The single right-turn phase protects only one right-turn movement on one axis of a junction. Straight-through and left-turn traffic also receives right of way during the phase, and all traffic on the opposite approach must stop.
3 An important advantage of the single right-turn phase is that it allows sharing of lanes by different turning movements, such as by straight-through and right-turn movements. This is an advantage on approaches where it is not possible to provide separate right-turn lanes. This advantage, however, will only be realised when traffic volumes on the opposing approach are relatively low.
4 The double right-turn phase protects both right-turn movements on one axis of a junction. The two right-turning movements receive flashing green light signals at the same time. No straight-through or left-turning traffic on this axis receives right of way during this time.
5 The double right-turn phase has the disadvantage that the flashing green right arrow light signals are sometimes not noticed by drivers. This problem can to some extent be addressed by providing additional signal faces that contain the flashing green arrow signals.

6.10.3 Leading and lagging right-turn phases

1 Right-turn phases can be provided as leading or lagging right-turn phases.
2 The leading right-turn phase, also sometimes referred to as a “late release”, appears with or before the main phase on the same approach.
3 The lagging right-turn phase, also sometimes referred to as an “early cut-off”, appears after or during the final part of the main phase interval.
4 The single lagging right-turn phase has one particular important problem that limits its application. This phase is introduced by terminating the main phase early in the opposite direction. This can result in a situation where a yellow light signal is displayed to right-turning traffic while conflicting traffic movements receive a green light signal - a combination of light signals which is not allowed. In this situation, the right-turning traffic receiving yellow may not know that opposing traffic is still receiving green, and may turn right into the face of this oncoming traffic, which could be dangerous.
5 For this reason, the lagging right-turn phase is NOT allowed unless:
   (a) there is no right-turning traffic in the opposite direction (as a T-junction or on one-way streets).
   (b) double lagging right-turn phases are provided on both approaches.
6 Apart from the situation where a single lagging right-turn phase is not allowed, both types of right-turn phases have advantages and disadvantages:
   (a) The leading right-turn phase has the important advantage, particularly on high-speed roads, that vehicles will only turn when opposing traffic has been at rest for some time. When a lagging phase is provided, vehicles will turn while opposing traffic is in the process of stopping.
   (b) The leading green also has the advantage that it could reduce the number of gap acceptance conflicts, which may lead to safer operations. With lagging green, more vehicles may accept gaps while waiting for the right-turn phase.
   (c) The leading green however, has the disadvantage that it may be creating a habit in which drivers turning right tend to pre-empt right of way, even when no right-turn phase is provided. The lagging phase has the advantage that normal signal operations and normal driving behaviour are better approximated.
   (d) A second disadvantage of the leading green is the tendency for false starts on the opposite approach. It is not a rare occurrence to find vehicles on the opposite approach pulling away at the same time as traffic receiving the leading green.
   (e) An advantage of the lagging right-turn phase is that it provides significantly better separation between right-turning vehicles and pedestrians. This is a particularly important advantage in areas with high pedestrian volumes.
   (f) A further advantage of the lagging right-turn phase is that it can be more efficient when vehicle-actuated control is implemented. The lagging phase is only called at the end of the main phase if right-turning vehicles remain that could not accept gaps. With leading green, the phase will be called independent of whether right-turning vehicles will be able to accept gaps.
7 No absolute advantages are inherent in either leading or lagging configurations. The choice of the optimum configuration will be dictated by specific conditions at a particular junction.
6.11 WARRANTS FOR RIGHT-TURN SIGNAL PHASES

6.11.1 General

1 The decision to install a right-turn phase at a junction is one of the most important decisions when determining phasing requirements at signals.

