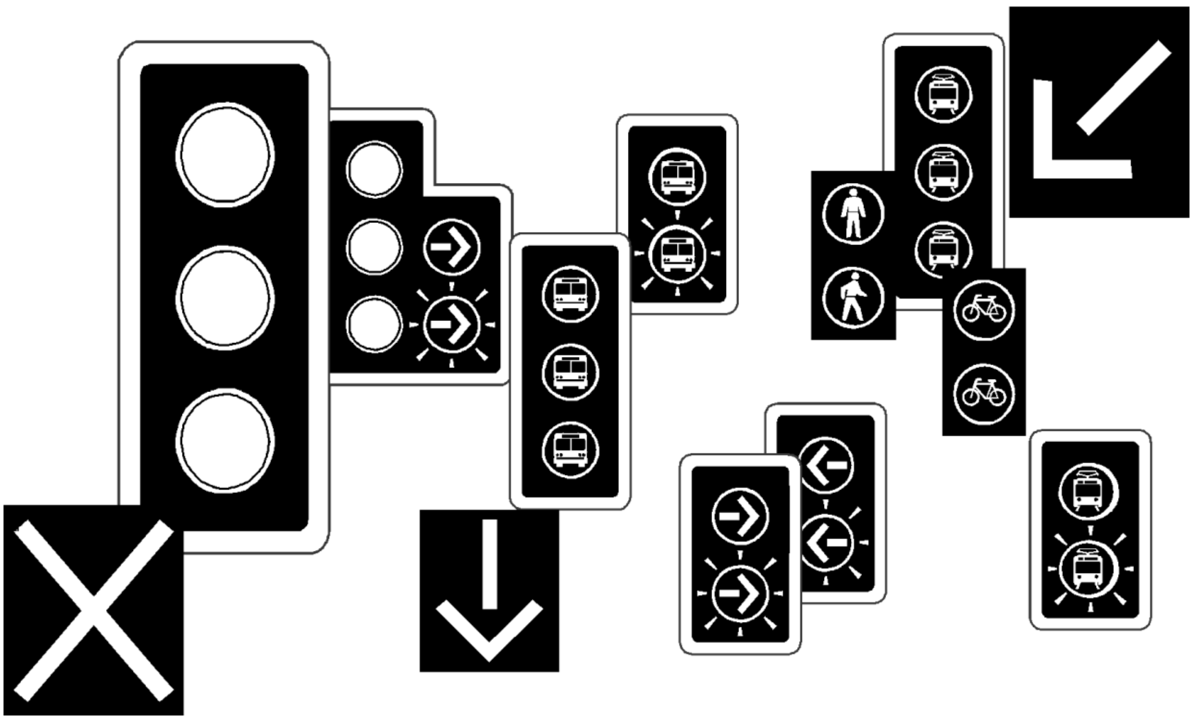
SOUTH AFRICAN
ROAD TRAFFIC SIGNS MANUAL

VOLUME 3: TRAFFIC SIGNAL DESIGN

DIGITISED VERSION – May 2012

PART 2
TRAFFIC SIGNAL EQUIPMENT



CHAPTER 16: LIGHT SIGNALS AND POSTS

16.1 INTRODUCTION

1 The traffic light signal is the means by which a traffic signal communicates with the driver, and is therefore one of the most important components of a traffic signal installation.

2 The light signal is the green, yellow or red signal displayed by illuminating a signal aspect. The various components involved with ensuring the effective display of the light signal are discussed in this chapter. This includes the background screen (backboard) as well as the posts used to support the light signal.

16.2 SIGNAL ASPECTS

16.2.1 General

1 The signal aspect is the unit that displays a light signal when illuminated. An example of a signal aspect is shown in Figure 16.1. It consists of various components, such as a lens, a reflector, lamp, louvres and a visor.

2 Traffic light signals should be manufactured and installed in a disciplined and standardised manner. The use of the South African standard specification SANS 1459: *Traffic lights* is prescribed. These specifications specify all components of the light signal, including the lamp that may be used.

3 According to the National Road Traffic Regulations, ***"every flashing light signal shall operate at a cycle frequency of between one and two flashes per second"***. The luminous intensity shall be zero for 30% - 50% of the period and not less than the specified minimum for 30% - 50% of the period.

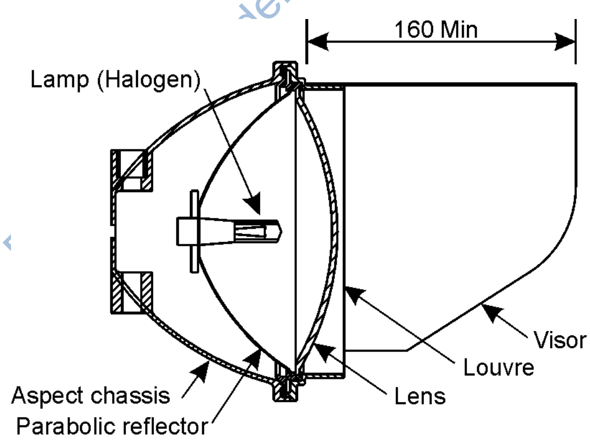


Figure 16.1: Components of a signal aspect

16.2.2 Luminous intensity

1 The luminous intensity level of a signal aspect defines the brightness of a light. Two intensity levels may be specified, namely NORMAL or HIGH.

2 Normal intensity lights should always be specified for pedestrian signals. Normal or high intensity lights may be used for vehicular signals, depending upon the operating conditions.

3 Conditions where high intensity lights should be used, include any one or more of the following:

(a) Where the speed limit on a road is 70 km/h or higher.

(b) Where increased visibility is necessary due to a confusing background of bright lights or other traffic lights or signs.

(c) Where visibility is affected by a rising or setting sun in the east/west direction.

(d) Where drivers would not normally expect to encounter a signal, such as in rural areas or on the edges of a town or city.

4 High intensity traffic lights may cause "discomfort glare" or "disability glare" at night, especially in dark surroundings and in the absence of street lighting. It is recommended that, in such situations, a facility for automatically dimming signal lamps at night should be provided. Such dimming can be operated by a photo-electric cell.

16.2.3 Aspect size

1 Two sizes of signal aspects may be used for pedestrian and vehicular signals, namely 210 mm and 300 mm nominal diameter.

2 The larger aspect is not often used because it does not contribute significantly to visibility as much as luminous intensity, particularly when used to display DISC light signals. It may assist to enhance recognition of a symbolic light aspect, such as the arrow signals. These arrow signals, however, are generally recognisable by their location relative to other light signals. The flashing green arrow light signal, in particular, is readily recognised because it is the only flashing green signal permitted.

3 Pedestrian aspects of 210 mm diameter should be adequate for normally-sighted people up to a distance of 35 m. The larger aspect may be considered for crossings wider than 35 m, but then it would be preferable to provide a staggered crossing. The larger aspect can be used at a crossing that is regularly used by people with impaired vision.

16.3 SIGNAL LOUVRES AND VISORS

16.3.1 General

1 Louvres and visors are provided to modify the angular visual coverage of the light signal and/or to shield the optical system from incidental light that may cause sun-phantom effects.

2 Sun-phantom is the phenomenon whereby a signal aspect that is not illuminated by its lamp, emits light due to the reflection of the rays of the sun when they strike the aspect. The aspect thereby gives the appearance of being illuminated and of giving a light signal.

3 Sun-phantom effects can be minimised by installing visors and, where possible, aligning a signal aspect so that it does not reflect the direct rays of the sun (although this is not always possible).

16.3.2 Signal louvres

1 Louvres are installed as either horizontal or vertical plates. Horizontal louvres can be used to minimise sun-phantom effects. Vertical louvres are used to provide additional shielding when visors are inadequate, such as at skew intersections.

