Code of Practice
Traffic Control at Work Zone

February 2018 Edition

Land Transport Authority

Code of Practice for Traffic Control at Work Zone

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This edition of the Code of Practice was prepared by the Committee for Traffic Control at Work Zone, and acted upon by the Deputy Director, Road Asset Regulation & Licensing Department. It comes into effect in June 2006 and supersedes all previous editions.

Clarifications on any aspect of this Code of Practice may be made with the Land Transport Authority, Singapore.

Origin and Development of Code of Practice for Traffic Control at Work Zone

Conflicts between traffic and works on or next to the road are inevitable. It is important to reduce such conflicts to optimise work efficiency and traffic safety, and to minimise traffic congestion, delay and inconvenience to road users. The first Code of Practice for **Temporary Traffic Control**, published in June 1998 dealt with the specific work area in the carriageway and its corresponding traffic control arrangement. This proved to be useful in providing contractors with typical temporary traffic control arrangement but inadequate when major temporary traffic schemes are involved.

In June 2001, the Code of Practice for **Traffic Control at Work Zone** was published to provide those involved in all forms of construction activities within the road reserve with a comprehensive guide to temporary traffic control. The Code not only explains the fundamental principles for the provision of good traffic control but also gives a detailed guide on planning and designing the traffic control plan.

After more than 4 years since publication, the Committee had been tasked to review the Code of Practice with the main objective of making the Code more user friendly and also to make general improvement. The revised Code of Practice for **Traffic Control at Work Zone** is now contained in one book with 5 Chapters covering topics from planning to operations of temporary traffic control in a work zone.

The revised edition includes worked examples of a temporary traffic control plan and examples of approved traffic control plans that have been used. New traffic control devices that have been introduced into the industry are also included in the revised Code. The sections and appendices have also been rearranged for ease of use.

Although the Code does not cover every possible situation, the emphasis is nevertheless on *safety first* under any situation. The safety philosophy for carrying out works on public streets is aptly epitomised by the maxim: “It is the works that should adapt to the traffic conditions whenever and wherever possible and not for the traffic to adapt to the convenience of the works!”

It has been assumed that the execution of the provisions in this Code is entrusted to suitably qualified and experienced people, for whose guidance it was prepared. Always consult a qualified person about the provision of temporary traffic control. In situations where the qualified person needs clarifications, he shall seek advice from the Authority.

Compliance with this Code of Practice does not of itself confer immunity from legal obligations.

This Code of Practice on Traffic Control at Work Zone is issued by the Land Transport Authority under Regulation 12 of the Street Works (Works On Public Streets) Regulations 1995. It deals with the standards, procedures and other requirements pertaining in particular to paragraph 2(a) of Regulation 12 for carrying out works on public streets.

LAND TRANSPORT AUTHORITY

Contents

Chapter 1 Introduction

1-1 Scope

1-1.1 This Code of Practice sets out the standards and procedures for **Temporary Traffic Control** when carrying out works on public streets. It gives practical guidance to users of the code when implementing temporary traffic control needed to do work on public streets and road related facilities. Work activities include but are not limited to bore-hole exploration, excavation, construction, maintenance, utility works and stationing associated construction vehicles and equipment.

1-1.2 This code is **not** intended to prohibit the use of new method or devices. Provided, sufficient technical data is submitted to the Authority to demonstrate that the new method or device is equivalent in quality, effectiveness, durability, and safety to that specified in this code.

1-2 Objectives

1-2.1 The **primary objective** of temporary traffic control is to manage the traffic as efficiently and safely as possible under all work conditions.

1-2.2 Traffic control aims to give adequate warning and clear information to motorists about the nature of works on site. This will translate into correct actions required in order to pass the work site safely. Traffic control shall also include measures to safeguard pedestrians when necessary. Proper traffic control also protects those who are directly involved in carrying out the works.

1-2.3 The provision of proper traffic control ensures compliance with legal obligations. Some of which are:

1) BOWEC Regulation 4 (1999 Ed) — Employer's and contractor's safety obligations.
2) Road Traffic Act Section 119 — Power to place traffic signs on public streets.
3) Road Traffic Act Section 115 (Chapter 276) Part VI — Provisions as to the use of highways.
4) Road Traffic (TRAFFIC SIGNS) Rules (1990) — Prescribed traffic signs placed on or near any roads.
5) Street Works Act 1995 Section 17 — Power to control works on public streets.
6) Street Works (Works on Public Streets) Regulations 1996 — Application and approval to work on public streets for any person other than the Authority.

Full texts of the relevant Act & Regulations are listed in **Appendix I**.

1-3 Application

1-3.1 This Code of Practice applies to the Land Transport Authority, all utility agencies/departments, contractors and other service providers who are involved in work on public roads and road related facilities.

1-3.2 Works on public streets within the Mass Rapid Transit (MRT) Railway Protection and Railway Safety Zones shall not be carried out without clearance from Development & Building Control Department of the Authority at 251 North Bridge Road, Singapore 179102.

1-3.3 It is obligatory to apply for approval to work in the Central Expressway (CTE), Kallang Paya-Lebar Expressway (KPE) and Marina Coastal Expressway (MCE), Fort Canning and Woodsville tunnels or on roads or expressways installed with the Expressway Monitoring and Advisory Systems (EMAS), TrafficScan, Junction Eyes or GLIDE system. Application forms are available from the Integrated Transport Systems Control Centre at 181 River Valley Road, Singapore 179034.

1-3.4 Approval shall be obtained from the various departments in LTA for carrying out road opening works on public

streets. All applications shall be made on prescribed forms to the Road Asset Regulation & Licensing Department at 71 Chai Chee Street, Block 1 #03-00, Singapore 468981.

1-3.5 Besides this Code, anyone who carries out works on public streets shall also be aware of and comply with the relevant requirements stipulated in other rules, regulations and codes of practice of the Authority.

1-4 Improvement Process

1-4.1 The standard of traffic control and road safety shall be improved continually to meet the rising expectations of road users. The process involves a continuous cycle of activities shown in the following diagram and further explained below:

Improvement process- a continuous cycle

(1) **Set New Standards**: Set standards against international practices by drawing from the experiences of developed countries.
(2) **Education**: Ensure that all personnel involved in traffic control and road safety has knowledge that is equal to their responsibility. Educate road users on traffic control and road safety measures.
(3) **Implementation**: Making the Code contractually binding by developer/contractor's client would ensure successful implementation.
(4) **Auditing**: Appoint an independent and qualified person to review the design and execution of the traffic control scheme. This is to ensure correct and consistent practice at different sites.
(5) **Evaluation and Review**: Evaluate and review current practices continually to correct mistakes and improve standards.

1-5 Definitions.

For the purposes of this Code of Practice, the following definitions apply unless the context otherwise requires:

"approved", in relation to this Code of Practice, means approved by the Authority.

"Authority" means the Land Transport Authority of Singapore established under the Land Transport Authority of Singapore Act 1995.

"carriageway" means that part of the road inclusive of any shoulders constructed for use by vehicular traffic.

"Peak hours" means the traffic peak hours specified by the Authority under clause 6.10.1 of Code of Practice for Works on Public Streets, which include the hours from Monday to Saturday, 6.00am to 9.30am and from 5.00pm to 8.00pm. A listing of roads with different traffic peak hours is available on LTA.PROMPT system via URL – https://prompt.lta.gov.sg and will be updated from time to time.

"Professional Engineer" means a person who is a registered engineer with a valid practising certificate in the relevant discipline under the Professional Engineers Act.

"qualified supervisor" means a full-time site personnel who possesses a Certificate in Pavement Construction and Maintenance issued by the Building and Construction Authority.

"road" means public street as defined in the Street Works Act 1995 or any part thereof as implied by the context.

"traffic control" means the process required to regulate, warn and guide road users and advise them to traverse a section of a road in the proper manner.

"traffic control devices" means the signs, cones, barriers, flashing lamps or other devices placed temporarily on or adjacent to a road to regulate, warn, or guide road users.

"work zone" means the entire section of the road over which temporary traffic control related to the work activity is exercised.

"worksite" means the space where the work is taking place and where the workers, equipment and material storage are confined.

"detour" means traffic is directed to another road to bypass the closed area.

"diversion" means traffic is directed to a temporary road or lane placed in or next to the carriageway.

"road related facility" includes any traffic sign, directional sign, street name sign, traffic light, bus shelter, railing, lighting apparatus and any optical, electronic, communication, monitoring or computerised equipment necessary for the control and management of traffic, and any other road related structure and facility maintained by the Authority.

Chapter 2 Fundamental Principles of Traffic Control

2-1 General.

2-1.1 This Chapter elaborates on the fundamental principles in ensuring that a good and proper traffic control system is provided in a work zone. It is not possible to provide standards and applications to cover all conditions. Therefore a good understanding of the 9 fundamental principles stated in sections **2-2** to **2-10** is essential. Complying with the fundamental principles shall take precedence over standard details and typical applications.

2-2 Safe Road Environment

2-2.1 Safe passages should be provided for both motorists and pedestrians going through the work zone. This can be achieved by:

(1) *Warning* road users in advance of changing road environment;
(2) *Informing* road users of the condition to be encountered;
(3) *Guiding* road users through unusual sections of road;
(4) *Controlling* road users at conflict point**;** and
(5) *Forgiving* road users' mistakes when accidents happen.

2-3 Minimum Risk

2-3.1 Risks for road users going through the work zone can be mitigated by ensuring:

(1) No surprises;
(2) No hidden traps;
(3) Free of unforgiving hazards;
(4) Controlled release of information;
(5) Consistent messages and repeats if necessary to reinforce; and
(6) Good visibility under all road conditions.

2-4 Planning Ahead

2-4.1 Traffic control requirements at work zones shall be planned in advance in the following phases:

(1) *Planning and Design Phase* — To identify and incorporate traffic control requirements into contract specification.
(2) *Start of Construction Phase* — To integrate traffic control into the construction planning processes.
(3) *Start of Every Major Phase* — To re-examine and adjust traffic control scheme to suit prevailing site condition.

2-5 Good Traffic Control Plan

2-5.1 Traffic Control Plan (TCP) can be designed effectively by:

(1) *Designing traffic control plan in advance* — To develop the TCP in detail at the beginning of each of the phases stated in **2-4**.
(2) *Complying with basic design principles of permanent roads* — The road provided in the work zone should be similar to that of a normal road.
(3) *Exercising sound engineering judgement* — To take into consideration the unique characteristics of each work site.

2-6 Effective Traffic Control Devices

2-6.1 Traffic Control Devices (TCD) should be designed, placed, operated and maintained effectively to meet the basic requirements of:

(1) Warning, informing and guiding road users;
(2) Commanding the attention of road users to the devices;

(3) Conveying a clear and simple message;
(4) Commanding the respect of road users so that they will obey instructions; and
(5) Allowing adequate time for road users to respond in an orderly and predictable manner.

2-7 Trained Personnel

2-7.1 By ensuring that only qualified Traffic Engineer and competent persons are involved in traffic control.

(1) Appointment of a person with authority to control the progress and to be overall in-charge;
(2) Training of site supervisors who are already conversant with safe methods of work in traffic control. Site supervisors should be appointed to supervise the selection, placement, operation, maintenance and removal of the traffic control devices; and
(3) Training of workers to be fully conversant with safe methods of placing, operating, maintaining and removing devices on the road.

2-8 Workers Safety

2-8.1 Workers are to be protected from the hazards of working in the work zone. This can be achieved by:

(1) Training all workers on the basics of road safety;
(2) Informing motorists of the workers' presence through traffic signs and such;
(3) Placing continuous barricades along workspace to separate workers from traffic. This will also prevent workers from straying into traffic space during work;
(4) Providing appropriate means for workers access when entering or leaving the work zone especially along high-speed roads;
(5) Placing temporary safety barriers to protect workers from vehicular traffic;
(6) Reducing vehicular speed if necessary for the safety of workers and road users;
(7) Providing proper lighting for night work so that the work site is visible at night for the safety of workers and road users. However, the lights used shall not be blinding to motorists;
(8) Providing a lead vehicle to warn oncoming traffic and to shield workers. To shield workers and divert traffic with a shadow vehicle; and
(9) Providing workers with high visibility clothing so as to be more conspicuous and visible by day and night.

2-9 Pedestrian Safety

2-9.1 The following provisions shall be made to separate the pedestrians from work-site activities and adjacent traffic:

(1) Advance information signs to direct pedestrians to a safe road crossing;
(2) A smooth and clearly delineated path similar to a normal footpath;
(3) A well lit covered walkway to protect pedestrians from falling debris, especially during long-term work;
(4) Continuous barricades to keep pedestrians from interference with the work activity thereby preventing accidents;
(5) Continuous barricades to separate pedestrians from traffic and prevent accidental encroachment; and
(6) Watchmen, temporary traffic control devices and/or audible-warning devices to control the movement of works vehicles and equipment across pedestrians' way.
(7) Provisions for barrier-free access along a footpath/walkway affected by the works. The contractor shall ensure that the same provisions are made along the temporary footpath/walkway affected. The footpath should never be less than 1 m wide, and whenever possible should be at least 1.5 m.

2-10 Vehicles and Equipment Safety

2-10.1 All vehicle and equipment used on site shall not be a safety hazard to both road users and workers. Safety can be assured by:

(1) Controlling work traffic by providing portable traffic signals;
(2) Controlling parking by providing safe designated parking space for work vehicles, plants and equipment within work site to prevent them from causing obstruction to others;
(3) Improving conspicuous of the vehicles/equipment and to alert road users by displaying revolving amber lights whenever vehicles or equipment are in operation;
(4) Inspecting TCDs regularly by using a Safety Inspection Vehicle loaded with additional devices to replace damaged devices;
(5) Fitting all protective vehicles with Truck Mounted Attenuators (TMA) and large arrow panel with amber lights;
(6) Providing recovery/service vehicle to remove stalled vehicles immediately; and
(7) Installing Video or Sky Cameras where necessary to monitor traffic conditions effectively and provide real-time information on the effects of roadwork on traffic.

2-11 Road Surface Condition

2-11.1 As part of a traffic control layout, there will be occasions when areas of carriageway are brought into operation that would not normally be used. The adequacy of these temporary surfaces should be considered before use. In particular, the effect on traffic of the following should be borne in mind:

(1) cross falls on chevron areas;
(2) drain covers in hard shoulders and in central medium at crossovers;
(3) clearances if traffic runs on edge strengthening;
(4) the need to sweep the surface of steel decking or road and provide good skidding resistance.

2-11.2 The effect on carriageways of carrying unexpected traffic loads also needs to be considered (e.g. drain covers on the hard shoulder may need to be strengthened). There is also a need to provide a regular maintenance regime to reduce incidents during wet weather periods.

Chapter 3 Planning and Design of Traffic Control Plan

3-1 General.

3-1.1 Traffic control at work zone starts from the first advance warning sign and ends at the last traffic device where traffic returns to normal. This Section provides guidelines for the traffic engineer to plan and design the Traffic Control Plan (TCP).

3-1.2 TCP ranges from being very detailed and customised (An example is given in **Appendix IV**), to a mere reference to a typical drawing(s) in this Code or specified drawings contained in contract documents.

3-1.3 Traffic control requires forethought and provision shall be included in the contract specification for the contractor to develop the TCP.

3-2 Phases of Traffic Control

3-2.1 There are five phases of traffic control for major project and complicated work on roads.

(1) **PLANNING PHASE** — To identify and include traffic control requirements in the contract specification, works program & method of construction.