2 Although a separate right-turn phase can improve the right-turn movement, unwarranted right-turn phases can be wasteful and can lead to deterioration of the capacity of a traffic signal. A right-turn phase wastes a valuable part of the cycle time, which cannot be used by other conflicting movements. It is unacceptable to operate a right-turn phase to the detriment of the main traffic movements through the junction, so that the right-turning traffic has an inequitably high level of service in relation to the main traffic movements, some of which may be of much greater importance in the road system, e.g. the co-ordinated through traffic on an arterial.

3 It is highly unlikely that a right-turn phase will be justified for 24 hours a day or on every day of the week. Right-turn phases are usually necessary only during peak periods. A right-turn phase should therefore be considered only where a separate peak-period signal timing plan can be run, during which the right-turn phase can appear, when it is needed. It should NOT be included in another signal plan when it is not justified, e.g. the off-peak or night plans.

4 The motivation for a right-turn phase will generally be based upon safety and operational considerations.

6.11.2 Safety considerations

1 A right-turn phase justified by safety considerations would usually be operated in protected/only mode in which gap acceptance is not allowed, although a protected/permitted right-turn can also contribute towards an improvement in safety.

2 The safety considerations would include the following:
   (a) Where accident experience indicates that turning traffic is unable to utilise sufficient safe gaps in which to turn.
   (b) Where drivers turning right cannot properly see traffic approaching from the opposite direction, such as:
      (i) When wide medians are provided and the offset of opposing turning lanes is such that the opposing turning vehicles restrict sight distances.
      (ii) When the junction is located on a horizontal curve and the view of turning vehicles is blocked by turning vehicles on the opposite approach.
      (iii) When two or more turning lanes are provided in such a way that the sight distance of vehicles on one lane will be blocked by vehicles in another lane.

(c) Where conflicts occur between right-turning traffic and parallel pedestrian movements during the main signal phase. Such conflicts can be reduced by providing a protected-only right-turn phase and prohibiting the right-turn movement when the parallel pedestrian phase is provided.

6.11.3 Capacity considerations

1 A right-turn phase is justified on the basis of capacity (or operational) considerations when the volume of traffic wishing to turn right cannot do so because of the volume of opposing traffic and consequent lack of suitable gaps, resulting in long queues of right-turning vehicles. If safety considerations permit, the right-turn phase can be operated in protected/permitted mode.

2 Various methods are available for the motivation of right-turn phases based on operational considerations. Most of the methods require the use of a suitable model for the calculation of a level of service or a performance index, usually based on vehicular delay (and possibly number of stops). The junction is then modelled with and without the proposed right-turn phases, and the alternative with the best overall level of service is selected.

3 A manual method for establishing signal timings for fixed time signals is described later in this chapter. According to this method, a right-turn phase will be needed when the right-turn traffic cannot be handled at an acceptable degree of saturation without a right-turn phase. Typically, this would be found when right-turn volumes exceed about 100 to 150 vehicles per hour on an approach.

6.12 THE INTERGREEN PERIOD

6.12.1 General

1 The intergreen period is defined as the yellow plus the all-red or clearance period. This period is fundamentally important for the safe operation of a signal and is monitored by the controller apparatus.

2 The yellow period provides an indication that a red light signal will be displayed shortly, allowing the driver to stop if possible. The all-red (or clearance) period provides for a clearance time of the junction.

3 Ideally, a yellow period should give sufficient warning to allow drivers to stop safely, even under adverse weather conditions. When such a driver is too near the junction to stop safely, sufficient time should be provided for the driver to enter the junction on yellow, and to clear the junction during the all-red period.

4 The ideal requirements, however, can result in relatively long yellow periods. Drivers tend to abuse long yellow periods, using the yellow as effective green that can result in unsafe conditions. A more pragmatic approach is therefore recommended in which the yellow period is reduced and the all-red period correspondingly increased, while effectively providing the same intergreen period.

5 The reduced yellow period may result in drivers entering a junction during the all-red period being prosecuted unfairly. It is therefore recommended that an enforcement tolerance should be provided and that law enforcement should only commence during the last one second of the all-red interval.