2 The use of louvres should be restricted because of the loss of efficiency of the optical system. They should only be used when the visors alone are unable to provide the necessary cut-off.

3 Louvres SHALL not be used in association with symbolic displays such as arrows, pedestrian and pedal cyclist signals.

16.3.3 Signal visors

1 A suitably designed visor SHALL be fitted to each vehicular signal aspect. Pedestrian and pedal cyclist signal aspects may also be fitted with visors. The visor shall have a length of at least 160 mm at the top (see Figures 16.1 and 16.2).

2 The visor should not prevent required visibility standards from being achieved. Cut-away visors may be used to increase visibility from one side, as shown in Figure 16.3.

3 Visor compliance with SANS 1459: *Traffic lights* is prescribed. Visors shall have a matt black finish inside and outside.

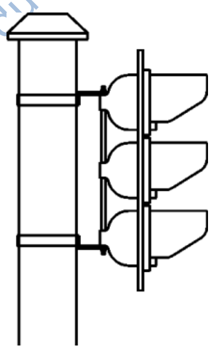


Figure 16.2: Signal head with standard visors

16.4 SIGNAL HEADS AND BACKGROUND SCREENS

1 Signal heads are fixed to posts by means of brackets as shown in Figures 16.2 and 16.3. The brackets should facilitate adjustment of the alignment of a signal in both the vertical and horizontal planes. The brackets should operate with self-locking screw clamps, and crimping of straps should not be allowed.

2 According to the National Road Traffic Regulations ***"a background screen SHALL be provided for each vehicular signal face"*** while ***"background screens may be provided*** (but are not necessarily recommended) ***for pedestrian and pedal cyclist signal faces". "Background screens shall comply with standard specifications SANS 1459: Traffic lights".***

3 Background screens (or backboards) are normally 500 mm wide with a white border of 50 mm wide. According to the National Road Traffic Regulations, "***where it is necessary to increase the conspicuity of a traffic signal, the border of the*** white ***background screen provided for a signal face may be*** white ***retro-reflective".***

16.5 POSTS FOR SUPPORTING LIGHT SIGNALS

1 Traffic signal posts should have a diameter of at least 100 mm. Signal posts should preferably be protected against rust by galvanising, and be provided with a removable weatherproof cap that will facilitate wiring.

2 Signal posts can be mounted directly in the ground and a concrete foundation is not required. From a traffic safety viewpoint, it is safer not to provide a concrete foundation. Where heavy winds occur, a base plate can be provided for additional stability. Standard posts should be installed at least 900 mm deep, and extended posts at least 1200 mm deep.

3 Overhead cantilever and gantry supports will require concrete foundations. These foundations should be designed according to appropriate engineering principles, taking all superimposed loads, such as wind loads, into account. The size of these foundations should, however, be kept to a minimum subject to stability requirements.

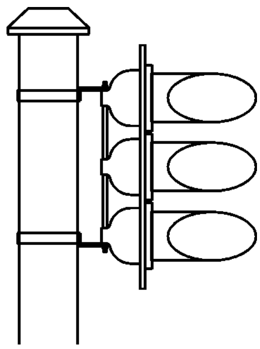


Figure 16.3: Signal head with cut-away visors

4 According to the National Road Traffic Regulations, ***"in the case of a road signal the standard, post or cantilever shall be golden yellow, portions of which may be retro-reflective".*** However, ***"this provision shall not be applicable to an overhead traffic signal mounted on a GANTRY".***

5 Retro-reflective strips may be provided on traffic signal posts to increase the conspicuity of the posts at night, particularly when there is a loss in the electricity supply. Three horizontal yellow retro-reflective strips can be fitted on ALL yellow signal posts, as shown in Figure 16.4. The width of the strips may be between 120 and 150 mm. The width of the openings should be about the same as that of the strips. The bottom strip should not be installed lower than 1,2 m and the top strip not higher than 2,1 m above the ground level.

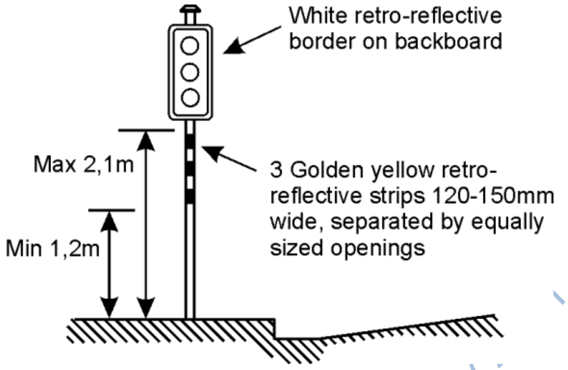


Figure 16.4: Improving conspicuity of signals

CHAPTER 17: FACILITIES FOR DISABLED USERS

17.1 INTRODUCTION

1 Facilities can be provided at signalised junctions and pedestrian crossings for pedestrians with physical disabilities (no such facilities are required by disabled drivers). The following groups of disabled persons can be accommodated at signals:

(a) those confined to wheelchairs; and

(b) those with visual impairments.

2 With regard to persons confined to wheel-chairs, it is particularly important that recessed ramps should be provided in the corner kerb, and that push buttons can be reached (a mounting height of 1,1 m would be acceptable). It may also be necessary to provide a longer flashing red man clearance interval.

3 The remainder of the chapter will be devoted to the needs of pedestrians with visual impairments.

17.2 THE PROBLEMS OF PEDESTRIANS WITH VISUAL IMPAIRMENTS

1 Pedestrians with visual impairments are confronted by a host of problems when attempting to cross a street at a signalised junction or pedestrian mid-block crossing. These can be summarised as:

(a) Knowing when to begin crossing.

(b) Crossing in the correct direction.

(c) Using push buttons.

2 In the absence of audible signals, visually impaired pedestrians rely on hearing the surge of traffic at signalised junctions moving in a parallel direction as a marker for the start of crossing. A problem with a scramble or exclusive pedestrian signal phase is that a surge does not occur and, short of being told by a bystander, the visually impaired pedestrian would find it difficult to know when to begin crossing.

3 Parallel traffic provides an acoustic guideline to help pedestrians with visual impairments to cross the street without veering to one side or the other. Intermittent traffic does not offer the required guidance. Such pedestrians may also find it difficult to cross the road if the crosswalk is far removed from the parallel traffic flow.

4 The geometry of the junction can also be a source of confusion to pedestrians with visual impairments. Have they successfully crossed the street or have they merely found the median island? It may also be difficult to differentiate between medians and islands provided at slipways.

5 Push buttons present two problems, namely locating the push button and then establishing the direction of movement to which it applies. Visually impaired pedestrians memorise the position of push buttons and the direction to which they apply as they learn a particular route. Push buttons should therefore be located as consistently as possible relative to the position of the crosswalk. Preferred locations for push buttons are shown in Chapter 4 of this manual (Volume 3).

17.3 FACILITIES TO ASSIST VISUALLY IMPAIRED PEDESTRIANS

17.3.1 General

1 The provision of facilities for pedestrians with visual impairments is not a simple matter, and no satisfactory solution has as yet been developed. The following are a number of facilities that have been provided and tested:

(a) Audible signals.

(b) Vibrotactile signals.

2 In addition to the above facilities, a number of special devices have been developed that require highly sophisticated equipment and technology to communicate with or identify visually impaired pedestrians. Many of these are still in an experimental phase and are not available in commercial systems. These systems are not discussed in this manual.

17.3.2 Audible signals

1 Audible signals may be used to indicate to visually impaired pedestrians that the green man light signal is provided (no such signal is required for the flashing red man clearance interval). The signal is sounded for a short duration at the start of the green man light signal.

2 Although audible signals may, at first glance, appear to be the best available solution, they are not always as useful as they could be. There are a number of problems. The first of these is the problem of noise pollution. For the visually impaired pedestrian, there is also the problem of identifying which crosswalk has the walk signal.