(2) **DESIGN PHASE** — To design the TCP in detail, with regards to types, location and layout of traffic control devices for submission to the authority for approval.

(3) **IMPLEMENTATION PHASE** — To install the temporary traffic control devices safely in accordance with the approved TCP.

(4) **OPERATION AND MAINTENANCE PHASE** — To inspect the TCP and devices regularly by day and night to ensure that they are effective and absolutely safe.

(5) **CLOSE OUT PHASE** — To remove all the traffic control devices safely and reinstate the permanent traffic scheme.

3-3 Planning for traffic Control

3-3.1 The purpose of planning is to: —

(1) Select an appropriate traffic control scheme at planning and design stage for incorporation in the contract specifications.

(2) Integrate the works program, the method of construction and the traffic control scheme, as they are closely interrelated.

(3) Enable the contractor to integrate traffic control into the planning process before work starts.

(4) Enable the contractor to review the plan before the start of each major phase of work.

3-3.2 Planning normally involves the 8 following steps (see flowchart 3.1): -

(1) **Assemble data** — A detailed understanding of the scope of works, method of construction and road/traffic data, shall be required.

(2) **Study roadway occupancy** - The following information are needed when assessing traffic control requirements:-

(a) Duration of works affecting the road.

(b) Carriageway space occupied by the work.

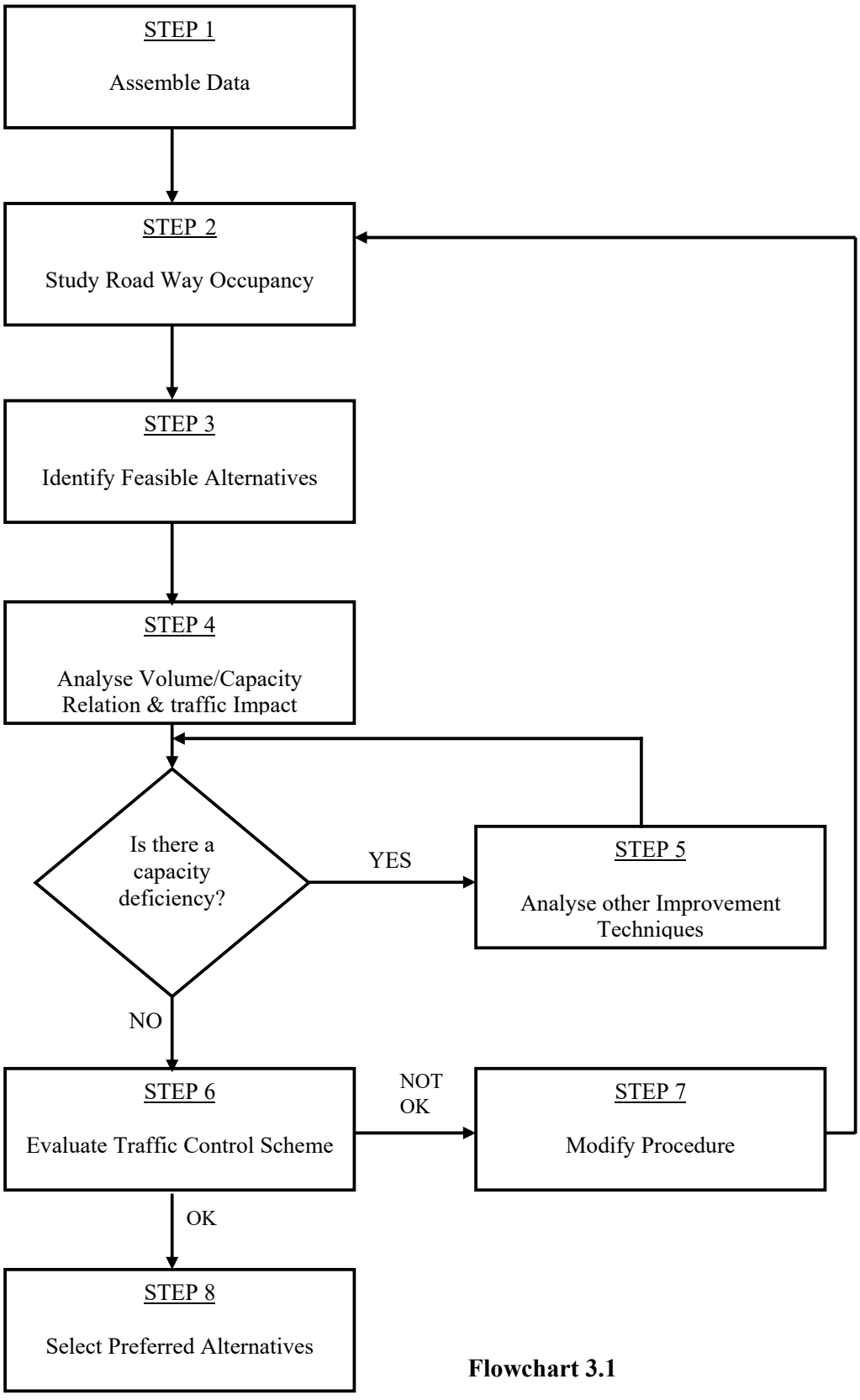
(c) The area occupied by the work at any one time or day.

(d) The numbers of hours that work affect the road.

(3) **Identify feasible alternatives** — Choose the traffic control scheme appropriate for the work zone. There are 8 typical traffic control schemes for work on existing road as shown below: -

(a) *Lane Constriction* — To reduce the lane width to 3.3m (min) for expressway and 3.0m (min) for other roads temporarily. Consideration should be given to providing a wider lane width at tight bends and horizontal curve.

Planning Flowchart



Flowchart 3.1

(b) *Lane closures* — To reduce the number of lanes temporarily.
(c) *Share right-of-way* — To operate with the same lane as two-way traffic with "stop and go" traffic control on a single carriageway road.
(d) *Median crossover* — To divert traffic from one carriageway to the other of a divided road via a paved median or emergency gate etc.
(e) *Detour* — To divert traffic to other existing road.
(f) *Temporary by-pass/diversion* — To divert traffic to a temporary road.
(g) *Intermittent Closure* — To stop traffic passing through the road intermittently.
(h) *Use of Shoulder or Median* — To divert traffic to the road shoulder of expressway or paved median.

(4) **Analyse volume/capacity relation & traffic impact** — The ability to cope with the traffic demand is a basic requirement of a feasible traffic control scheme.

(5) **Analyse other improvement techniques** — Propose other measures that can be used to overcome traffic problem. Such as: -
(a) *Off-peak works* — allow work only at off-peak hours.
(b) *Night works* — allow work only at night when the traffic is lighter.
(c) *Remove parking* — prohibit roadside parking temporarily.
(d) *Reschedule works* — defer work to a suitable time later.
(e) *Weekend work* — allow work on weekends only, when traffic is lighter.
(f) *Reversible lane* — provide tidal flow of traffic lanes to increase road capacity at peak hour demand.
(g) *Restrict turning* — prohibit certain turning movements at a road junction.
(h) *Modify signal time* — change the phasing time of a traffic signal.

(6) **Evaluate traffic control schemes** — Compare the impact of the alternatives in terms of: -
(a) *Vehicle delay and stop* — increase in operation cost and delay to road users.
(b) *Safety and accidents* — increase medical and social costs due to higher risk to workers and road users.
(c) *Project and traffic control cost* — increase contract period and contract sum on employers/client.
(d) *Air pollution and business losses* — environmental pollution and losses in business due to work etc.

(7) **Modify Procedure** — Review design and work procedure to determine the need for alternative construction methods or procedure to reduce the impact.

(8) **Select preferred alternatives (traffic control schemes)** — Identify the preferred traffic control schemes for each stage of the work.

3-4 Design Considerations

3-4.1 Design shall start after preferred temporary traffic control scheme has been selected for each stage of the work. Important design consideration shall include the following:

(1) Work Duration
(2) Road Speed
(3) Road Type
(4) Road Locations
(5) Work Location
(6) Traffic Condition
(7) Type of Work
(8) Type of Operation
(9) Position of the construction site access.

3-4.2 **Work duration** refers to how long the work takes to complete. It is important because risk is proportional to the exposure time and the degree of injury, and hence influences the choice of devices. Simplified TCP and portable devices shall be used for shorter duration work to minimise the time motorists are exposed to road works and workers exposed to the traffic. Detailed TCP with better and elaborate devices shall be used for longer duration work (long-term and short-term) as there is ample time to install them. And benefits can be derived from the use of full range of devices. Duration is divided into :

(1) *Long Term* > 7 days.
(2) *Short term* — from overnight to 7 days.
(3) *Short duration* — up to 12 hrs or less than a day's shift.
(4) *Short duration mobile* — works that move intermittently or continuously.

3-4.3 **Road speed** determines the design of the TCP. Permanent road design standards shall apply to temporary road design. Traffic diversion and detour shall be provided with suitable road geometry. *Detour* usually means traffic is directed to another road to bypass the closed area. *Diversion* means traffic is directed to a temporary road or lane placed in or next to the right-of-way. The geometric design elements are summarised in Tables **3.1, 3.2, 3.3** and **3.4.** The design speed limit in the work zone should not fall below more than 20 km/hr of the existing permanent gazette speed limit.

3-4.4 **Road Type** refers to the hierarchy of roads in Singapore. Roads are classified in accordance with the planning and building control requirements.

(1) *Expressway* — Major road for continuous, high speed, high volume and long distance travel.
(2) *Semi*-expressway – Major road built for distributing traffic between residential, industrial and business areas to complement expressways.
(3) *Arterial* — Major road for distributing traffic between residential, industrial and business area etc. major arterial and minor arterial are to complement expressways.
(4) *Primary Access* — Minor road for distributing traffic within local area.
(5) *Local Access* — Minor road for direct access to buildings and land within local area.

3-4.5 Important characteristics of roads are summarised in Table **3.5**.

3-4.6 **Road Location** determines the types of road-related facilities and traffic control measures to be provided for the road users. The important considerations of locations are: -

(1) Local traffic
(2) Pedestrian volume/movement
(3) Local business
(4) Bus stop locations
(5) Parking facilities (roadside, etc)
(6) Access to properties/buildings
(7) Vehicles stopping

3-4.7 The locations as stated above can be differentiated by the following types: -

(1) **Public Housing** — has more road-related facilities and more commuters.
(2) **Private Housing** — has very few facilities and low pedestrian volume, but many property accesses.
(3) **CBD** — has more road-related facilities and heavy pedestrian volume during office hours.
(4) **Industrial Areas** — have special provision during working hours.
(5) **School Zones** — have special provision for school children during school peak.

3-4.8 **Work Location** determines the design of the TCP in guiding drivers through the obstruction safely and how work access and work traffic are being controlled. Work on the fast lane is hazardous due to higher speed of vehicles while work on the middle lane will result in an island situation. Where possible, access on the fast and intermediate lanes should only be done as a last resort. As far as possible, access points should also not be located after the inside of a bend

with limited forward sight visibility or immediately after the junctions. Typical work locations are as shown in Table **3.6**.

Geometric Design Tables *

Table 3.1 : Horizontal Alignment							
Design Parameter	Symbol Units	Recommended Boundary Values					
1	2	3	4	5	6	7	8
Design Speed	V_D, Kph	90	80	70	60	50	40
Desirable Minimum Radius	R_s, m	355	270	195	145	95	65
Absolute Minimum Radius	R_n, m	340	255	185	135	90	60
Desirable Maximum Superelevation(%)	e_a, %	5	5	5	5	5	5
Desirable Minimum Superelevation(%)	e_t, %	6	6	6	6	6	6

Note: Please read in conjunction with the latest COP on LTA Civil Design Criteria.

Table 3.2 : Minimum Sight Distances							
Design Parameter	Symbol Units	Recommended Boundary Values					
1	2	3	4	5	6	7	8
Design Speed	Kph	90	80	70	60	50	40
Stopping Sight Distance	Ds, m	145	120	95	75	55	40
Intermediate Sight Distance	2Ds, m	-	-	-	150	110	80
Overtaking Sight Distance	Do, m	-	-	-	300	200	150

Note: Sight Distance is for a level road or where the road gradient is less than 2 percent.
Intermediate Sight Distance is only applicable to undivided 2-way road (single lane each way).
Overtaking Sight Distance is only applicable to undivided 2-way road (single lane each way).

* : The values in the relevant latest Geometric Design Tables in LTA Code of Practice on Civil Design Criteria shall take precedence over the values in the Tables of this Code.

Geometric Design Tables (Cont.')

Table 3.3 : Downgrades Stopping Sight Distance							
Design Parameter	Symbol Units	Recommended Boundary Values					
1	2	3	4	5	6	7	8
Design Speed	Kph	90	80	70	60	50	40
Downgrade Gradient	-2%, m	145	120	95	75	55	40
Downgrade Gradient	-4%, m	150	125	100	75	60	40
Downgrade Gradient	-6%, m	155	125	100	80	60	45
Downgrade Gradient	-8%, m	-	-	-	80	60	45

Table 3.4 : Upgrades Stopping Sight Distance							
Design Parameter	Symbol Units	Recommended Boundary Values					
1	2	3	4	5	6	7	8
Design Speed	Kph	90	80	70	60	50	40
Upgrade Gradient	+2%, m	140	115	90	70	55	40
Upgrade Gradient	+4%, m	135	110	90	70	55	40
Upgrade Gradient	+6%, m	135	110	90	70	55	40
Upgrade Gradient	+8%, m	-	-	-	70	55	40

Table 3.5 : Road Characteristics						
Types	Expressway	Semi-Expressway	Major Arterial	Minor Arterial	Primary Access	Local Access
Desirable Speed (km/h)	90	80	70	60	50	50 to 40
Access Control	Full	Restrictive	Restrictive	Partial	None	None
Junction	Grade Separated	At grade or Separated	At grade or Separated	At Grade	At Grade	At Grade
Shoulder	Yes	Yes	No	No	No	No
Stopping/ Waiting	No	Restrictive	Restrictive	Restrictive	Yes	Yes
Parking/ Driveway	No	No	No	Restrictive	Restrictive	Yes

3-4.9 **Traffic Condition** refers to road capacity and traffic demand. Traffic condition will determine the need for temporary lane closure, road widening and/or traffic diversion. The two basic conditions are:

Traffic Condition I
Traffic demand is always less than road capacity.
Closure of lane will not cause road congestion.
Works shall be allowed to proceed in all traffic flow conditions.
Lane closure may be allowed for long-term works.

Traffic Condition II
Traffic demand at peak is equal to or higher than road capacity.
Closure of lane will cause serious road congestion.
Works shall be allowed to proceed only when demand is less than the available carriageway's capacity.
Temporary road widening or traffic diversion is required before works are allowed to remain in all traffic flow conditions.

3-4.10 **Type of Work** refers to the ability to suspend the work in progress and remove the obstruction quickly when traffic congestion has reached an unacceptable level. The two basic types of works are:

Work Type I
Work can be suspended and obstruction can be removed quickly.
Traffic can be restored to normal condition once the obstruction has been removed.
Simple planning would suffice

Work Type II
Work **cannot** be suspended and obstruction **cannot** be removed quickly.
Traffic can be restored to normal condition once the obstruction has been removed.
Detailed planning shall be needed before site possession.

3-4.11 **Mode of Operation** refers to the need for workers' presence in operating the traffic control plan. There are basically two modes of operation and the choice of devices is related to it in the following ways:

Mode I
Operates only when work is in progress and workmen are in attendance.
Workmen can reinstate the devices that have been displaced.
Simple/ portable devices should be used.