3 The problem of noise pollution can to some extend be addressed by carefully adjusting the volume of the audible signal. Provision can also be made for automatically adjusting the volume of the signal in response to ambient sound levels.

4 The problem of identifying which crosswalk has the walk signal can be addressed by using different tones or signals. Standardised tones may be adopted at different junctions and crossings in an area to indicate crosswalk directions. Verbal messages may also be given indicating the name of the street that can be crossed.

5 Where pedestrians experience problems in locating push buttons, audible locator signals may be considered to assist pedestrians in finding the push buttons. A special tone is required to allow the pedestrian to locate the push button. These signals, however, make the problem of noise pollution even worse since they have to be in continuous operation.

17.3.3 Vibrotactile signals

1 Vibrotactile devices communicate information to pedestrians through a vibrating surface by touch. These devices address the problem of noise pollution associated with audible signals, but only if they are designed in such a way that the vibrations are not audible.

2 Vibrotactile signals can be provided in the form of a vibrator attached to a signal post. The vibrator should be continuously vibrating to indicate to the pedestrian that it is in operation and not out of order. Two levels of vibration are used, one to indicate that the green pedestrian signal is being displayed, and the second to indicate the red or flashing red light signal.

3 The frequency and amplitude of vibration would have to be carefully selected to ensure that the pedestrian can differentiate between the two signals. It is also important that the pedestrian does not confuse the vibration with an electrical shock.

4 The vibrators should be installed on the same posts as the normal pedestrian push buttons. The position of the post can be used to indicate the direction to which the vibrotactile signal applies. Where this is not adequate, a raised arrow may be mounted on the vibrator indicating the direction of the signal.

CHAPTER 18: TRAFFIC SIGNAL CONTROLLERS

18.1 INTRODUCTION

1 Traffic signals are controlled and switched on and off by electrical or electronic equipment called “traffic signal controllers” (or simply “controllers”). It is normal practice to have a controller for each signalised junction, although one controller may sometimes be used to control signals at two closely space junctions.

2 The controller is essential for the proper and safe operation of a traffic signal. In addition to the basic function of switching signals on and off according to timing plans, it must also be able to prevent green signals being displayed to conflicting traffic movements. When required, the controller must also be able to interface with communication facilities required for co-ordinated control.

3 Traffic signal controllers in South Africa shall comply in all respects with the requirements contained in the South African standard specification SANS 1547: *Traffic signal controllers*.

18.2 CONTROLLER TYPES

1 Various technologies are used in traffic signal controllers. The SANS 1547 specifications classify the technologies as electromechanical, solid state and microprocessor. The controllers are classified as Class A, B and C controllers.

2 Class A electromechanical controllers were the earliest type of controller and use an electrical motor to drive a revolving camshaft that opens and closes electrical contacts. The sequence of signal stages is predetermined and fixed by the sequence of the cam breakouts on the camshaft. These controllers are not generally able to perform the same range of functions as modern electronic controllers. Despite this limitation, however, electromechanical controllers have retained their popularity, mainly because of their robustness.

3 Class B solid state electronic controllers utilise relatively basic transistorised electronic circuitry, although electromechanical relays are used for lamp switching.

4 Class C microprocessor controllers utilise integrated circuits (or microchips) and solid state lamp switching for the control of signals. Some controllers require the “burning” in of programs using various forms of read only memory (ROM). Other controllers utilise general-purpose, industrial type programmable processors that allow software to be readily modified.

18.3 CONTROLLER FUNCTIONS

1 Controllers must be able to serve a variety of functions, not only aimed at improving traffic flow and road safety, but also at reducing the effort required to maintain the traffic signal. Some functions are essential for safe operations, while other functions are provided to improve operational efficiency.

2 Some of the functions of a controller are shown schematically in Figure 18.1. All traffic signal controllers must be capable of providing at least the following minimum subset of functions:

(a) **Manual interface** which allows for the timing of the controller and setting of signal phases. A manual control facility can also be provided.

(b) **Signal timing and phasing** for the control of signal phases and stage intervals.

(c) **Signal switching** which provides for switching each signal light (or groups of signal lights) on or off.

(d) **Conflict monitoring** to prevent a controller giving right of way to conflicting signal groups that could result in traffic accidents.

3 Other additional functions that can optionally be provided by a controller are also shown in Figure 18.1. These are the following:

(a) **Fault monitoring** for the detection of controller and other faults (particularly signal lamps).

(b) **Detector units** used in combinations with vehicle detection devices.

(c) **Communication** functions allowing for communications with other controllers or a central control system.

(d) **Signal synchronisation** used to synchronise traffic signal controllers in a co-ordinate network of traffic signals.

4 A very important requirement of controllers is that they should not lose traffic signal settings in case of power loss or failure. In electronic controllers, this can be achieved by providing non-erasable memory or a backup battery.

18.4 CONFLICT MONITORING

1 Conflict monitoring is an essential function of the controller and is required to prevent a controller giving right of way to conflicting signal groups that could lead to traffic accidents.

2 In electronic controllers, conflict monitoring occurs on the output side of the controller where the power output to signals is monitored. In electromechanical controllers conflict monitoring is provided by locking cams on a single shaft and interlocking of shafts.

3 If it is found that conflicting signals are receiving power at the same time, the signal is switched to flashing mode.

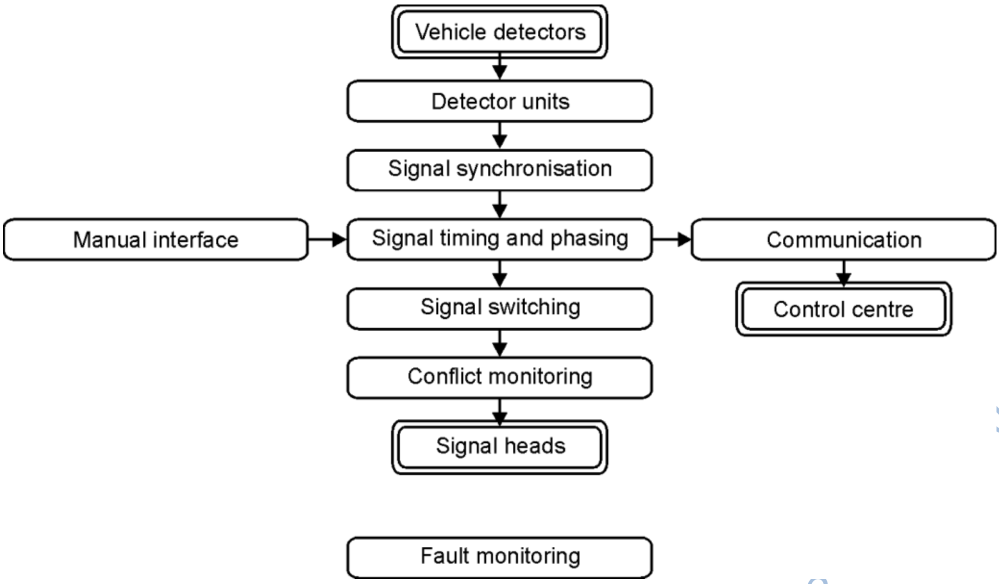


Figure 18.1: Schematic presentation of controller functions

18.5 FAULT MONITORING

1 Fault monitoring is an important function that can be provided by some controllers and is used for the detection of various faults that may occur in traffic control equipment, including the signal lamps.

2 Lamp fault monitoring is used to detect the failure of signal lamps. In its most basic form, it may be used to detect whether all red lamps on one signal group have failed. Should this occur, one or more of the actions listed below are initiated. Where lamp fault monitoring is a requirement, it is recommended that separate signal groups be allocated to each separate approach. This will allow the controller to detect whether all red lamps on one approach have failed.

3 On detection of a fault, the controller can initiate one or more of the following actions:

(a) In the event of a fault compromising the safety of the junction, switch to flashing control.

(b) In the event of other faults, activate a warning light or similar device at the controller.

(c) Report the fault to the central control computer if under central control.

18.6 SIGNAL SYNCHRONISATION

1 Accurate synchronisation of signal controllers is critical to the establishment and maintenance of traffic signal co-ordination. If the time in any of the controllers drifts with respect to other controllers, the signal timings will fall out of step. This could have a serious impact on progression along a road or street.

2 Although accurate timing equipment is available, it is difficult, if not impossible, to achieve perfect synchronisation of controllers. This means that timing units will have to be reset at regular intervals, either manually or by linking with a central control unit. The need for resetting controllers can be reduced by using more accurate timing units (which would reduce communication costs).

3 Different techniques are available to improve the accuracy of the timing unit. These include the following:

(a) Electrical mains frequency.

(b) Electromechanical motors with synchronous motors.

(c) Electronic crystal clocks.

(d) Global positioning system clocks.

4 The **electric mains frequency** of the electrical power supply can be used to improve timing accuracy. Timings may still drift during the day, but synchronisation is still maintained because all the controllers reference the same time source (except where power is taken from different electrical supplies). Synchronisation can, however, not be maintained where there are frequent power interruptions or where the quality of the power is poor.

5 **Electromechanical controllers with synchronous motors** can be used effectively under certain circumstances, again provided that all the controllers receive power from the same source. This, however, is not a very accurate method, and periodic resetting of the controllers will be required to maintain co-ordination.

6 **Electronic crystal clocks** can be utilised to provide a common time base between different traffic signals. This method, however, is still not sufficiently accurate to provide the required accuracy in signal timings over a long period without the clock being corrected periodically.

7 **Global positioning system (GPS)** receivers can be used in controllers to access the time component of the data stream transmitted from one or more GPS satellites on a continuous basis. This provides an exceptionally accurate time signal with the advantage that it does not require periodical resetting of timing units.

18.7 CONTROLLER CABINETS

1 The controller is housed in a cabinet that should be robust, corrosion resistant and generally of high quality.

2 Particular attention should be given to the quality of the doors. Seals and gaskets should be provided that will prevent the ingress of moisture and insects. Doors must be provided with strong locks to prevent unauthorised access. The door should also be fitted with a bracket to allow retaining the door in the open position.

3 Provision should be made inside the cabinet for storage of a controller log and other documents.

4 The controller should preferably be located at a junction or crossing in a position where:

(a) It can be readily accessed for maintenance purposes.

(b) The likelihood of accident damage is a minimum.

(c) Where the cabinet door is unobstructed and can be opened to its fullest extent.

(d) Where most of the traffic signal faces can be readily observed from.

CHAPTER 19: CENTRAL CONTROL SYSTEMS

19.1 INTRODUCTION

1 A central traffic control system co-ordinates and controls the operation of a network of signal junctions and crossings. The objective of such a system in the first place is to improve the efficiency of traffic flow, but it also has a secondary objective of managing the signalised system itself.

2 Central control systems utilise a central computer (or master controller) for controlling the signal network. Such a system consists of two main components:

(a) An instation located at a control centre and/or a control room. The instation equipment comprises traffic computers, computer peripherals, software and instation data transmission equipment.

(b) Outstations located at various local controllers under the control of the central system. Outstation equipment comprises outstation data transmission equipment connected to, or integral within, the local traffic signal controller, traffic detectors and other items of street equipment such as variable message signs.

3 Central control systems can vary in complexity from the relatively simple systems, to the most complex of systems. In its simplest form, the central computer may purely monitor the performance of on-street equipment. The more complex systems have facilities to update signal plans at a local controller, possibly in response to traffic demand.

19.2 CONTROL CENTRES AND ROOMS

1 A control centre is provided to accommodate the central computer system as well as control equipment for data communications. It also provides for manual operations and intervention of the control system.

2 The control room is typically equipped with control consoles and a dynamic wall map. This map can either be physically constructed, or can be a computer-projected image. The map takes the form of a simplified map of the street network under control, showing the location of signalised junctions and crossings. The operational state of each signal is indicated on the map.

3 A control room can also be equipped with a closed circuit television system (CCTV) which is used for manual monitoring of traffic. The operator may implement signal plans based on events observed on the television monitors.

19.3 CENTRAL CONTROL COMPUTERS

19.3.1 Computers and equipment

1 Depending on the number of signals controlled, one or more instation computers may be required. The configuration will depend on:

(a) The number of intersections restricted by the software or equipment (dependent on the supplier).

(b) The maximum number of signal controllers that should be controlled by one computer. A guideline is about 200 signal controllers.

(c) The control strategy followed.

2 It may be desirable to use a computer system whereby one computer acts as a Traffic Management Computer and one or more Traffic Control Computers provide the signal control functions. Alternatively, different computers may provide the same function, which has the advantage that in the event of a computer failure a standby facility exists.

3 Other peripheral computer equipment would typically include:

(a) Control console for accessing the computers.

(b) Log printer(s).

(c) Storage device for regular data backup.

(d) Additional hard disk drive for data storage e.g. traffic counts, fault logs etc.

(e) Dial-in modem enabling remote access to the system. For improved security a dial-in/dial-back facility can be specified whereby the authorised dial-back numbers are specified.

(f) A "roving terminal" which allows communication with the control system by on-street personnel via a cellular telephone link (if such a facility is available).

(g) Wall display map or alternatively an overhead projection device.

4 The central control computer should be capable of running unattended and be fully operational for 24 hours per day, throughout the year. The number of system parameters and commands required to take the system off- and online should be a minimum.

5 The control computer should be relatively fast and be able to perform all tasks as and when required. The system should be capable of operating with all junctions on minimum cycle times with no obvious or apparent degradation in performance or speed of response.

6 Providers of central control systems normally supply all of the system software required for the maintenance and operation of such systems. Some systems, however, may require the use of additional software developed by a third party. Traffic adaptive and responsive systems, in particular, may require such third-party software at additional cost.

19.3.2 User interface

1 The central control system should preferably be operated in a multi-tasking operating system, if possible with a graphical user interface. Significant benefits can be achieved if the system can also handle graphics and diagrams.

2 The system terminal should typically be able to display and dynamically update information such as the following for a selected signal controller or other items of street equipment:

(a) Current date, day of the week, and time.

(b) Equipment identification number, equipment type and other references.

(c) The current mode of control.

(d) The current plan number, cycle length, stages (including omitted stages), offset times, minimum and maximum green and intergreen times as well as times of scheduled plan changes.

(e) Control and reply messages dynamically updated in real time.

(f) Details of current faults as well as fault summaries per sub-region, region and total.

3 Efficiency can be improved if systems have the facility to display progression diagrams. It should be possible to display such diagrams in either "live update" mode with the diagram driven by stage green reply data from the controllers, or "predictive" mode, whereby a prediction of the effect of a selected set of plan timings is displayed without those timings being implemented.

19.3.3 System log

1 The central control system should have the capacity to store all system log data output for at least five years. A backup of such data should also be kept.

2 The disc system log would normally contain the following information:

(a) All messages output by the system.

(b) All implemented operator commands which affect the system.

(c) All operator comments.

(d) All generated fault messages.

(e) All operator recorded faults.

3 All messages should be dated and time stamped, while operator commands and comments should include the identity of the operator initiating the command or the comment.

4 The system should provide a command log that will allow the system to be restarted after a computer fault, system restart or reboot, or a power failure. The purpose of the command log is to automatically return all instation and outstation equipment to the same method of control and operational state prior to the restart.

19.4 OUTSTATION CONTROL

1 Outstations are controlled by the central control system by means of a communication system in which a control message is transmitted to each outstation. Outstations should be able to respond to and implement the commands.