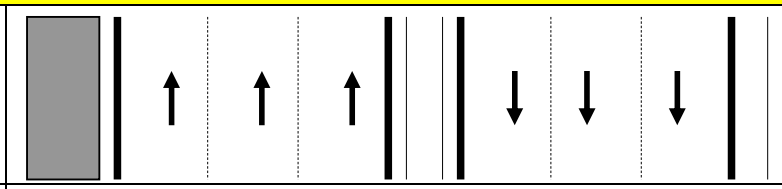
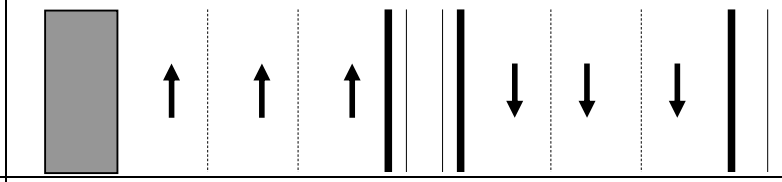
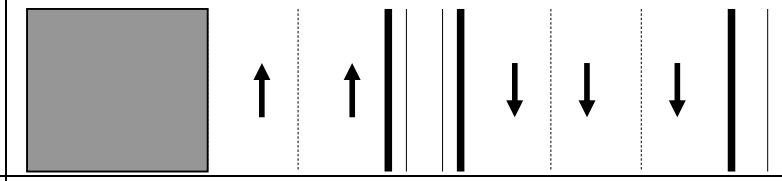
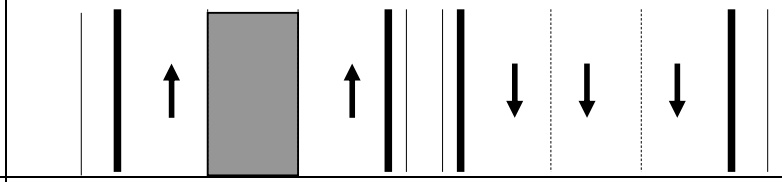
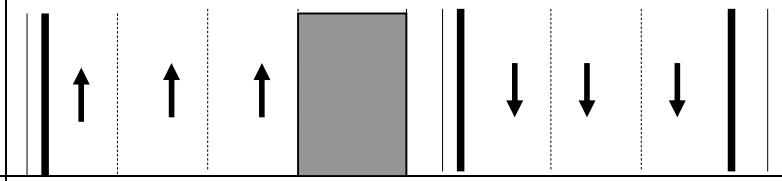
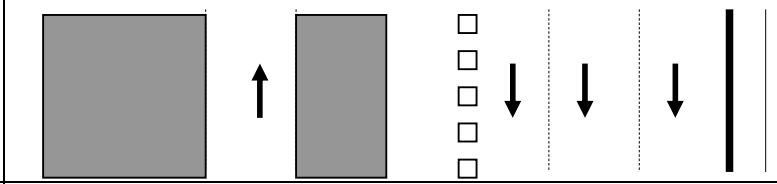
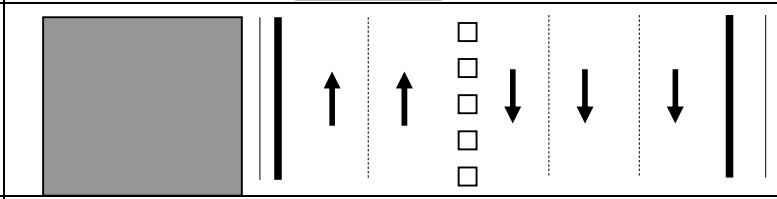
Mode II
Operates day and night and would be left unattended.
Devices that are displaced could be dangerous to motorists.
Devices used should be sufficiently robust and placed clear of the traffic lanes to prevent them from being buffeted by passing vehicles.

3-5 Design Process

3-5.1 Work Zone is typically subdivided into four zones, ADVANCE WARNING ZONE, TRANSITION ZONE, ACTIVITY ZONE and TERMINATION ZONE, each serving different functions as shown in Figure **3.1.**

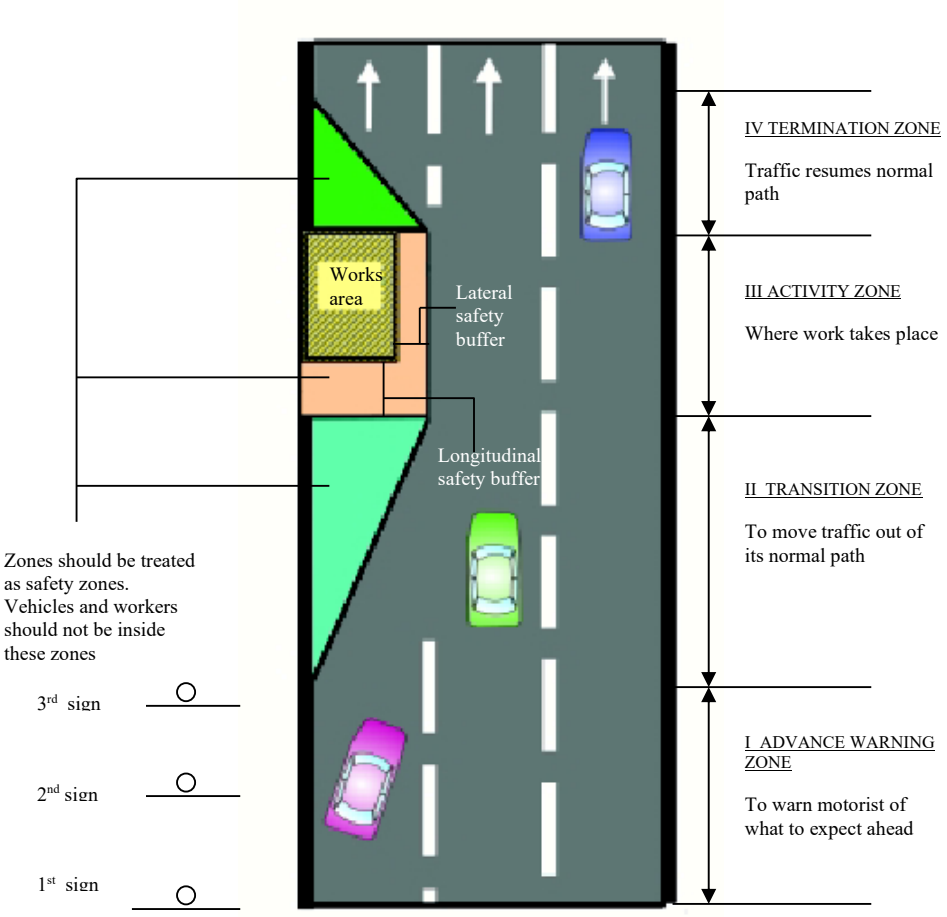
3-5.2 Design of a traffic control plan normally follows the sequence as shown below: -

(1) ACTIVITY ZONE
(2) TRANSITION ZONE
(3) ADVANCE WARNING ZONE
(4) TERMINATION ZONE

Table 3.6: Typical Lane Closure and Location of Work	
OUTSIDE / NEAR CARRIAGEWAY	
SHOULDER	
LEFT LANE	
INTERMEDIATE LANE	
FAST LANE	
MULTI LANES	
MEDIAN	
ENTIRE CARRIAGEWAY	
JUNCTION OR INTERCHANGE	Design by Engineer to suit the site condition accordingly.

Closed Lane and Work Area

Figure 3.1 Components of a Work Zone



3-5.3 **Designing the Activity Zone.** The Activity Zone comprises the following components (shown in Figure **3.2**):

(1) **Work Area** – Area occupied physically by the works.

(2) **Work Space** — Space set aside around the works area for workers, equipment and material. Method of construction will determine the space needed for the work.

(3) **Traffic Space** — Area where traffic is routed through the activity area. Traffic space must be properly delineated and channelled to guide traffic through safely. Road capacity and traffic demand will determine the width of the traffic space.

(4) **Safety Buffer** — Space separating traffic space from workspace. No storage of equipment and material, parking of vehicles, or presence of worker (except maintenance activity) is allowed for the safety of the workers and road users. It allows an errant vehicle to stop in time before hitting the workspace. The two types of safety buffers are the longitudinal safety buffer and the lateral safety buffer.

(a) **Longitudinal safety buffer** is a space upstream of a workspace. The recommended dimensions are as shown in the Table **3.7.**

(b) **Lateral safety buffer** is to separate workspace from traffic space. The recommended dimensions are as shown in Table **3.8.**

Figure 3.2 Components of an Activity Zone

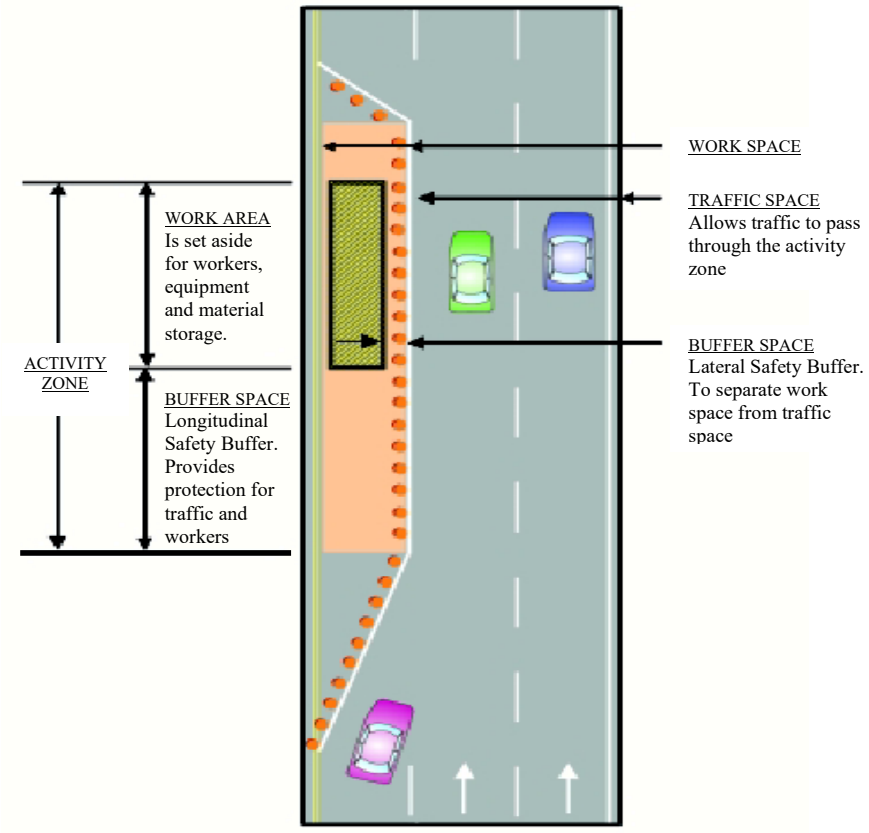


Table 3. 7 : Longitudinal Buffer	
Speed (km/h)	Length (m)
=> 80	60
70	30
60	20
50	10
40	10

Table 3. 8 : Lateral Buffer		
Speed	Minimum Width (m)	
Km/h	Desirable	Absolute
=> 80	1.2	0.6
70	0.9	0.6
60	0.5	0.3
50	0.5	0.3
40	0.5	0.3

3.5-4 Shadow vehicles are considered hazardous and the same safety buffers are recommended to protect road users.

3.5-5 Typical cross-sections of activity zone shown in Figures **3.3** to **3.6** will assist the engineer in the design of an activity zone.

3-5.6 **Designing the Transition Zone.** A transition would be required when traffic is redirected from a normal path to a new path. A suitable taper length and geometry should be provided to meet the requirements of the design speed. The recommended lengths of various types of taper are shown in the table **3.9**.

3-5.7 The definitions of the tapers (shown in Figure **3.7**) referred to in the above paragraph are: —

(1) **A Merging Taper** — used where two lanes merge into one lane. It needs a longer distance for the drivers to adjust their speed to merge with an adjacent lane before the end of transition.

(2) **A Shifting Taper** — used when a lateral shift is needed without merging.

(3) **A Shoulder Taper** — used on an expressway when work is in progress on a shoulder lane.

Table 3. 9 : Recommended Ratio for Taper Length (N)						
Speed (km/h)	90	80	70	60	50	40
Merging	1 : 50	1 : 40	1 : 30	1 : 20	1 : 10	1 : 5
Shifting	1 : 25	1 : 20	1 : 15	1 : 10	1 : 5	1 : 3
Shoulder	1 : 5	1 : 5	NA	NA	NA	NA

Note: If the ratio shows 1:50, N = 50

Fig. 3.3 : Typical cross-section of a 3-lane temporary diversion for outer lane closure on expressway.

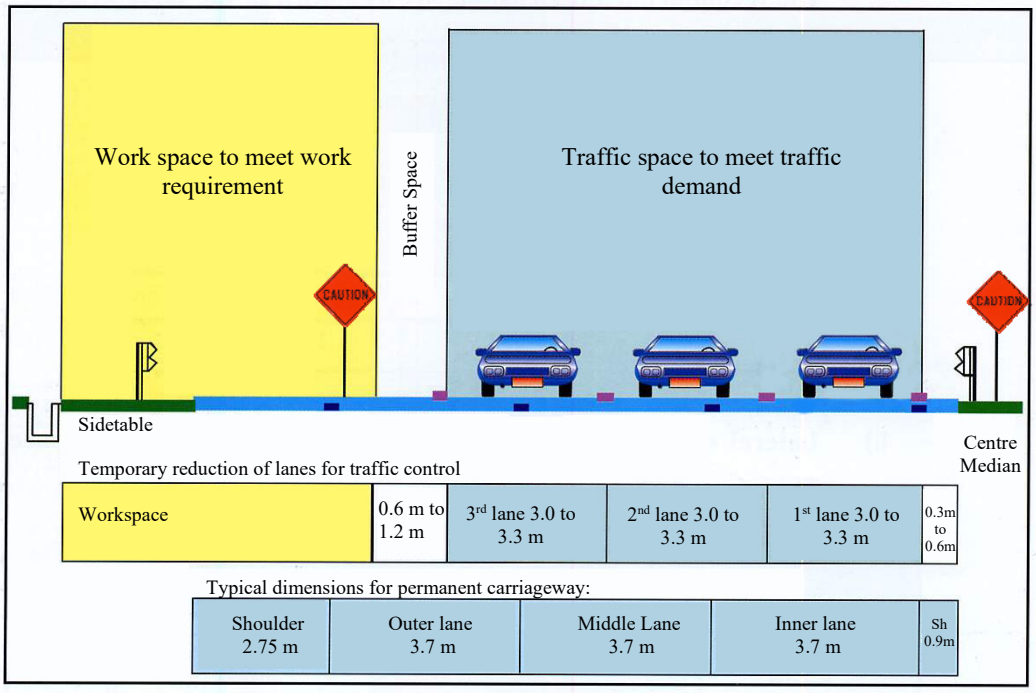


Fig. 3.4 : Typical cross-section of slow lane closure on a 3-lane expressway.