2 The most basic facility that can be provided is that of remote monitoring of the operation of outstations with the purpose of ensuring the correct functioning of on-street equipment. *Remote Monitoring Systems* (RMS) should at least provide for the following facilities:

(a) Fault monitoring of outstations by requesting and receiving data on faults detected at local controllers (such as signal lamps and transmission errors).

(b) Synchronisation of timing equipment at local controllers.

3 In addition to the above facilities, it is preferable that provision should also be made to at least download signal plans to local controllers and to interrogate the local controllers on signal plans currently in operation.

4 In more advanced adaptive and traffic responsive control systems, outstations should also be able to return traffic data collected at vehicle detectors. Such data may include the following:

(a) An indication that there is a demand for a particular stage or the presence of a queue at a queue detector.

(b) Data collected at a traffic counting detector.

(c) The presence of an emergency and other vehicle priority signals.

5 Some advance systems also have additional facilities for the control of variable message signs from the central system. Such variable message signs can be used in traffic management systems such as parking area control.

19.5 COMMUNICATIONS

1 Data transmission between in- and outstations can be achieved by various means. The most common method is by means of leased Public Switched Telephone Network (PSTN) lines (although some authorities do have private data transmission networks). It is also possible to utilise the GSM (Global System for Mobile Communication) network for this purpose.

2 Each outstation utilises a modem to communicate with the central control system. Each controller effectively has its own allocated number (similar to a telephone number). The cost of providing such communication could therefore be high and is an important factor in the provision of a central control system.

3 Traffic responsive systems may require a permanent communication link to all outstations. The cost of such communication could be prohibitively high, requiring thorough consideration when such systems are considered for implementation.

4 Fixed time traffic control systems do not require transmission of large amounts of data. Such systems therefore have the advantage that a permanent communication link is not required, thus avoiding potentially high communication costs. Dial-up facilities are used to institute communications only when (and for as long as) required.

5 All equipment connected to the PSTN or GSM network must be approved by the operator of the network. It is important that written confirmation of such approval is obtained.

6 A problem that is often experienced is that data transmission protocols are in many instances proprietary, prohibiting or complicating the connection between different makes of equipment. Some protocols also carry copyrights and care must be taken to ensure that the copyrights are not infringed. In order to address the problem of different data transmission protocols, it is necessary to prescribe standardised protocols. At the time of writing this manual, some countries have started developing such standards, but no such standards were available for use in South Africa.

19.6 SIGNAL TIMING PLANS

1 The basic function of the central control system is to either implement signal timing plans, or to adjust a current timing plan.

2 The system should provide for the following types of plans (given from highest to lowest priority):

(a) Temporary plans

(i) Emergency signal plans (highest priority).

(ii) Fixed time plan imposed by manual request from a computer console.

(b) Permanent plans

(i) Traffic adaptive or responsive plans updated based on collected traffic data.

(ii) Fixed time plans selected according to a timetable.

3 Requests for a plan change should be served in order of priority. When a request for a plan is received, it will only be serviced if the current plan was requested from a source of lower priority. When multiple requests occur from the same source level, the latest request will be served.

4 To prevent a temporary plan from being implemented over a too long period, provision should be made for the system to make an alarm after some time. One method is to give an alarm at the next plan change time.

5 A temporary plan can be implemented by specifying user-defined start and termination times. Provision should, however, be made to cancel such plans prior to, or during these times. It must be possible to cancel a temporary plan at any time by manual intervention.

6 The introduction, implementation and cancellation of all plans should be recorded in the system log and a suitable message output to the logging printer.

19.7 EMERGENCY SIGNAL PLANS

1 The provision of emergency plans is one of the important benefits of a centrally controlled system. Such plans are provided as an aid to emergency vehicles. The signal timings required to assist such vehicles are commonly referred to as “green waves” and do not form part of the signal plans.

2 Green wave plans can be developed as standard signal plans, except that co-ordination would normally only be provided in one direction. A greater proportion of available green time would also be provided on the emergency route. Where necessary, turning phases would also be provided.

3 Provision should be made for a variety of green wave plans, between various origins and destinations.

4 Emergency plans should be implemented for a predetermined period of between 5 to 10 minutes, although provision can be made to manually extend this period.

5 When an emergency green wave plan has timed out, the system should revert to the signal plan that would have been running if the green wave had not been introduced. The time at which a green wave plan is introduced and removed as well as the green wave plan number should be output on the log printer in the control centre.

CHAPTER 20: DETECTORS

20.1 INTRODUCTION

1 Detectors are used extensively at traffic signals to detect the presence of vehicles or pedestrians with the purpose of either adjusting signal timings or providing signal phases.

2 A traffic detector will generally comprise:

(a) A detection device, e.g. an inductive loop in the roadway.

(b) An electronic detector unit to serve the input provided by the detection device.

(c) A feeder cable connecting (a) and (b).

3 The detector unit is usually located in the controller cabinet and the unit interfaces electrically with the controller to provide the inputs required by the controller.

20.2 PEDESTRIAN PUSH BUTTONS

1 Pedestrian push buttons can be provided to call pedestrian phases. They are strictly speaking not detectors, as they respond only to action on the part of the pedestrian in pushing the button.

2 The push button unit itself must be intrinsically safe electrically and should only be used to complete a low voltage electrical circuit. The push button should be resistant against vandalism, and the button plunger should be designed to minimise the risk of jamming by foreign objects, moisture or corrosion.

3 The push button can incorporate a mechanism for providing tactile and audible “feedback” to visually impaired pedestrians (see Chapter 17 of this manual).

4 Push button units should be coloured yellow and provided with a black walking-man symbol.

20.3 VEHICLE DETECTORS

1 A wide range of vehicle detecting devices has been developed for use at traffic signals. These include the following:

(a) Ultrasonic detectors, which depend upon the reflection of sound waves from the vehicle.

(b) Infrared detectors, which depend upon the reflection of infrared light from the vehicle.

(c) Microwave detectors, which depend upon the reflection of very high frequency electromagnetic waves from a vehicle.

(d) Magnetometers, which depend upon the change in a magnetic field produced by the metal of a vehicle. These detectors are installed below the road surface.

(e) Inductive loop detectors, which depend upon the change in an inductive field produced by the metal of a vehicle.

2 The inductive loop detector is currently the most widely used method for the detection of vehicles in modern traffic control systems.

20.4 DETECTOR OPERATION

1 Modern traffic detectors can provide a variety of functions and can be operated in various modes, irrespective of the means used for the detection of traffic.

2 There are two fundamental modes in which detectors can operate:

(a) Passage (Pulse) detection - used to indicate that a vehicle has crossed a detector. No indication is given of the time the vehicle has spent while crossing the detector and the pulse is of very short duration. The signal received from the detector is therefore basically a binary "yes" or "no" code. Any extension of green commences when a vehicle reaches the detector.

(b) Presence detection - used to indicate that a vehicle is present on a detector. The vehicle is detected for the duration of time it spends on the detector. Any extension of green commences after the vehicle has departed from the detector.

3 The majority of detection systems operate in presence mode rather than passage mode. Vehicle-actuated systems in particular require the presence mode. A call is registered, and green is extended, while the presence of a vehicle is detected in such presence mode. Extension detectors will extend a green signal for a short time period when the presence of a vehicle is no longer detected.

4 Detectors may also be provided with either latching (locking) or non-latching (non-locking) detector memory circuits. A non-latching detector permits a waiting call to be dropped as soon as a vehicle leaves the detection area. A latching detector, however, will hold the call until it has been satisfied by the provision of green, even if the vehicle leaves the detection area.

5 The latching and non-latching circuits can be used for purposes such as improving the capabilities of stop line calling detectors. The locking circuit can, for instance, be used to prevent dropping of calls by vehicles that cross and stop beyond the stop line call detector. On the other hand, this facility will place demands for vehicles that clear the junction, resulting in unnecessary false calls for a green signal. It may therefore be beneficial to address this problem by providing a longer stop line detector and locating the detector in such a position that it will cover the majority of positions where vehicles will stop.