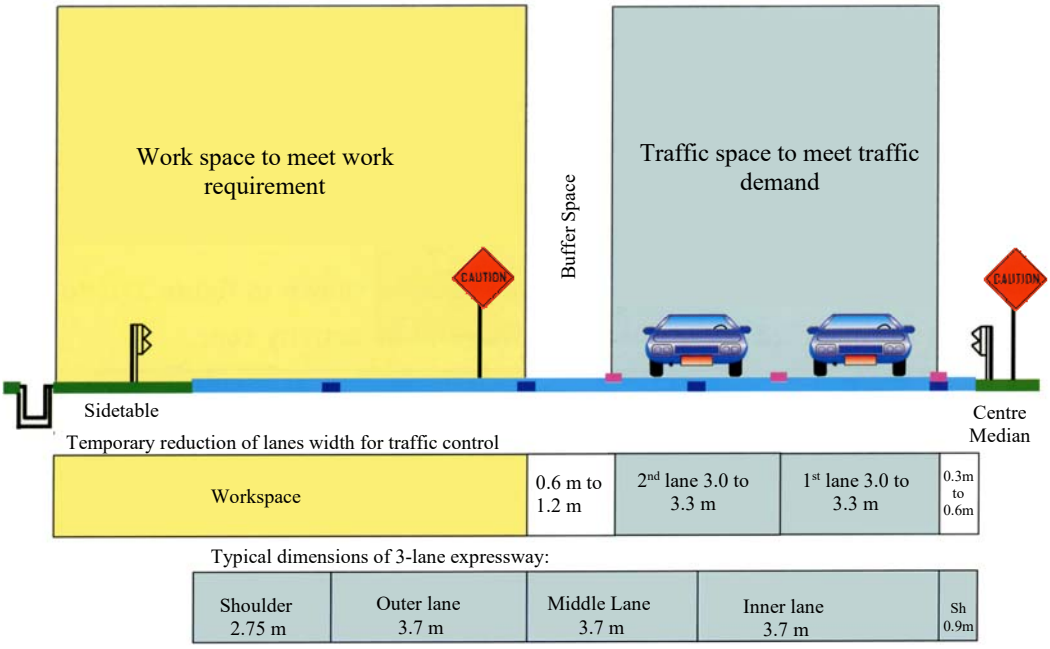


Fig. 3.5 : Typical cross-section of middle lane closure on a 3-lane expressway.

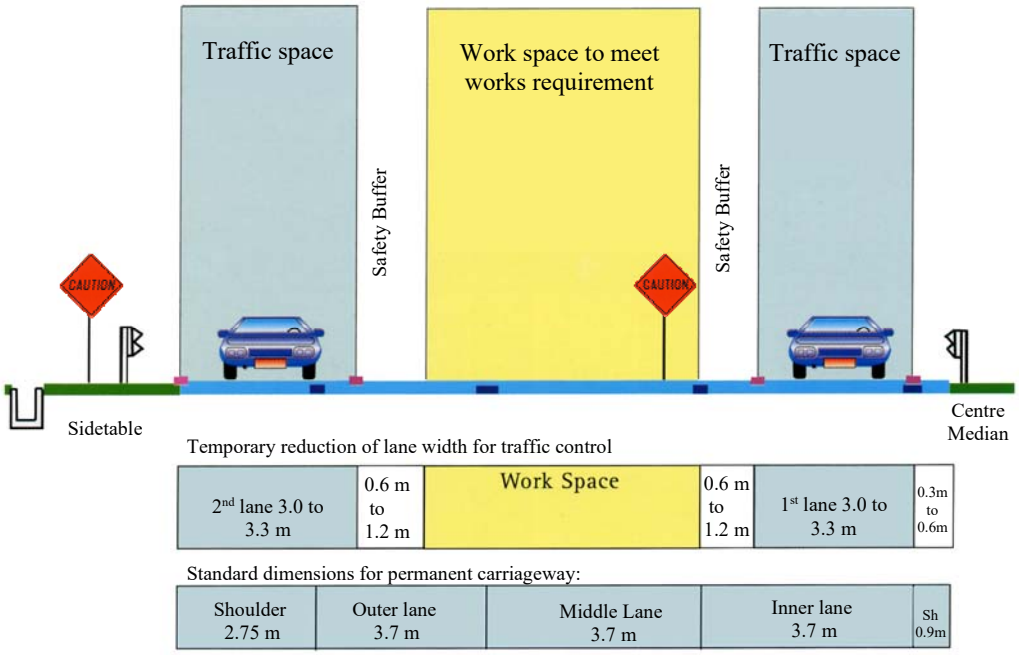


Fig. 3.6 : Typical cross-section of fast lane closure on a 3-lane expressway.

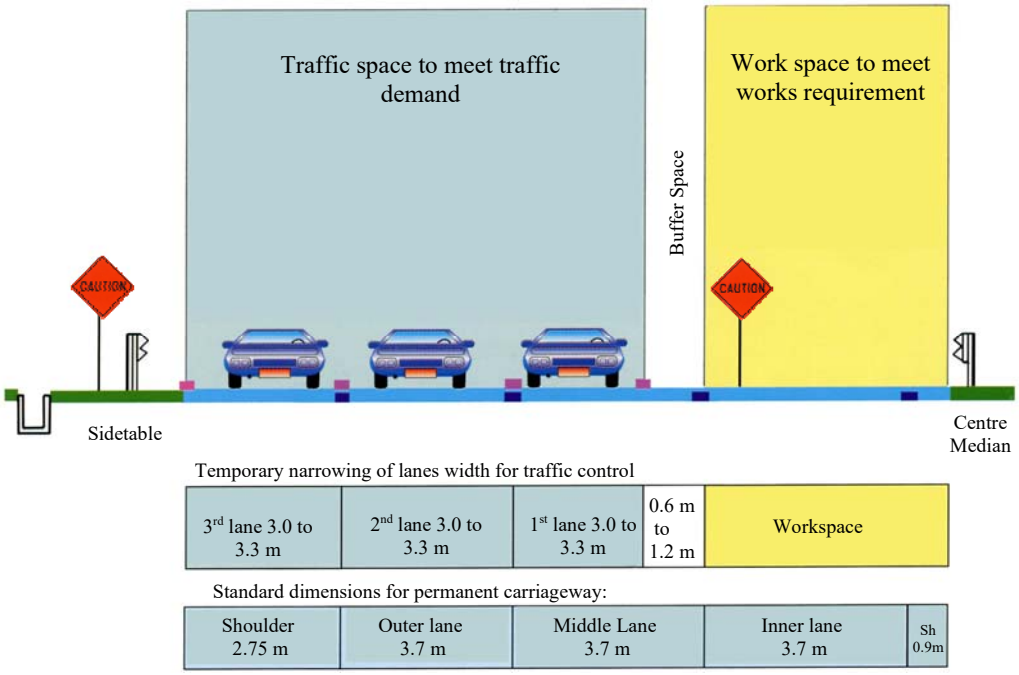
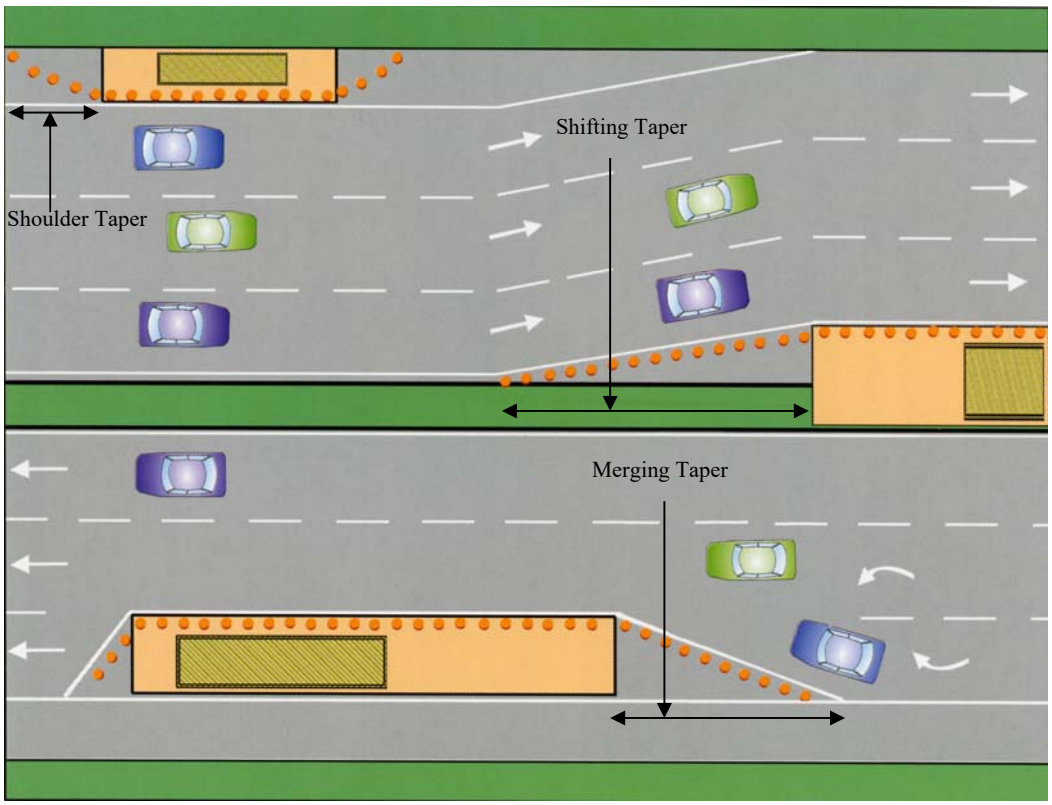


Fig. 3.7: Types of Tapers



Examples of the taper length calculation are shown in Table **3.10** and **3.11**.

Table 3.10 : Taper Length for merging taper (2 to 1 lane for I = 3.7m)					
Design Speed	N	N x I	Proposed Length L	0.05 x L	0.1 x L
Km/h	-	(m)	(m)	(m)	(m)
(1)	(2)	(3)	(4)	(5)	(6)
90	50	185	200	10	20
80	40	148	150	7.5	15
70	30	111	120	6	12
60	20	74	80	4	8
50	10	37	40	2	4
40	5	18.5	20	1	2

Table 3.11 : Taper Length for shifting taper (I = 3.7m)					
Design Speed	N	N x I	Proposed Length L	0.05 x L	0.1 x L
Km/h	-	(m)	(m)	(m)	(m)
(1)	(2)	(3)	(4)	(5)	(6)
90	25	92.5	100	5	10
80	20	74	80	4	8
70	15	55.5	60	3	6
60	10	37	40	2	4
50	5	18.57	20	1	2
40	3	11.1	10	0.5	1

3.5-8 The following factors shall be considered when designing a taper. They are: —

(1) Tapering of more than 1 lane should be done one lane at a time. The distance of the tapers is twice the normal taper length.

(2) A longer taper is not necessarily better than a shorter taper (particularly in urban areas) because an extended taper tends to encourage sluggish driving and delay lane changes.

(3) The start of the taper should be located such that its full length is visible at 60m to 100m ahead. The start of the taper should be located at the upstream of a bend so that it is clearly visible on the approach.

(4) Transition area is also a safety zone. Nothing other than traffic control devices are allowed in the transition zone.

(5) Devices should be spaced such that the taper would appear uniform and continuous to approaching motorists, and traffic cannot weave around them easily.

3-5.9 **Designing of Taper Length for SHORT-DURATION Work.**

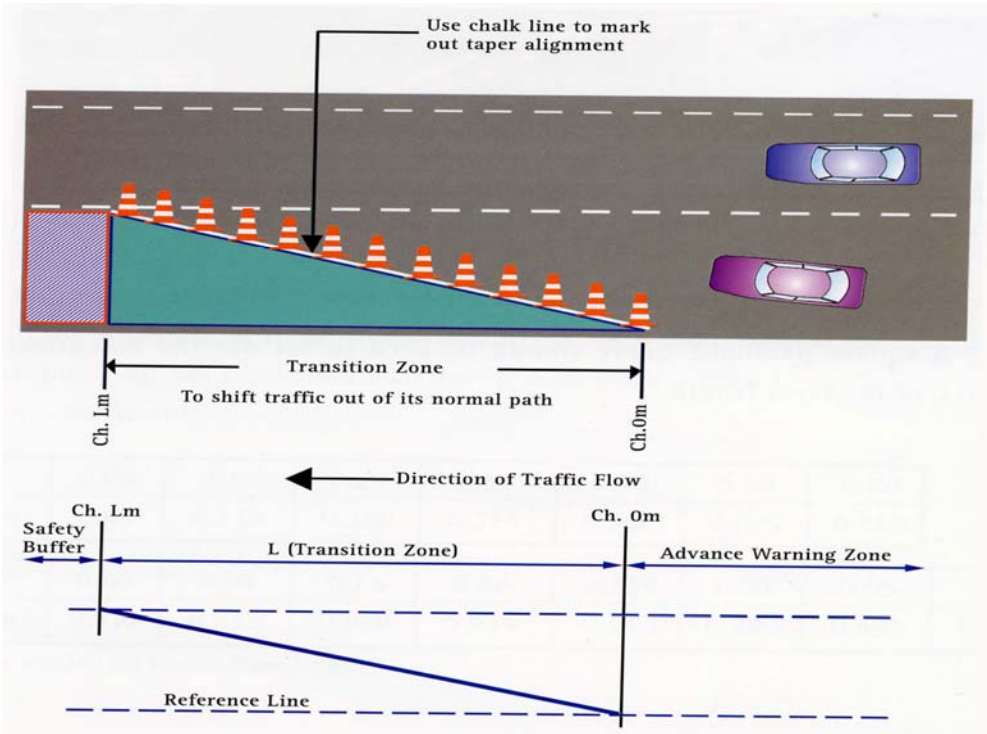
Typical taper for SHORT-DURATION work (i.e. < 12 hours) shall be a straight line as shown in Figure **3.8**. Portable temporary traffic control devices shall be used to delineate the taper as follows: —

(1) Traffic Cones spaced at 6m and 3m c/c for expressway and other road respectively.

(2) Plastic barricades with the retro-reflective board facing the traffic, spaced at 6m and 3 m c/c for expressway and other roads respectively.

(3) Continuous water-filled barriers with retro-reflective disc.

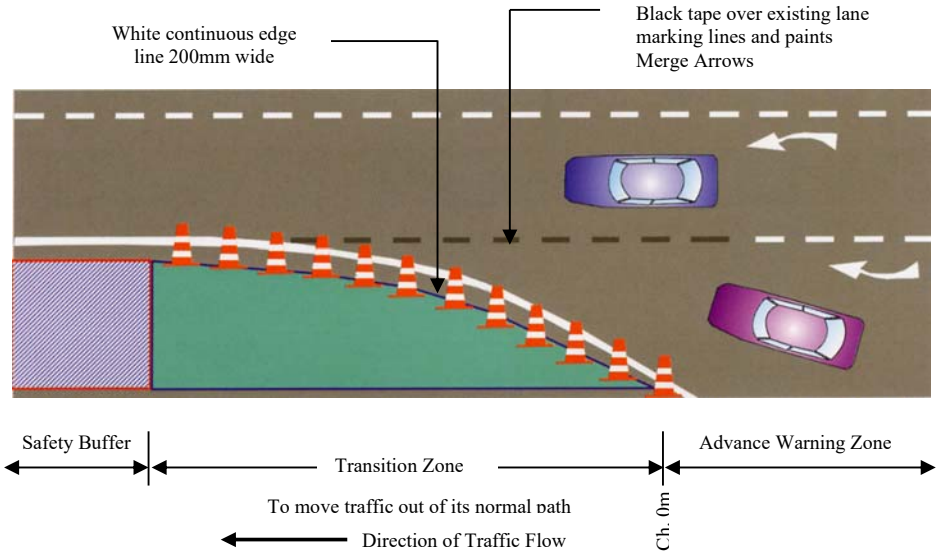
Fig. 3. 8 : Taper for Short-Duration Work



3-5.10 **Designing of Taper Length for SHORT-TERM and LONG-TERM Work.**

The taper for SHORT-TERM and LONG-TERM work (i.e. overnight to 7 days and longer) shall be as shown in Fig. **3.9a.** The downstream of the taper is a smooth curve for smoother and better traffic flow.

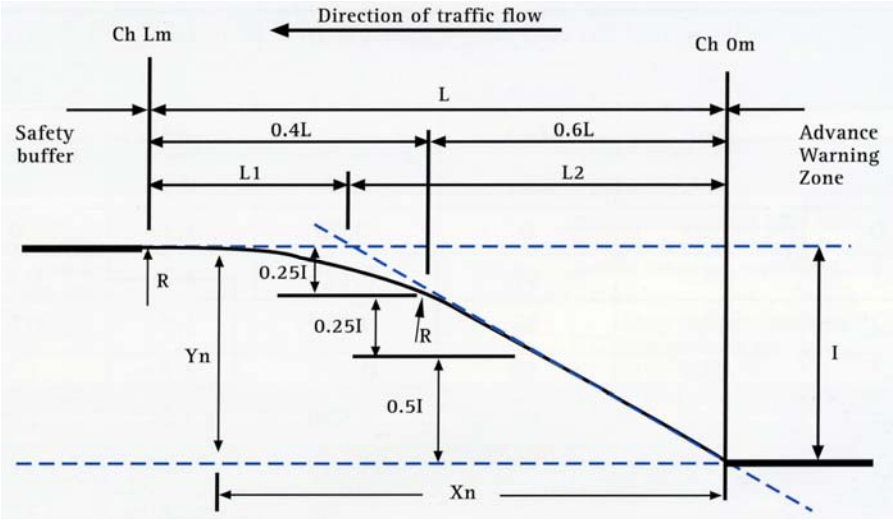
Fig. 3. 9a : Taper for short and long-term work



NOTE: A square parabolic curve should be used to set out the downstream at 0.6L to L of the taper length.

3.5-11 The typical setting up of the taper curve is as shown in Fig. **3.9b**. The taper is a straight line from Ch 0 m to Ch 0.6L m and a square parabolic curve from Ch 0.6L m to Ch L m. A working example is given in table **3.12** to assist the designer to design the taper for short-term and long-term work.

Fig. 3. 9b : Taper curve for short and long term work



Taper length L (m) = N x I
N = refer to **table 3.9**
I (m) = lateral shift of the horizontal alignment from the original line.
Xn (m) = Length at n location = A x L, A = 0.00, 0.05, 0.10, ..., 1.00
Yn (m) = off-set from reference line at n location = En x I
En: coefficient

A*	0.00	0.10	0.20	0.30	0.40	0.50	0.60
En	0.00	0.125	0.250	0.375	0.500	0.625	0.750

A*	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
En	0.810	0.855	0.910	0.935	0.965	0.980	0.995	1.00

* Closer spacing for shorter taper length

Example: Setting-out of merging taper for 2 lanes to one lane.

Expressway: V = 80 kph N = 40
Reducing width: I = 3.7m
Min Taper length: L = N x I = 40 x 3.7 = 148m
Chosen Taper length: L = 160m for easy setting out. 0.1L = 16m, 0.05L = 8m

Table 3.12 : Setting out for merging taper (2 to 1 for I = 3.7 m)					
A	L	Xn = A x L	En	I	Yn = En x I
-	(m)	(m)	-	(m)	(m)
(1)	(2)	(3)	(4)	(5)	(6)
0.0	160	0	0.00	3.7	0
0.1	160	16	0.125	3.7	0.43
0.2	160	32	0.250	3.7	0.93
0.3	160	48	0.375	3.7	1.39
0.4	160	64	0.500	3.7	1.85
0.5	160	80	0.625	3.7	2.31
0.6	160	96	0.750	3.7	2.78
0.7	160	112	0.855	3.7	3.16
0.8	160	128	0.935	3.7	3.46
0.9	160	144	0.980	3.7	3.65
1.0	160	160	1.00	3.7	3.70

3-5.12 **Designing of Taper Length for LONG-TERM Work.**
The taper for extended LONG-TERM WORK and complicated traffic diversion shall be a S-curve as shown in figure **3.10a** for a smooth flow of traffic. A square parabolic S-curve shall be used to set out a taper length for changes to cross-section due to changes in lane width, median width, carriageway width, number of lanes, auxiliary lane, slip road etc. This is the inner edge of the 200mm wide thermoplastic pavement edge marking.

3.5-13 The typical setting up of the taper S-curve is as shown in Fig. **3.10b**. A working example is given in table **3.13** to assist the designer to design the taper.

Fig. 3.10a Taper for extended Long Term work and Complicated Traffic diversion

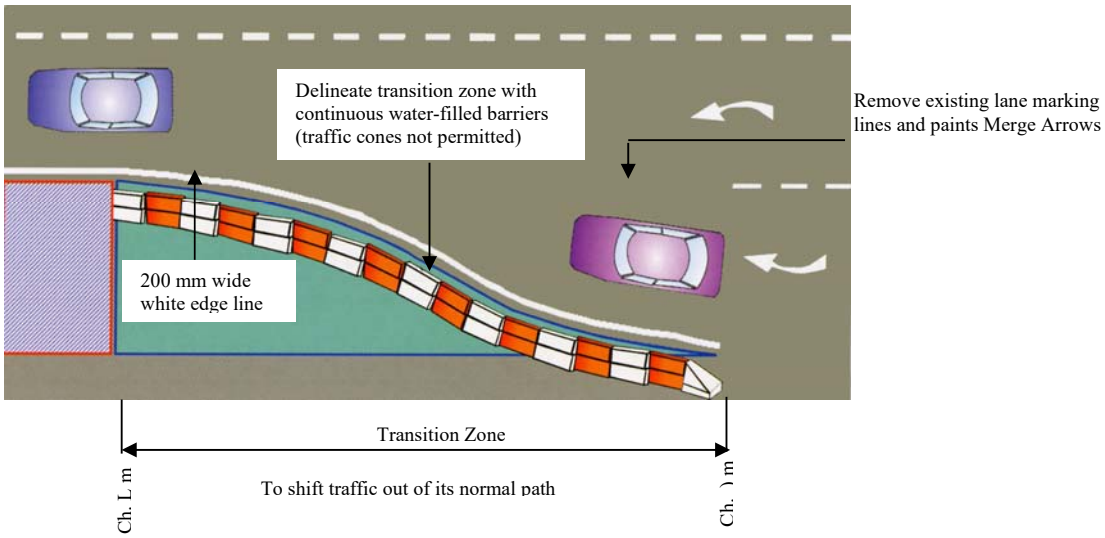
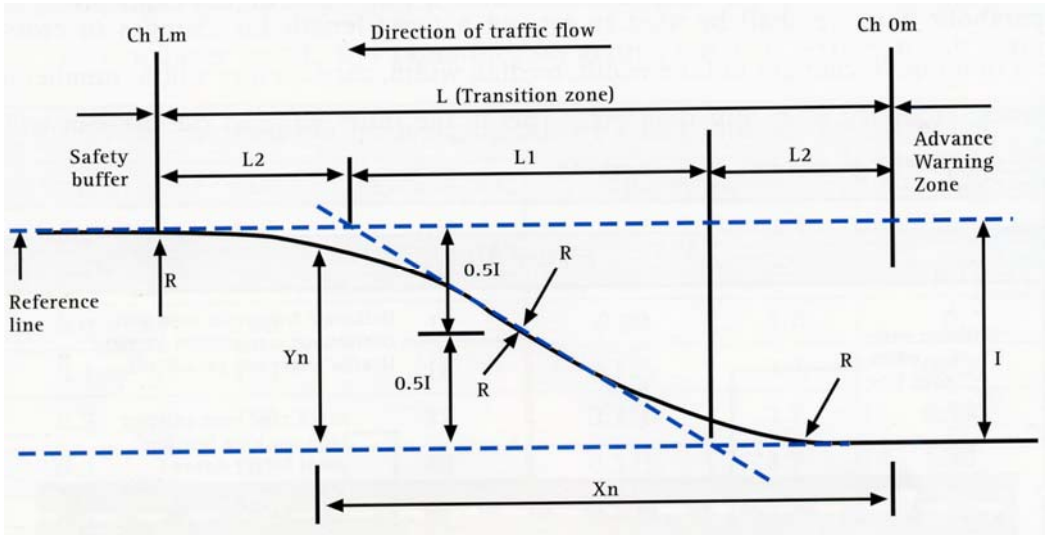


Fig.3.10b Taper Curve for extended Long Term work and Complicated Traffic diversion



min L = V x (I/3)$^{0.5}$ Recommended L = N x I
V (kph) = Design speed e.g. 80 kph
I (m) = change in width to carriage-way e.g. 3.7m
L (m) = Taper length = N x I min L = 80 x (3.7/3)$^{0.5}$ = 80 x 1.11055 = 88.84.
Xn (m) = length at n location A x L, A = 0.00, 0.05, 0.10, ..., 1.00.
Yn (m) = off-set from reference line at n location = En x I
En: coefficient

A*	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
En	0.00	0.005	0.020	0.045	0.080	0.125	0.180	0.245	0.320	0.405	0.500

A*	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	0.10
En	0.595	0.680	0.755	0.820	0.875	0.920	0.955	0.980	0.995	1.000

* Closer spacing for shorter taper length

Example: Setting-out data for reducing 3.7m width of an expressway (80kph).
Taper length L = 160m 0.1L = 16m 0.05L = 8m.

Table 3.13 : Setting out for merging taper (2 to 1 for I = 3.7 m)					
A	L	Xn = A x L	En	I	Yn = En x I
-	(m)	(m)	-	(m)	(m)
(1)	(2)	(3)	(4)	(5)	(6)
0.0	160	0	0.00	3.7	0.00
0.1	160	16	0.02	3.7	0.07
0.2	160	32	0.08	3.7	0.32
0.3	160	48	0.18	3.7	0.76
0.4	160	64	0.32	3.7	1.18
0.5	160	80	0.50	3.7	1.85
0.6	160	96	0.68	3.7	2.52
0.7	160	112	0.72	3.7	3.03
0.8	160	128	0.92	3.7	3.40
0.9	160	144	0.98	3.7	3.83
1.0	160	160	1.00	3.7	3.70

Xn = AxL	0	8	16	24	32	40	48	56	64	72	80
Yn = NxI	0.00	0.02	0.07	0.17	0.30	0.46	0.67	0.91	1.18	1.50	1.85

Xn = AxL	88	96	104	112	120	128	136	144	152	160	-
Yn = NxI	2.20	2.52	2.79	3.03	3.24	3.40	3.53	3.63	3.68	3.70	-

3-5.14 **Designing the Advance Warning Zone.**
The function of the advance warning zone is to give advance warning to the approaching traffic of the activity area and transition area ahead. Drivers shall be able to see the warning signs, understand the conditions ahead and know what is expected of them.

3-5.15 Typically, two temporary advanced warning signs shall be provided for at every approach to work site along expressway and major road as shown in table **3. 14**. Signs warning motorists of the nature of road restriction ahead will follow this. Examples of such signs are given in table **3.15.**

Table 3.14 : Compulsory Advanced Warning Signs		
1st sign	To alert and command road user's attention. A caution sign is normally used to alert and command driver's attention to the work zone. Typical visibility of 1st sign = Minimum Stopping Sight distance.	
2nd sign	To notify road users of the general nature of the work ahead. Logo identifies the organisation carrying out the work.	

Table 3.15 : Example of Temporary Signs showing lane changes		
3rd sign	To guide road users of the action to be taken e.g. merge to middle lane, slow, do not over-take, workmen present …..etc.	
3rd sign	To warn road users of changes in lane conditions. e.g. Closure of road shoulder, merge to middle lane.	

3.5-15 Posting of temporary advance warning signs shall comply with the following requirements: —

(1) Provide temporary warning signs at every approach to work zone along the expressway and major road.

(2) Clear visibility upstream of the 1st temporary warning sign shall be at least equal to the minimum stopping sight distance.

(3) The number of signs and spacing shall be adjusted to suit the site condition e.g. poor geometry, adverse sight distance and obstruction etc. ***At times, a solitary caution sign would suffice to warn motorists. This is to prevent too many signs too close and ending up confusing motorists. Designers and site personnel must work together to decide on the optimum number of warning signs needed.***

(4) Temporary warning signs shall only be duplicated on the right side of the carriageway if signs on the left-hand side are likely to be obscured or overlooked.

3.5-16 The typical distances of temporary warning signs upstream of the taper are as shown in the table **3.16.**

Table 3.16 : Distances of Temporary Signs						
Distance from taper starts	Expressway 90/80 km/h	Major Road 70 km/h	Major Road 60 km/h	Major Road 50 km/h	Primary Access 50 km/h	Local Access 40 km/h
3rd sign	240 m	200 m	160 m	120 m	120 m	60 m
2nd sign	360 m	300 m	240 m	180 m	180 m	90 m
1st sign	480 m	400 m	320 m	240 m	240 m	120 m

3.5-17 Typical arrangement of advance warning signs on a dual 3-lane expressway are as shown in table **3.17** and **3.18** for the guidance of the designer of traffic control plan.

3.5-18 **Designing the Termination Zone.** The termination zone is used to channel traffic back to its normal traffic path and also to inform motorists that they have passed the work zone.

3.5-19 The design considerations for termination zones are: —

(1) A taper of 1:10 or at least 30m shall be provided to ease traffic back to its normal path for expressway, major arterial, distributor, and 1:1 for other roads.
(2) Delineator and channelling devices shall be used to form the taper.
(3) End of Work zone Sign shall be used at the end of the work zone to inform and thank road users for their understanding and co-operation. (Table **3.19**)

3.5-19 **Designing the Temporary Safety Fences/Devices.**
Temporary safety devices shall be provided for high-risk situations to protect the road users and the workers. High risks or hazardous road locations shall include site conditions such as:—

(1) Next to embankment
(2) Next to vertical drop
(3) Next to existing rigid obstructions
(4) Next to deep drains
(5) Next to deep excavations
(6) St sharp bends
(7) Adverse opposing traffic conditions

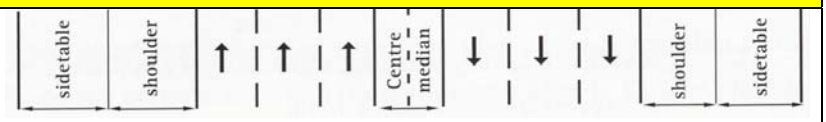
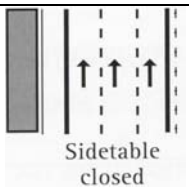
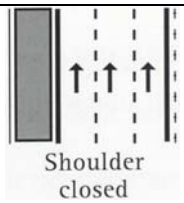
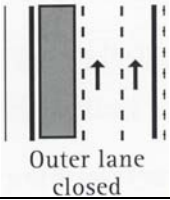
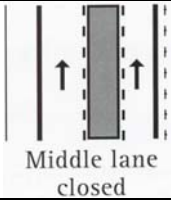
3-6 Drawings

3-6.1 **Typical Traffic Control Plan.**
Examples of Traffic Control Plan (TCP) for typical situations are given in **Appendix IV** of the Code to guide the designer. Designers should use the guiding principles to decide if a standard TCP is applicable or a customised plan is needed. New TCPs shall be evaluated and when accepted by the Authority, may be added to the list in the code for future reference.