6 In addition to the above functions, most modern vehicle detectors are able to ignore the continued presence of a vehicle beyond a predetermined interval. This is to avoid (illegally) parked vehicles continually calling phases that are not legitimately required.

20.5 INDUCTIVE LOOP DETECTORS

20.5.1 General

1 Inductive loop detectors are the most widely used method of detecting vehicles, mainly as a result of their relatively low installation cost. However, when loop detectors are not properly installed and maintained, they could be prone to high rates of failure.

2 The inductive loop consists of one or more turns of wire placed in a slot cut into the street surface. The loop works on the principle that an electromagnetic field is generated by an electrical current passing through the loop. Any ferrous metal object passing through the field will disturb the field, and this disturbance can be sensed by the electronic detection unit.

20.5.2 Loop shapes and sizes

1 Inductive loops have been used in a variety of shapes and sizes. Preference is normally given to small size loops rather than large loops due to improved sensitivity and the lower cost of maintaining smaller loops. Often a number of small loops will be installed rather than one large loop.

2 Most loops are in the shape of a rectangle, diamond or parallelogram, as shown in Figure 20.1. The rectangular corners of the different shapes result in “hot spots” where the electromagnetic fields overlap, which are very effective in detecting vehicles. The efficiency of the loop can also be improved by orientating the loop 45 degrees to the kerb, as with the diamond and parallelogram shapes.

3 The increased efficiency of the diamond and parallelogram shaped loops is more important at higher speeds. These loops are therefore recommended when it is necessary to detect vehicles travelling at speed.

4 The rectangular shaped loop is recommended for the detection of stopped vehicles. The diamond and parallelogram shapes may be more effective in terms of sensitivity, but some areas of the roadway will not be covered by these loops. It is thus possible, for example, that stopped motorcycles will not be detected. The greater efficiency of these loops is also not really required when vehicles are stopped. The most effective shape for the detection of stopped vehicles is therefore the rectangular form.

5 A skewed stop line detector is shown in the right-most lane in Figure 20.1. Such detectors are required to prevent false calls being placed by right-turn vehicles from the crossing street encroaching on the wrong side of the road (but only where median islands are not provided).

6 In order to reduce false calls being placed by vehicles straddling two lanes, the edge of a loop should not be closer than 0,6 m from the lane line. Such spacing will also reduce the incidence of cross-talk between two adjacent loops.

20.5.3 Detector loop and unit requirements

1 The operations of loop detectors can be affected by a variety of factors, such as the ambient conditions. Loop detectors should therefore be self-tuning, allowing them to adjust to such conditions, and even to the presence of a parked vehicle within the detection area.

2 Particular care must be taken in providing protection against lightning surges. Detector loop input terminals should be electrically isolated.

3 A variety of loop wires are used, some more costly than others. The wire should be of a high quality and tough and be resistant to abrasion, heat and moisture. Even when wires have been manufactured according to specifications, it is good practice to pre-test the wire isolation by submerging the wire in water and testing the wire for electrical leaks (a few bends should be made in the wire before it is tested). The wire isolation should also be tested for resistance to heat that may be generated by the slot sealant.

4 The number of turns of wire should be calculated according to the recommendations of the manufacturer of the detection unit. The number of turns depend on the size of the loop and the type of vehicles to be detected.

5 The loop wire is installed in a slot, cut into the road surface as shown in Figure 20.2. The slot is cut sufficiently deep to accommodate the wire, filling material and the slot sealant. The wire should lay on a bed of suitable material (e.g. silicon sand) to prevent possible damage from an uneven surface. The wire should also be covered by some suitable material (such as silicon sand or a neoprene cord) to reduce the possibility of damage due to heat generated by the slot sealant while curing. Some sealant materials may also induce unwanted stresses in the loop wire after it has cured.

6 The slot sealant should be of good quality. It must be flexible to allow for possible movement in and thermal expansion of the pavement, but at the same time be tough enough to withstand vehicle tyre abrasion and the possible penetration of debris which could damage the loop wire. It must also be able to withstand the corrosive effects of road salts, fuel, and other fluids found on road surfaces. The sealant must also be able to adhere properly to both concrete and asphalt road surfaces, preferably without a primer.

7 In order to prevent breakage or cracking of the insulation, the loop wire should not be bent to form sharp corners, or even right angles. All corners of the loops should be cut across to reduce the angle of bending, as shown in Figure 20.1.

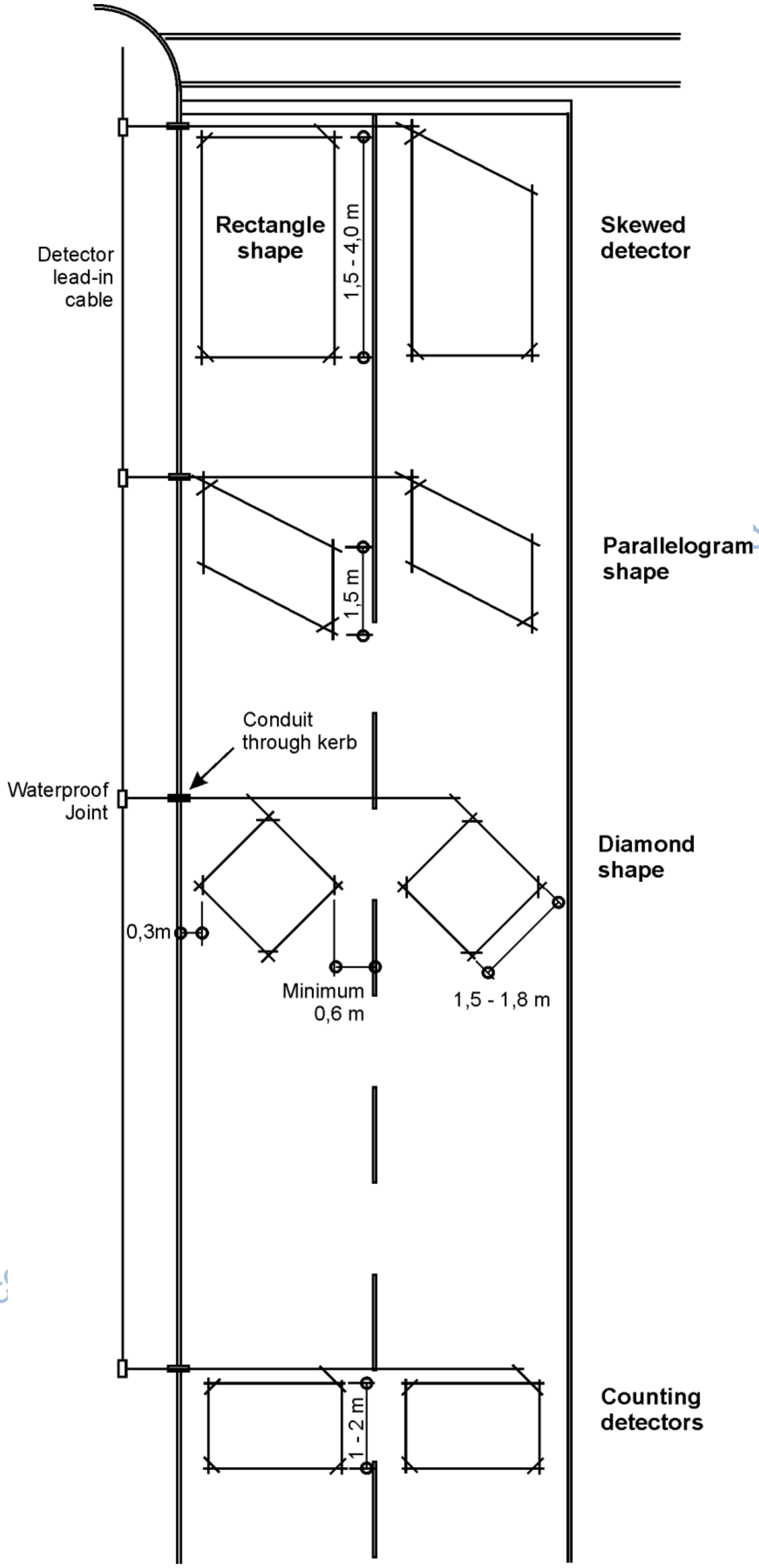


Figure 20.1: Inductive loop shapes and sizes

20.5.4 Loop installation procedure

1 Loops need to be properly and carefully installed to ensure trouble-free operation. The most common causes of failure are breakage of the wire or breakdown of the insulation, causing ingress of water and variations in resistance to earth and induction.