3-6.2 **Project Safety Review.**
A safety review is required for Temporary Traffic Control scheme of 9 months or longer. It shall comply with the requirements in the LTA Procedure Manual on Project Safety Review for Roads.

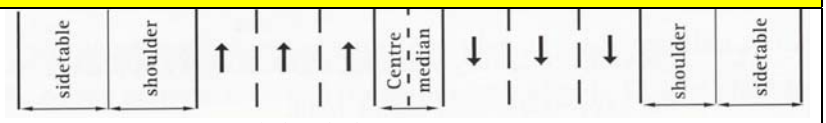
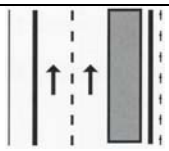
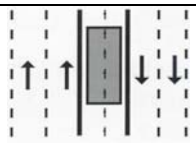
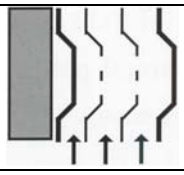
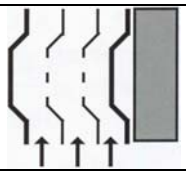
3-6.3 The following information as provided in table **3.20** shall be submitted to the Authority for prior approval.

Table 3.17 : Typical arrangement of advanced warning signs on expressway

Termination Zone	Normal traffic condition	 Typical Dual 3-lane expressway			
Activity Zone	Works location	Sidetable	Shoulder	Outer lane	Middle lane
	Traffic scheme				
Transition Zone	Taper length for V = 90 Km/h	NA	1 : 5	1 : 50	1 : 50
Advanced Warning Zone	3rd warning sign	Nil			
	2nd warning sign				
	1st warning sign				

 Closed Lane and Work Area

Table 3.18 : Typical arrangement of advanced warning signs. – Cont.

Termination Zone	Normal traffic condition	 Typical Dual 3-lane expressway			
	Works location	Inner lane	Centre Median	Right Shift	Left Shift
Activity Zone	Traffic scheme				
Transition Zone	Taper length for V = 90 Km/h	1 : 50	NA	1 : 25	1 : 25
Advanced Warning Zone	3rd warning sign		NA		
	2nd warning sign				
	1st warning sign				

 Closed Lane and Work Area

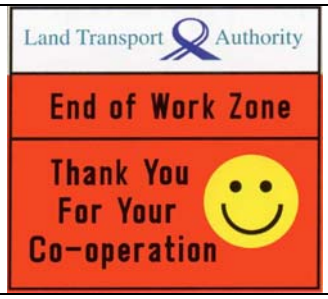
Table 3.19 : End of Taper Sign	
End Taper	Expressway, major arterial and distributor – 1:10 or minimum 30m. Other road – 1:1 or minimum 2 traffic cones at 1.2m c/c.
End of Work Zone sign at 30m after the End Taper	

Table 3. 20 : Drawing Information Table		
Title	Scales	Use
Location plan	1:20,000/10,000/5,000	To locate the work zone within the general vicinity
Survey plan on current site condition	1:1,000/500/100	To show all existing feature, topography and boundaries
Setting out plan	1:1,000/500/100	To show detail lines, dimension, position, orientation and direction of the components
Layout plan/Site plan	1:1,000/500/100	To show the spacing, types, layout and position of the devices used in each component
Traffic plan	1:1,000/500/100	To show the traffic scheme proposed for the temporary traffic control
Longitudinal section	1:1,000/500/100	To comply with permanent road design drawings' detail
Cross section	1:20/10	To show the position, dimensions and details of the components' cross section
Detail plan	As required	To amplify in detail all important information of traffic control and road safety

Summary of Planning Process

Planning Process of Traffic Control		
Step	Description	Detail
1	Assemble Data	• Scope of works, Method of construction, Road data, Traffic data, etc. should be required
2	Study roadway occupancy	• Duration of the works • Carriageway space occupied by the work • Road occupied at any one time or day • The hours by which the road will be affected each day
3	Identify feasible alternatives	• Lane constriction • Lane closure • Shared right-of-way • Median crossover • Detour • Temporary by-pass/diversion • Intermittent closure • Use of road shoulder or median
4	Analyse volume/capacity relation & traffic impact	• Traffic impact study • Ability to cope with the traffic demand
5	Analyse other improvement techniques	• Off-peak works • Night works • Remove parking • Reschedule works • Weekend works • Reversible lane • Restrict turning • Modify signal time
6	Evaluate traffic control schemes	• Vehicle delays and stops • Safety and accidents • Project and traffic controls' costs • Air pollution and business losses • Etc
7	Modify procedure	• Review designs • Work procedure • Alternative construction methods • Other procedure
8	Select preferred traffic control scheme	Identify preferred traffic control scheme for each stage of the works

Summary of Design Considerations

	Type	Differentiation	Characteristic
1.	Work Duration	Long Term > 7 days	• Higher risk for longer exposure • Elaborate Devices • Detailed TCP
		• Short term =< 7 days • Short duration < 12 hours • Short duration mobile	• Lower risk for shorter exposure • Simplified TCP • Portable devices
2.	Road Speed	• Design speed for diversion and detour. • Road Geometry	• Horizontal alignment • Vertical profile • Cross-section • Sight distance • Taper length • Safety buffer • Sign spacing
3.	Road Type	• Expressway • Arterial • Primary Access • Local Access	• Legal speed • Access control • Junction type • Shoulder • Stopping/waiting • Parking/driveway
4.	Road Location	• Rural area • Urban area • Public housing • Private housing • CBD • Industrial area • School Zone	• Local traffic • Pedestrian • Local business • Bus stop • Parking • Driveway • Stopping
5.	Work Location	• Outside/near carriageway • Shoulder lane • Slow/left lane • Intermediate lane • Fast lane • Multi lanes • Median • Junction/interchange	• Road encroachment • Work access • Work traffic • Speed gradient • Fast/right lane is hazardous • Special attention on fast lane
6.	Traffic Condition	• CONDITION I: Demand always< road capacity • CONDITION II: Demand at peak> road capacity	• Long term lane closure may be allowed for condition I • Lane closure will not be allowed on peak hours. Temporary widening or traffic diversion required for long term work

Summary of Design Considerations (Cont.)

	Type	Differentiation	Characteristic
7.	Type of Work	• TYPE I: Can be removed quickly. • TYPE II: Cannot be removed easily.	• Simple planning would suffice for Type I • Detailed planning needed for Type II for unforeseen delays
8.	Mode of Operation	• MODE I: Workmen are always in attendance. • MODE II: Work left unattended.	• Use simple and portable devices for Mode I • Use robust devices and keep clear of passing vehicles.

Summary of Design Procedure

	Design sequence	Sub-components	Input	Output
1.	ACTIVITY ZONE	Work area	Permanent work, Temporary work.	Layout plan of work area & work space, Traffic Layout Plan, Safety buffer upstream of work space, Safety buffer between work space & traffic space, Cross section, Layout plan of Activity Zone Traffic scheme.
		Work space	Plants, Equipment, Material, Vehicles, Workmen, Work Traffic & Access	
		Traffic space	Existing Traffic Scheme, Traffic Demand, Facilities	
		Longitudinal safety buffer	Road Speed	
		Lateral safety buffer	Road Speed	
2.	TRANSITION ZONE	Merging, Shifting, Shoulder, single or multiple lanes taper	Activity Zone, Downstream traffic scheme, Road speed, Visibility	Taper length, Taper type, Layout plan, Setting out plan, Cross-section, Traffic scheme
3.	ADVANCE WARNING ZONE	To alert & command attention. To warn of the nature of works ahead. To inform of the lane status ahead. To provide a guide on the action to be taken.	Road speed, Downstream traffic scheme, Site obstructions, Visibility	Combination of Signs, Spacing & locations, Duplication on median
4.	TERMINATION ZONE	End Taper	Road speed, Upstream traffic scheme, Site obstructions, Visibility.	Taper length, Combination of signs, Spacing & Locations.
5.	Temporary Safety Fence	Activity, transition & termination zone.	Work conditions, Site conditions, Traffic conditions, Road geometry, Road speed, Visibility.	Layout & Type of safety devices.

Chapter 4 Design and Application of Traffic Control Devices

4-1 General

4-1.1 Traffic control devices are used to ensure orderly and predictable movement of traffic, as well as to warn and guide road users safely through the work zone. Temporary traffic control devices include:-

(1) Temporary traffic signs
(2) Channelling and delineation devices
(3) Barricades
(4) Temporary safety devices
(5) Visibility enhancing devices.

4-1.2 **Traffic control devices when clearly seen and understood in time can spare confusion and save lives**. This section provides guidance on the function, design and application of traffic control devices. It assists road engineers and site supervisors to select, place and operate such devices effectively. Specification of some of the typical traffic control devices are found in the **Appendix II** of this Code. **The placement of such devices shall not obstruct the visibility of existing traffic signs**.

4-2 Traffic Signs

4-2.1 Traffic signs by means of legend (words or symbols), shape and colour are used to convey:

(1) Regulatory messages
(2) Warning messages
(3) General information and messages.

4-2.2 Signs shall be displayed only for a specific purpose and shall be removed or covered when the conditions change. Installing too many signs will result in some of the signs losing their effectiveness.

4-2.3 Road signs are typically located in the following manners:

Type	Location
Regulatory Sign	At the locations where the intended directions/controls are needed.
Temporary Warning Sign	In advance of the condition to which it calls for attention.
Information Sign	Way in advance to keep road users well informed.

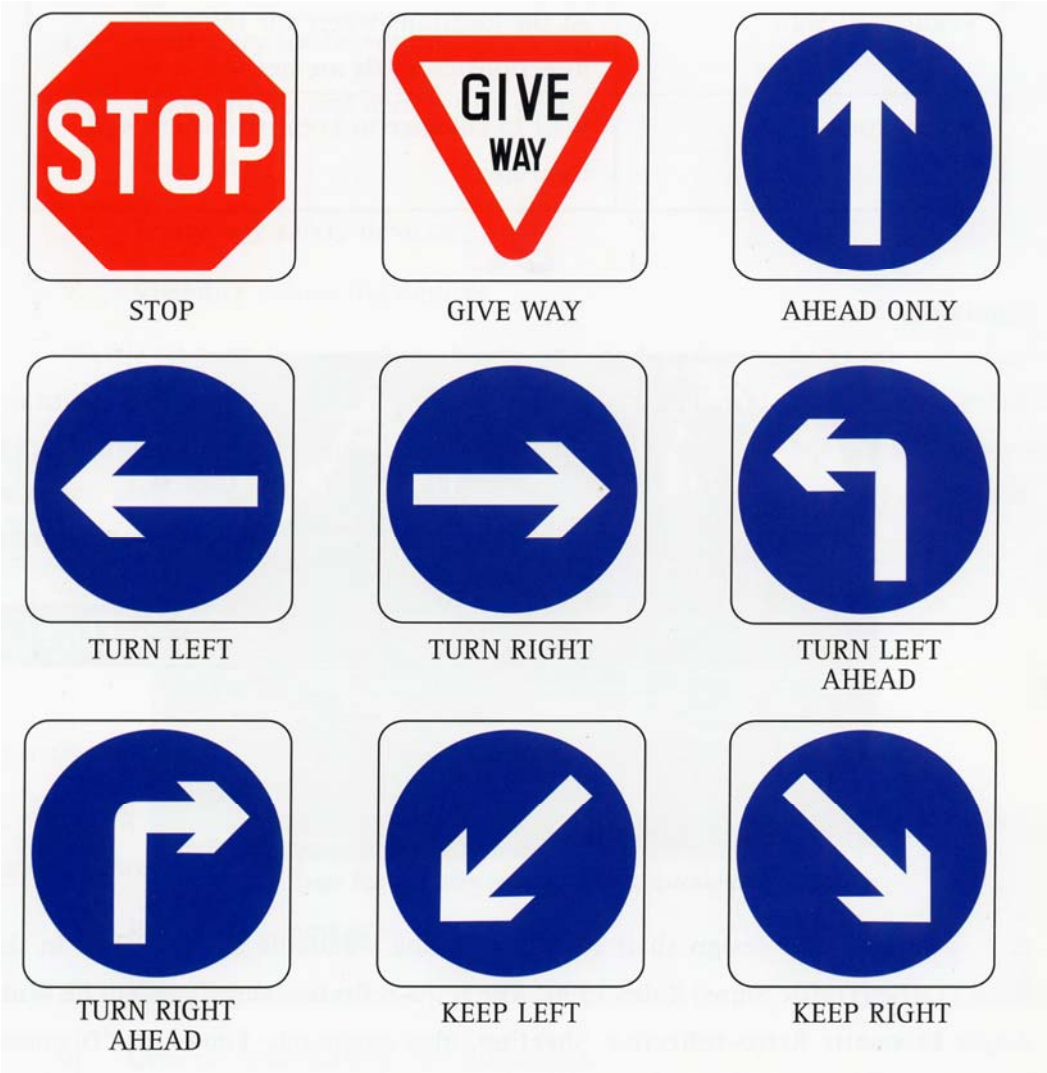
4-3 Regulatory Signs

4-3.1 **Design** - The design shall comply with the standards as prescribed in the Road Traffic (Traffic Signs) Rules 1990. *The sheeting shall be Wide Angle Prismatic Retro-reflective Sheeting.* The size of the sign shall be as follows: —

Road Type	**Size**
Expressways	900mm x 900mm (min)
Other Roads	600mm x 600mm (min)

4-3.2 **Application** - Regulatory signs are mandatory, prohibitory or restrictive in nature. They put the motorists under a legal obligation to obey them. Approval from the Authority is required if these signs are to be used or altered.

Examples of Mandatory Signs



Examples of Prohibitory Signs

NO ENTRY

SPEED LIMIT

SPEED LIMIT

SPEED LIMIT

SPEED LIMIT

SPEED LIMIT

WEIGHT LIMIT

WIDTH LIMIT

HEIGHT LIMIT

NO RIGHT TURN

NO LEFT TURN

NO STOPPING

NO WAITING

4-4 Temporary Warning Signs

4-4.1 **Design** – Temporary warning signs shall be diamond-shape with a black legend on a *Fluorescent Orange Wide Angle Prismatic Retro-reflective Sheeting* or approved equivalent as the background. The size of the sign shall be as follows: —

Road Type	Size
Expressways	1200mm x 1200mm (min)
Other Roads	900mm x 900mm (min)

4-4.2 **Application** - Warning signs call for attention to potential hazardous conditions on or adjacent to a road. Temporary traffic warning signs are placed in advance of the site to alert road users of the obstructions or conditions caused by the works ahead. Typical applications of temporary warning signs are given in the table **4.1**. The complete temporary warning sign applications are given in the **Appendix III**.

Table 4.1 : Typical Warning Signs and Usage

Ref. No.	Name	Use	Design
W1	Caution	• Warn road users of the work zone ahead. • Convey the warning that road users should be more cautious. • Usually the 1st warning sign to be seen.	
W2	Works Ahead Sign- e.g. LTA works	• Warn road users of the works ahead by the relevant department (identified by the department's logo). • Usually the 2nd warning sign to be seen.	
W14	Works Ahead Sign- For Private Works	• Warn road users of the works ahead by the Private body. • Usually the 2nd warning sign to be seen.	
W16	Lane Status Sign- e.g. Road narrowed on the left	• Warn road users of the road narrowing on the left ahead. • Usually placed after the "Works Ahead" sign and before the road width is reduced. • Use when only part of the left lane is closed.	

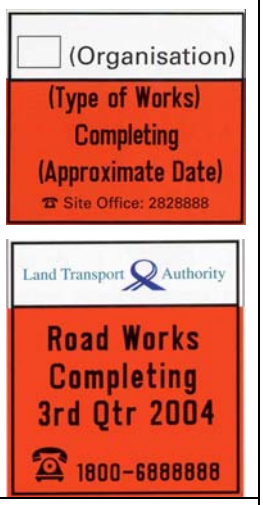
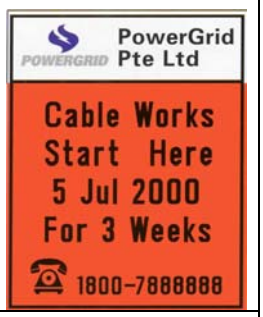
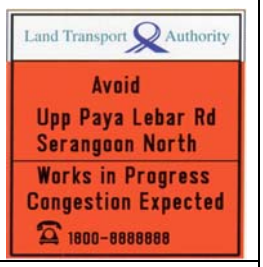
Table 4.1 : Typical Warning Signs and Usage (Cont.)			
Ref. No.	Name	Use	Design
W25	Series of Bends Ahead Sign- e.g. Right first	• Warn road users of a series of bends ahead (with the 1st bend on the right). • Usually placed after the "Works Ahead" sign and before the bend.	
W28	Shoulder Lane Closed Ahead Sign	• Warn road users of road shoulder being close ahead. • Usually placed after the "Works Ahead" sign and before the shoulder is closed.	
W35	Distance supplementary plate	• Supplement any warning sign to indicate the distance to the hazardous condition.	

4-5 Information Signs

4-5.1 Design – Unless otherwise directed, all temporary information signs shall be rectangular-shape with a black legend on a *Fluorescent Orange Wide Angle Prismatic Retro-Reflective Sheeting* or approved equivalent as the background. The design of the legend should comply with the guidelines as specified in the *LTA Standard Details of Road Elements* issued by the Authority.

Road Type	Factor
Expressways	x 6 (min)
Other Roads	x 4 (min)

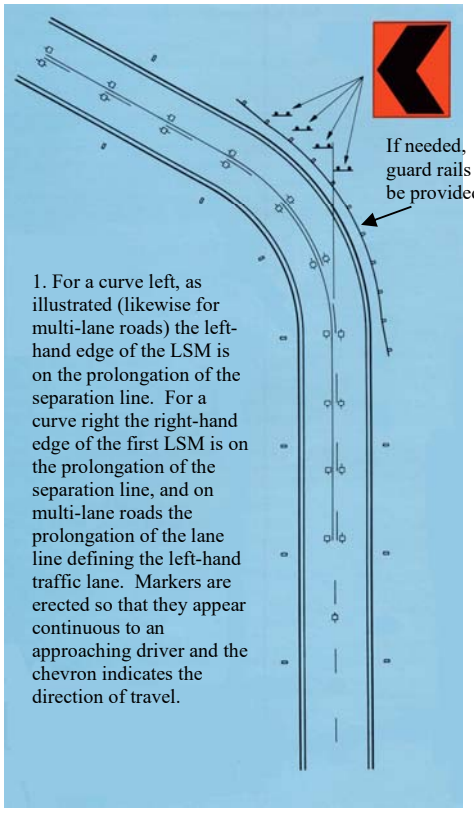
4-5.2 **Application –** Information signs are mainly used to give road users simple and direct information of the works or direction. Typical applications of temporary information signs are given in the table **4.2**. The complete information sign applications are given in **Appendix III**.

Table 4.2 : Typical Information Signs and Usage			
Ref. No.	Name	Use	Design
I 1 & I 2	Project Information Sign – e.g. Work carried out by LTA	• Used to inform road users of the nature of work by the relevant department (identified by the department's logo) and expected date of completion of the works. • Usually placed well in advance or at the activity zone. • Telephone number allows road users to give feedback on project related issues. • Not necessary for Short Duration and Mobile works.	
I 4	Coming Your Way Sign- e.g. Power Grid work.	• Inform road users of the impending works to be carried out by the relevant department (identified by the department's logo) at the location. • Usually placed at the location of the work.	
I 5	Avoid Road Sign – e.g. LTA work.	• Inform road users to avoid using the road where works are being carried out and congestion may be expected. • Usually placed well in advance of the work zone.	
I 7	No Road Marking Sign	• Installed during the period where resurfacing /milling /premixing works are freshly completed and new road line or markings are absent. • Placed in advance of the location.	
I 15	End of Work Zone Sign	• Inform road users of end of a work zone and thank them for their understanding. • Placed 30m past the end of work zone. • Used only for work zone longer than 1 km. • Placed as the last sign.	

4-6 Lateral Shift Markers (LSM)

4-6.1 Design – LSM shall be provided to show a lateral change of direction of the carriageway through a work zone or to indicate a sharp bend on a diversion or detour road. It shall be 600mm wide by 750mm high with a black legend on *Fluorescent Orange Wide Angle Prismatic Retro-Reflective Sheeting* or approved equivalent as the background.

4-6.2 Application – They shall be used as supplements to other delineators e.g. at the approach taper together with traffic cones. They shall be placed, on the outside of a turn or curve, in line with and at approximately a right angle to the approaching traffic. Spacing of the LSM should be such that the road user always has at least two in view, until the change in alignment eliminates the need for the signs.

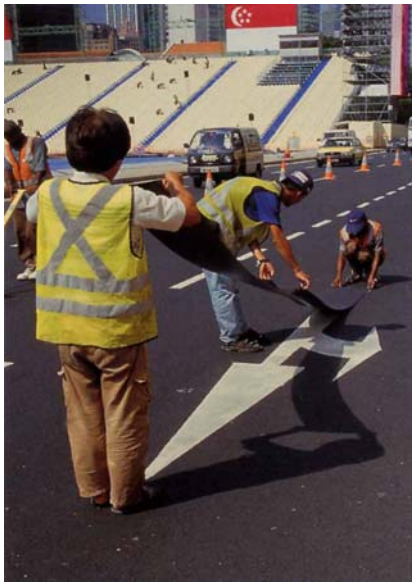


4-7 Removable Pavement (road) Marking Tape

4-7.1 Design — Pavement markings used in the work zone shall be the same as for permanent roads. The markings must comply with the standard application and designs as prescribed in the Road Traffic (Traffic Signs) Rules 1990. Approval of the Authority shall be required if pavement marking is to be used or altered.

4-7.2 Application — Following situations shall apply to the use of temporary marking tape:-

(1) Removable Reflective Pavement Marking Tape shall be used if changes to road lines are anticipated or existing road surfaces are to remain in place.
(2) Black Pavement Marking Tape shall be used when existing pavement markings need to be temporarily covered.
(3) Black paint shall not be used over existing road lines as it may confuse motorists under certain lighting conditions.
(4) Thermoplastic Paint could be used for temporary markings if the road is eventually to be resurfaced and no changes in road lines pattern are anticipated. Thermoplastic paints shall not be used if changes are anticipated, as its removal will result in "ghost" marks that will confuse road users.

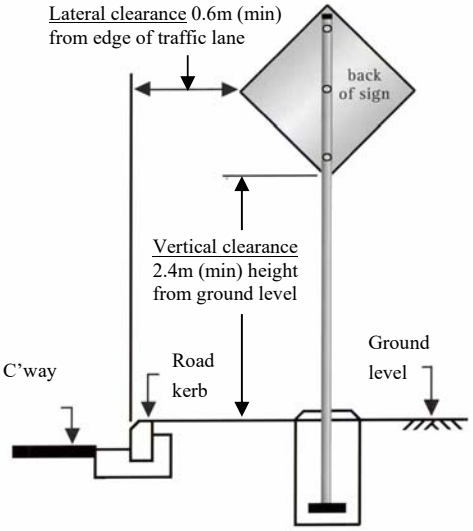


4.8 Sign Mounting & Covering

4-8.1 Signs should normally be mounted:

(1) Approximately at right angle to the line of sight facing the traffic.
(2) Slightly skewed from the traffic if mirror reflection occurs such that it reduces legibility of the sign.
(3) Do not obstruct existing traffic signs.
(4) Typical clearances for post-mounted signs are as follows:

	Minimum Clearance
Vertical	2.4 m above ground level
Lateral	0.6m from edge of traffic lane



Example of support for post-mounted sign

4-8.2 Signs shall always be *installed in front of any physical obstruction.* Signs shall never be installed directly behind a tree, lamp pole or other obstructions such that they obscure the full message on the sign face.

4-8.3 Post-mounted fix-in-place signs *cast in concrete footing are used for long-term works. Portable sign supports that are likely to be used for short-term works and placed on the carriageway or sidetables shall be made of durable plastic. Metal sign supports shall not be used in these instances. Similarly, the signs shall also be made of durable plastic. The use of plastic will greatly minimise injury in case of an accident.* The support details for temporary traffic signs are found in **Appendix II**.

4-8.4 Portable sign supports are used for short-duration and short-term works. These portable supports can be designed to be collapsible or folded for ease in carrying, quick assembly at site and storage e.g. A-frame. The sign should be at least 300mm above the ground.

4-8.5 A sign that has already been installed shall be temporarily covered with an adhesive film/sticker over its entire surface if it is not yet required. This adhesive film/sticker which shall be at least 0.5mm thick, in black colour, and manufactured to withstand the elements of weather and ultra-violet light can then be peeled of when the sign is needed.

Example of portable sign support

Example of a plastic sign support mounted with the lateral shift marker

Summary

Temporary Traffic Signs				
Types	Regulatory	Warning	Information	Lateral Shift Marker
				
Background colour	Comply with Traffic Rules	Fluorescent Orange	Fluorescent Orange	Fluorescent Orange
Legend	Comply with Traffic Rules	Black Pictograms/ Words	Black Pictograms/ Words	Black Pictograms/ Words
Shape	Comply with Traffic Rules	Diamond	Rectangle	Rectangle
Reflectivity	*Wide Angle Prismatic conforming to the Specifications in Appendix II*	*Wide Angle Prismatic conforming to the Specifications in Appendix II*	*Wide Angle Prismatic conforming to the Specifications in Appendix II*	*Wide Angle Prismatic conforming to the Specifications in Appendix II*
Size (mm) Expressway Other Roads	 900 x 900 600 x 600	 1200 x 1200 900 x 900	<u>Enlargement Factor</u> X 6 (min) X 4 (min)	 600 x 750 600 x 750
Sign posting	At location	In advance	Well in advance	At location
Sign facing	Approximate at right angle to line of sight or turned away slightly			
Lateral clearance	Min : 0.6m Absolute min : 0.3m			
Others	Refer to Standard Details of Road Elements	Signs shall not be obstructed by lamp posts or trees	Signs shall not be obstructed by lamp posts or trees	Signs shall not be obstructed by lamp posts or trees

4-9 Delineation and Channelling Devices

4-9.1 Delineation and channelling devices shall be used in conjunction with other devices to:

(1) Separate traffic from the workspace, pavement drop-offs, pedestrian paths, or opposing traffic.
(2) Guide road users safely by indicating clearly the edge of the route and the path they should take.
(3) Guide and direct the approaching vehicles smoothly and gradually into the designated lane/s to pass the work zone safely.

4-9.2 The two forms of devices serve slightly different functions.

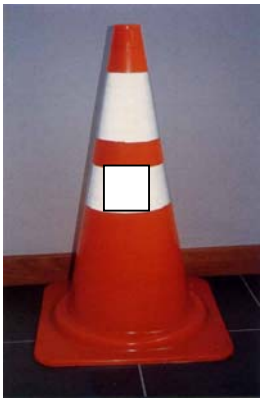
(1) **Channelling**: Refers more to the formation of the navigational paths. Devices are used to direct vehicles into pre-determined paths in a safe and orderly manner.
(2) **Delineation**: Refers more to the marking of boundaries. Delineation devices are installed to indicate clearly the alignment of the road and width of the path in which the vehicles should manoeuvre.

4-9.3 Sight restrictions, end treatment requirements and the need to provide gaps determine the choice of devices. All delineation and channelling devices shall be constructed and secured in a manner that they would yield or break away when struck by a vehicle. This is to prevent fragments or other debris from the devices from endangering the road users and workers in the vicinity.

4-10 Traffic Cones

4-10.1 **Design** — Traffic cones shall be fluorescent red for good daytime visibility. It shall be fitted with 2 retro-reflective bands for good night visibility. The retro-reflective bands shall conform to ASTM D 4965-95 Type III (commonly known as High Intensity Grade). The design of the cone should comply with BS 873 Part 8: 1985.

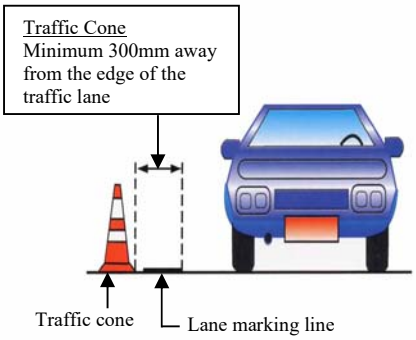
4-10.2 Traffic cones shall be minimum 700mm tall, stable and not easily blown over or displaced by moving traffic. The material of the cone and the ballast added to the base to provide stability shall not present a hazard if struck. The list of approved traffic cones to be used may be found in the "Product Listing Scheme" (PLS) administered by the Singapore Productivity and Standards Board (PSB).



Example of traffic cone with 2 bands and logo

4-10.3 **Application** — The portability of traffic cone is of particular advantage in emergencies for quick delineation, or in works that need regular changes of delineation.

(1) Traffic cones are mainly used for short duration delineation e.g. divide opposing traffic lanes, divide traffic lanes in the same direction and to prevent motorists from travelling over newly-applied wet paint.
(2) They shall not be left in position overnight unless workers are present to replace them if they are displaced.
(3) They may be used in long-duration works in conjunction with temporary pavement marking. They shall be placed at least 300 mm away from the edge of the traffic lane.



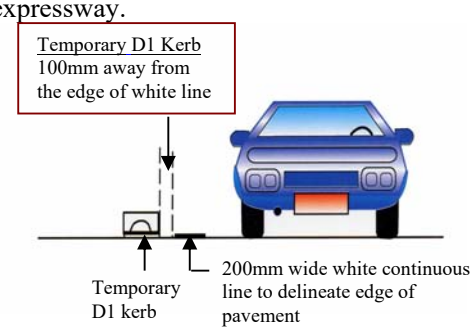
4-10.4 Only one type of traffic cone shall be allowed on site. Using different types on one site would appear haphazard to drivers.

4-11 Temporary Kerbs

4-11.1 **Design** — Temporary kerbs shall be Type D1 kerb as shown in the Standard Details of Road Elements.

Example of temporary D1 kerbs used in road widening

4-11.2 **Application** — The use of D1 kerbs are similar to the permanent K2 kerbs. It could be used to delineate the edge of the temporary carriageway and temporary traffic island for long-duration road works along all roads except expressway.



4-11.3 Delineation for long-term work shall be augmented with 200mm thick pavement edge marking. Temporary kerbs cannot prevent vehicle or pedestrian intrusions onto a work site effectively. They should not be a substitute for safety barriers when these are clearly needed.