2 Great care should be given to ensuring that the slot is cut properly. The cut must be done at an even depth, particularly at corners where the cut must continue slightly beyond the end of the loop to accommodate the circular shape of the saw.

3 Slots should be cut in the road surface, using a diamond saw of suitable width. The slot should be free from any sharp edges that could damage the loop wire insulation and should be clean and dry before laying the loop. The use of compressed air to blow debris from the slot is highly recommended.

4 The wire should be laid in the slot without the application of undue pressure or force. Wire should not be pushed into the slot with a screwdriver or any other sharp instrument.

5 The loop wires and wire tails from the loop should be one continuous length of wire and joints should not be permitted. The wire tails are joined to the detector lead-in cable (DLC) and the joint should be encapsulated in a waterproof resin compound.

6 If there is a kerb, a hole must be drilled through or below the kerb and a conduit provided for the wire tails.

7 Loops at the same position from the stop line and connected to the same detector unit can be electrically connected in series (subject to a maximum limit that can be accommodated by the electronic circuit).

20.5.5 Prefabricated loops

1 Prefabricated loops can be used on roads that are subject to settlement or movement. The loops are prefabricated in a workshop and are installed as a single unit.

2 Various methods can be used for constructing such loops. These include the following:

(a) Installing loop wires in a 12 mm PVC conduit or pipe. All joints are sealed watertight.

(b) Encapsulating the loop wires in fibreglass. The loop is prefabricated on a frame and then wrapped with fibreglass fabric and treated with resin.

(c) Installing loop wires in a precast concrete slab of about 1,2 m square and 200 mm deep. An oversize hole is made in the pavement and the precast slab is installed with concrete backfill.

3 The slot for the prefabricated loop is made by making two saw cuts and chiselling out material between the two cuts.

20.6 BIBLIOGRAPHY

1 Institute of Transportation Engineers, 1997, Traffic detector handbook, Washington DC.

2 Institute of Transportation Engineers, 1985, Traffic detector field manual, Washington DC.

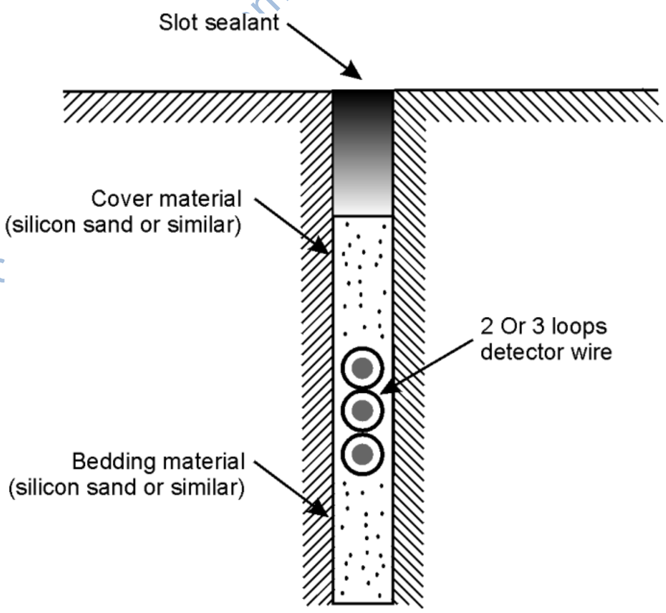


Figure 20.2: Inductive loop wire slot cut into the road surface

CHAPTER 21: AUTOMATED LAW ENFORCEMENT

21.1 INTRODUCTION

1 The intention behind traffic law enforcement is to enhance the level of safety experienced by road users. Automated law enforcement can be used to supplement the law enforcement programme of a road authority.

2 The technology exists to capture an image in digital format and transmit it to a central computer. The identification of the erring vehicle can be identified by a technique such as number plate recognition. It is also possible to automate the dispatching of legal notices to owners of vehicles.

3 Many violations cannot easily be detected by automated detection techniques. These include roadworthiness, alcohol limits, reckless driving, frequent lane changing, etc. Some violations, however, can be detected automatically and some of these can be incorporated as part of the traffic signal system.

4 Unfortunately, the very ease with which automated law enforcement can be applied, may tempt traffic officials to abuse or overuse the system and bring it into disrepute, particularly when the automated law enforcement is unbalanced in relation to other, non-automated, law enforcement efforts.

21.2 VIOLATIONS AT TRAFFIC SIGNALS

1 Violations at junctions include:

(a) Turning from the wrong lane, or changing lanes in the junction area.

(b) Entering the junction when it is not possible to clear the junction area.

(c) Travelling at high speed through the junction.

(d) Entering the junction in the face of a red light signal.

2 Most automated law enforcement systems are installed for the detection of the last-mentioned violation, namely red light running. This violation is a major problem and is probably one of the major causes of serious accidents at traffic signals.

3 It is also possible to install automated law enforcement to detect speeding offences. Excessive speeding at signalised junctions could be dangerous, perhaps more so than on the street sections between the junctions. Red light running and speed enforcement can be combined in the same set of equipment.

4 The other violations are more difficult to detect using automatic detection systems.

21.3 IMPLEMENTATION

1 The development and maintenance of standards for all equipment used for law enforcement in South Africa is the responsibility of the Technical Committee for Standards and Procedures for Law Enforcement. This committee operates under the auspices of the South African National Departments of Transport and Justice.

2 Equipment used for automated law enforcement must comply with an appropriate South African Bureau of Standards specification. Information on available specifications can be obtained from the South African Bureau of Standards. The following are a number of examples of standards that are available:

(a) South African standard specification SANS 1795-0: *Speed measuring equipment Part 0: General*. Specify mechanical, electrical and operation requirements for speed measuring equipment that is intended for traffic law enforcement and prosecution purposes.

(b) South African standard specification SANS 1795-3: *Speed measuring equipment Part 3: Distance-over-time measuring equipment (fixed distance/variable time)*. Specifications that measure speed over a fixed distance.

3 The committee also issues prosecution guidelines that should be adhered to in law enforcement actions. Failure to comply with these guidelines could result in the withdrawal of cases.

4 The SABS specifications and prosecution guidelines address issues such as the position and type of equipment, and the data required to ensure successful prosecution. For red light running violations, for instance, the photograph of the vehicle must clearly show the position of the vehicle in relation to the stop line, as well as the red light signal. The date and time of the incident should also be captured by the equipment.

CHAPTER 22: POWER SUPPLY

22.1 INTRODUCTION

1 Electrical power is essential at traffic signals for powering signal controllers, detectors, light signals and the central control system.

2 All electrical equipment in South Africa shall comply with the current requirements of:

(a) South African standard specification SANS 10142: *The wiring of premises*. A code of practice that covers general principles for the wiring of premises.

(b) South African standard specifications SANS 10199: *Design and installation of an earth electrode.* Covers methods used to earth electrical systems, including design, installation, testing and maintenance.

(c) Electricity Supply Commission (ESCOM) regulations and requirements.

(d) Any other requirements of the local authority.

22.2 ELECTRICAL REQUIREMENTS

1 A qualified electrician should properly test all electrical elements of a traffic signal installation. Wiring certificates stating that the tests have been successfully carried out should be signed by the electrician and kept on record.

2 All traffic signal components, including signal posts, should be properly earthed to an earth electrode or trench earth. This could even include components such as the door of the controller, by providing earth straps across the hinges. The preferred method of earthing is to run a bare copper conductor with the power supply cable in a trench (of relatively long length). Alternatively, earth spikes can be driven vertically into the ground in the trench bottom.

3 It is recommended that central control systems should be provided with an Uninterruptable Power Supply (UPS) unit with suitable capacity to ensure continued operation for a reasonable period, or until such time as emergency generator facilities can commence supply or full power is resumed.

4 At least one power socket should be provided within the controller cabinet to facilitate the operation of test equipment.

22.3 POWER SUPPLY CABLES

1 There are three distinct types of electrical cabling in traffic signal installations. They are:

(a) The mains power supply to the installation; the part up to the distribution board is usually provided by the electricity supply authority whilst the road authority is responsible for the part from that point to the controller.

(b) Cables connecting the signal lights to the controller. These are usually multi-core cables.

(c) Low voltage cables connecting inductive loop detectors to the detector units housed in the controller cabinet. Similar connections are provided for pedestrian push buttons.

2 During the installation of cables, provision should be made for some slack in the cables, particularly at the footing of each signal post, gantry, cantilever and the controller. Such slack is not only needed for maintenance purposes, but can also reduce the possibility of damage to the cable should a traffic accident occurs.

3 Joints in cables should be avoided as far it is practically possible. No jointed cable should be pulled or drawn through a cable duct.

4 All external cables and wiring should be shaped to provide a drip loop before entry into equipment. An example of such a drip loop is shown in Figure 22.1.

5 Multi-core cables are used for connecting light signals to a controller. Each signal group requires separate cores to power the green, yellow and red light signals. Two or three live cores are required per signal face for this purpose (two are required for two-aspect signal faces such as pedestrian signals). One common neutral core can be used for all signals. The total number of cores required at a signal can be calculated by means of the following formula:

Number of cores = $2+2\cdot N_2+3\cdot N_3$

In which N_2 is the number of signal groups serving two-aspect traffic signal faces (including pedestrian signal faces), and N_3 is the number of signal groups serving three-aspect signal faces.

6 The following additional number of cores are required when pedestrian push buttons are provided:

Number of cores for push buttons = $1+N_p$

In which N_p is the number of pedestrian signal groups.

7 The first formula given above, allows for one earth wire and one neutral wire in addition to the live wires required for each signal colour. The second formula allows for one neutral wire for push buttons.

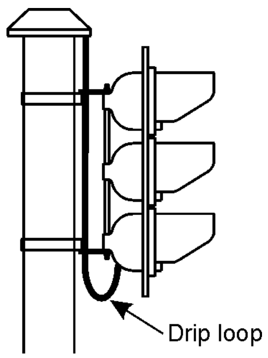


Figure 22.1: Drip loop on a power cable

8 Additional cores should be provided to allow for the possible expansion of signal groups in future. Where a turning phase is not currently provided, consideration can be given to providing an additional two or three cores for such purpose. Where pedestrian signals are currently not installed, additional cores may also be provided.

9 The method of cabling depends on the cost of cables and the type of cable held in stock by a road authority. Cables come in various sizes, such as 3-core, 4-core, 7-core, 12-core, 19-core, 27-core and 37-core.

10 The cabling method also depends on the junction layout as well as the cable ducts available at a junction. When a road is newly constructed, ducts should preferably be provided across all legs of a junction.

11 Different cabling methods have been developed and are used, such as the ring and radial systems. In the ring system, only one main core is used for all light aspects of a specific colour in one signal group. The main core is laid in a ring around the junction or crossing, and branch cores are used to provide power to individual light signals. In the radial system, a main core is used for each individual light signal – all branching occurs from the controller.

12 The ring system has the disadvantage that damage of the main core could cause the entire installation to be out of operation. The radial system, while more costly to implement initially, has considerable maintenance and functional advantages.

22.4 TRENCHING AND DUCTING

1 Cables should be installed underground, for both operational benefits and aesthetic reasons.

2 All cables laid across roads and other paved areas should preferably be laid in ducts terminating in draw boxes. One or two ducts should be provided depending on the number of cables to be installed (also taking possible future requirements into account). An example of the provision of ducts and draw boxes at a junction is shown in Figure 22.2.

3 Cables should be pulled through the ducts manually and no mechanical means should be used for this purpose. Dry talc may be used to lubricate cables for pulling (grease should not be used).

4 A suitably marked yellow PVC or polythene *marker tape* may be laid in all trenches above the cables as a safety measure.

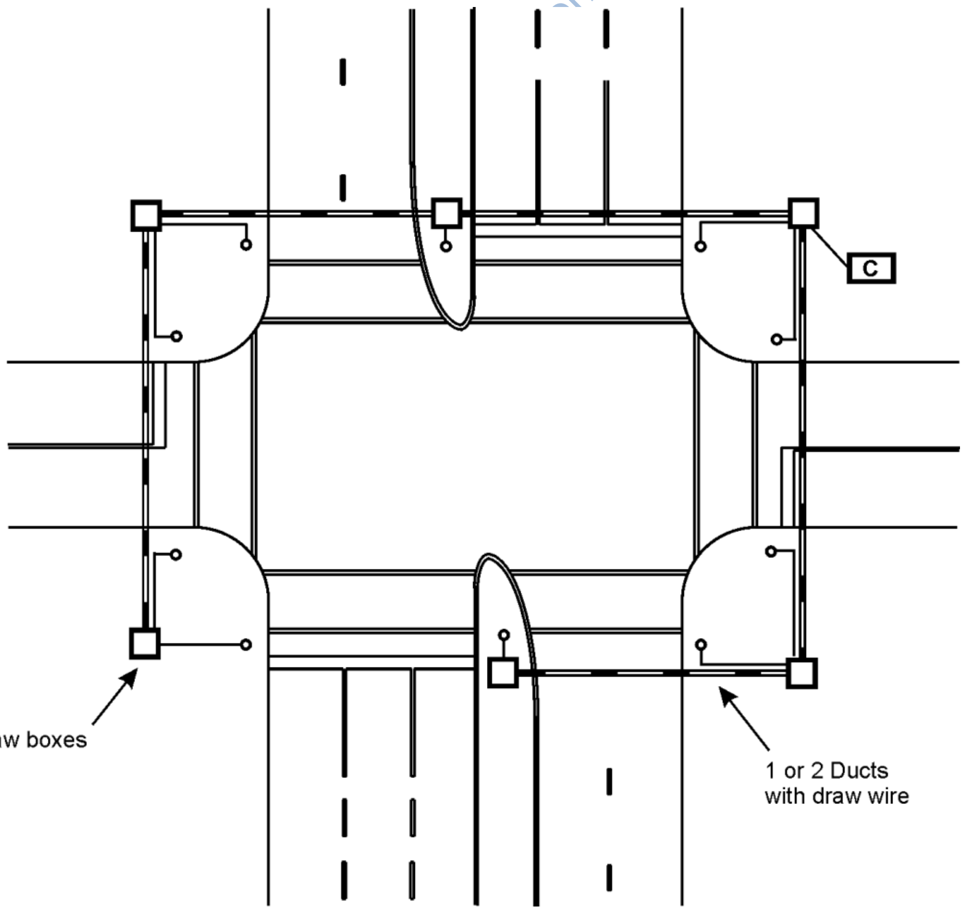


Figure 22.2: Example of duct and draw box layout at a junction