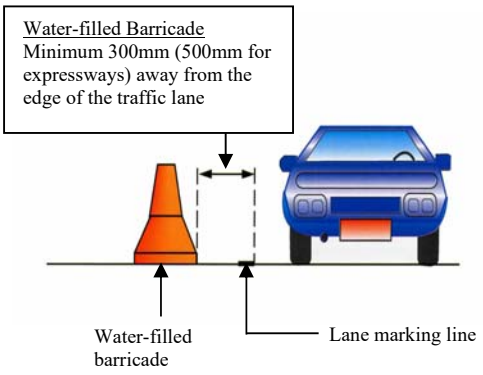
4-12 Water-Filled Barricades

4-12.1 **Design** — Water-filled barricades are proprietary-made modular water filled plastic containers of various sizes and shapes. They shall be minimum 1m tall for major roads and expressway and 0.8m tall for other roads. Each unit shall come with interlocking devices for use on tangent straight and horizontal curves with mounting devices for lighting. Contractors must take note that the **lettering to be pasted on the water-filled barricades,** "WARNING — THIS IS NOT A SAFETY BARRIER" **are for his and his agents use only so that the two different types of water-filled barriers are used correctly. The words should not cause confusion or distress to the public.**

Water-filled barricades used to delineate the carriageway

4-12.2 **Application** — It is very stable and offers better resistance to vehicle impact as compared to traffic cones and barricades. It shall be used as traffic delineator for long-term works, to separate traffic from pedestrians when walkway is temporarily diverted next to a carriageway.

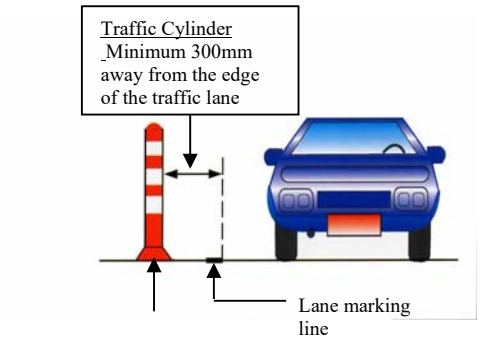
4-12.3 **Water-filled barricades are not temporary safety barriers as they would not be able to contain a vehicle during an accident. It shall not be used as a replacement for permanent barriers, such as vehicular impact guardrails, that has to be temporarily removed because of the works. When VIGs or such permanent barriers are removed and need to be replaced temporarily, water filled safety barriers (WFSB) as those shown in Section 4-18 shall be used instead.** It shall be placed at least 0.5m from the edge of the carriageway for expressway and 0.3m for other roads. Only one type shall be allowed on site. Using different types on one site would appear haphazard to drivers.



4-13 Traffic Cylinders/Vertical Panels

4-13.1 **Design** — These proprietary-made devices shall comply with BS 873 Part 8: 1985. The colour shall be fluorescent red that offers good day visibility. High Intensity Grade (ASTM D 4956-95 Type III) retro-reflective bands shall be fitted for night visibility. It shall be at least 750mm tall when fixed onto the ground, and at least 50mm wide.

4-13.2 **Application** — Traffic cylinders are similar to traffic cones. However they are less effective and shall be used only when space restriction does not permit the use of larger devices. They shall be easily fixed on the road or paved surface and not be easily displaced.



Summary

Delineation & Channelling Devices				
Type	Traffic Cone	Temporary D1 Kerb	Water filled Barricade	Traffic Cylinder
				
Colour	Fluorescent Red	Alternate Black and White	Alternate Red and White	Fluorescent Red
Reflective Collars/Bands	White, High Intensity Grade	NA	Mounted with Fluorescent Orange Retroreflective Disc	White, High Intensity Grade
Min height (mm)	700	Road Standard Detail	*1000 **1000 ***600	Height : 750 Width : 50
Min lateral clearance (mm)	300	100	*500 **300 ***300	300
Activity Zone spacing (m)	*12 **6 ***6	Continuous	Continuous	*12 **6 ***6
Taper length spacing (m)	*6 **3 ***3	Continuous	Continuous	*6 **3 ***3
Others	Design: BS873 Part 8: 1985	Do not use on expressway	With label: "WARNING – THIS IS NOT A SAFETY BARRIER"	Design: BS 873 Part 8: 1985

*Expressways, **Major Roads, ***Other Roads

4-14 Barricades

4-14.1 Barricades are used to:

(1) Deny road users access to the work site.
(2) Prevent accidental encroachment of the work or workers onto the non-work areas in the activity zone.
(3) Control traffic by closing, restricting or delineating all or a portion of the right-of-way.

4-15 Plastic Mesh Fencing

4-15.1 **Design** — The fence is a 1m high flexible plastic mesh made of UV-stabilised high-density polyethylene in red-orange colour. The vertical fence post shall be constructed and spaced at a maximum of 2.5m. The mesh is to be tied to the posts with plastic cable ties, which shall not distort when taut.

Example of plastic mesh fence, fence post and ties.

4-15.2 **Application** — It is used mainly to exclude pedestrians from a work area and for the containment of personnel. It shall be kept at least 500mm from the edge of excavation. It shall not be used near deep excavations where heavy pedestrian movement is expected or on carriageways. It shall not be used to fence up on going construction works area where frequent access by workers and machinery are expected. In such cases, plastic barricades shall be used instead of plastic netting.

4-16 Plastic Barricades

4-16.1 **Design** — Barricades are portable devices having two sign boards with alternating orange and white High Intensity Grade retro-reflective strips conforming to ASTM D 4956-95 Type III. The barricade shall be minimum 1m tall, be stable and not easily blown over, or displaced by moving traffic or pedestrians.

4-16.2 It is a proprietary-made product of plastic post/frame with mounting devices for reflective disc or lamps. The material of the barricade and the ballast added to the base to provide stability shall not become a potential hazard if struck.

Example of plastic barricade posts and double boards

4-16.3 **Application** — The portability of these devices is of particular advantage in emergencies or work that involve their regular displacement.

(1) It shall be erected without gaps along pedestrian paths throughout the activity work zone for the control of pedestrian movement to prevent injury or interference with the work activity.
(2) They may be erected at spacing not exceeding 20m along existing or new roads to inhibit access if road is closed to traffic use.
(3) Barricades shall not be used next to deep excavations or steep falls where heavy pedestrian movement is expected. Heavy objects such as rocks or concrete chunks shall not be used as ballast.

(4) They shall be placed such that a minimum distance of 0.5m separates the plastic barricade and the excavated pit. Plastic barricades shall not be used if heavy pedestrian movement is expected.

Summary

Barricades				
Type	Plastic Mesh Fencing	Plastic Barricades	Temporary Safety Fence	Water-Filled Barricades
				
Colour	Red Orange	Alternate Orange and White Board	Alternate Orange and White	Alternate Red and White
Material	Polyethylene Plastic	Polyethylene Plastic	Per PE's Design	Polyethylene Plastic
Minimum Dimension (m)	1	1	Per PE's Design	*1 **1 ***0.6
Retro-reflective Sheeting	NA	High Intensity	May be mounted with Fluorescent Orange Wide Angle Prismatic Discs	Mounted with Fluorescent Orange Wide Angle Prismatic Discs
Post Spacing	Maximum 2.5m	Proprietary	Per PE's Design	NA
Minimum Lateral Clearance (m)	Not applicable on carriageway	Not applicable on carriageway	Not to use in expressway **0.3 ***0.3	Not to use in expressway **0.3 ***0.3
Connection	Cable Tie	Proprietary	Per PE's Design	Interlocking Device
Others	Minimum 0.5m from deep excavation. Not allowed if heavy pedestrian movement is expected.	Minimum 0.5m from deep excavation. Not allowed at deep excavation and at heavy pedestrian areas.	Beginning member should be tapered or flushed with ground level for safety purpose.	Minimum 0.5m from deep excavation.

*Expressways, **Major Roads, ***Other Roads

4-17 Safety Barriers for Road Works

4-17.1 A safety barrier is a device that is used to shield errant vehicles from impacting roadside features by containing the impact and redirecting the vehicle back onto the carriageway. In a work zone, they are used to shield temporary works to ensure the safety of all road users including pedestrians and the work site personnel.

Use of safety barriers for temporary road works

4-17.2 **Warrants for a road safety barrier** –A risk assessment has to be conducted to determine the need to use a safety barrier. The following are some examples of high risk locations where the use of safety barriers has to be considered:

(1) Next to embankment where the slope is 1v:3h or steeper.
(2) Next to vertical drop.
(3) Next to existing rigid obstruction.
(4) Next to deep drains or uncovered drain within the clear zone of the road.
(5) Next to deep excavations.
(6) At sharp bends where the desirable minimum radius of the carriageway is used.
(7) Adverse opposing traffic conditions.
(8) Along expressways.

4-17.3 Based on the principles of roadside hazard management, road safety barriers should only be considered if the roadside hazards cannot be removed, relocated or retrofitted. Considerations should always be given to provide as much clear zone as possible based on the road environment to enable the errant vehicles to recover by themselves without impacting on any rigid roadside hazards.

4-17.4 If the use of safety barriers is required, the design of the work zone and temporary traffic scheme has to consider the need to provide adequate space to install the safety barriers properly so that it will be able to function as intended.

4-17.5 **Requirements for a road safety barrier** – Due to the dynamic nature of a vehicle impact, the crash worthiness of a road safety barrier can only be assessed by subjecting it to a full crash-test and evaluated according to the requirements of the National Cooperative Highway Research Program (NCHRP) Report 350 or BSEN 1317. Safety barriers that meet these requirements are termed as type-approved.

4-17.6 The contractor has to demonstrate that the intended road safety barrier system has been certified to meet with the requirements of NCHRP Report 350 or BSEN 1317. The certification authorities include the U.S. Federal Highway Administration (FHWA) or the U.K. Highway Agency.

4-17.7 **Types of road safety barriers** – Road safety barriers can be generally categorised as either a non-rigid safety barrier or a rigid safety barrier. A non-rigid road safety barrier will dynamically deflect to contain and redirect an errant vehicle. Hence, there should be sufficient clear zone behind the safety barrier for it to fully deflect when impacted.

4-17.8 In comparison, for rigid safety barriers, the containment and redirection of an errant vehicle are achieved by the surface profile of the barrier itself. The energy of the impacting vehicle is dissipated as the vehicle glides along the traffic face of the rigid safety barrier.

4-17.9 Generally road safety barriers are classified either as:

(1) Non-proprietary; or
(2) Proprietary

Non-proprietary barriers are safety barriers whose design specifications can be found in international highway agencies websites or design manuals and available for users to refer to. For proprietary barriers, these have to be designed and installed according to the system manufacturer specifications.

4-17.10 **Examples of type-approved road safety barriers** – Examples of non-proprietary safety barriers includes the following :

Non-rigid safety barriers
(1) w-beam VIG.
(2) Thrie-beam VIG.

Rigid safety barriers
(1) Cast-in-situ concrete barrier.
(2) Pre-cast concrete barrier. (Pre-cast concrete barriers have to be anchored to the ground if there is no room for the barriers to deflect when impacted. The barriers may be painted in yellow and black bands shaped in an arrow similar to lateral shift markers.)
(3) Bridge parapet (e.g. P1-2).

4-17.11 In addition to the above, there are also typed-approved proprietary safety barriers that can be used for temporary road works, such as:

(1) Water-filled safety barrier.
(2) Steel safety barriers.

Example of pre-cast concrete safety barriers

Example of water-filled safety barriers

Example of steel safety barriers

4-17.12 **Selection of road safety barriers** – Only typed-approved safety barriers shall be used. Non-rigid safety barriers are used where there is sufficient clear zone behind the barrier for it to deflect when impacted. Typically for a standard w-beam VIG, a clear zone of 1.0m is required. There should not be any rigid objects such as lamp poles, sign posts, open drains etc within the clear zone. If the clear zone is not available on site, rigid safety barrier should be considered.

4-17.13 For work zone application, the selection of the safety barriers would also depend on the type of road works to be carried out. If the carriageway of the diversion scheme needs to be realigned over several stages, moveable safety barriers or water-filled safety barriers would be more suitable.

4-17.14 The selected safety barrier has to be used as a complete system and non type-approved modifications are not permitted.

Clear zone provided behind the w-beam VIG

4-17.15 **Design considerations** – The safety barriers have to be properly installed on site to ensure that they will be able to perform as intended and that the barriers themselves do not create a hazard to motorists. Some of the design considerations are as listed below:

(1) Protection of leading terminal – A type-approved end treatment has to be provided to shield the leading terminal of the safety barrier to reduce the severity of impact of a head-on collision.

(2) Terminal anchorage – Both leading and trailing terminals of the safety barriers have to be properly anchored to ensure that the deflection of the safety barriers will be within the designed limits.

(3) Flare rate – The flare rate of the safety barrier has to be designed based on the operating speed limit of the carriageway. This is to reduce the severity of the impact.

(4) Transition section – Where a non-rigid safety barrier will be joined to a rigid safety barrier, a proper transition section has to be provided to ensure that there is a gradual transition in the relative stiffness of the different types of safety barriers.

(5) Site terrain and features – The site terrain and features have to be designed as necessary to ensure that the safety barriers can function properly. Site terrain and features such as sloping ground conditions and road kerbs could have adverse effects on the function of the safety barriers.

4-17.16 Similar to the main section of the safety barriers, other components of the safety barrier such as the end treatment, terminal anchorage and transition section must also be certified to comply with the requirements of NCHRP Report 350 or BSEN 1317.

4-18 Water-Filled Safety Barriers

4-18.1 **Design** — Water-filled safety barriers are modular plastic containers of various sizes and shapes. Each unit shall come with interlocking devices for application on tangent straight and horizontal curves, and mounting devices for lighting.

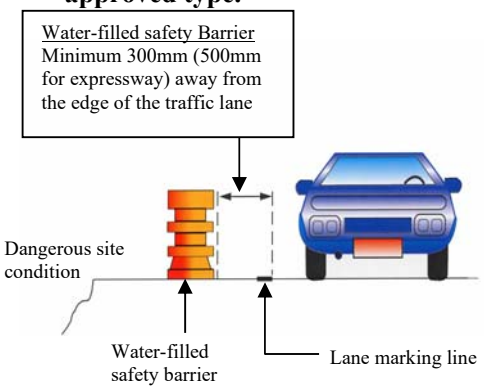
Example of safety barrier that meets NCHRP Report 350 Test Level 2 Crash Test

4-18.2 **Application** — Temporary safety barriers are used to prevent vehicles from penetrating work area and minimising injuries to people in the errant vehicles. Protective requirements of a work zone govern the use of temporary safety barriers.

(1) Used between traffic and severe hazards such as bridge piers or deep excavations or to separate opposing traffic and to protect workers on major roads and expressways.
(2) When erected parallel to the traffic flow, the effect of hitting the ends of the barrier shall be mitigated by flaring the ends away from the traffic or by the use of impact attenuators.
(3) Placed at a minimum of 0.3m away from the delineation in alternate white and orange to provide superior day and night visibility.
(4) Other requirements for application shall comply with the manufacturer's recommendation.

(5) The device used on roads with speed limit not higher than 70km/hr shall meet NCHRP Report 350 Test Level 2 Crash Tests (National Co-operative Highway Research Programme) , and if speed limit is higher than 70 km/hr, it shall meet NCHRP 350 Level 3 Tests.

Site Supervisors should ensure that WFSB used on site to temporarily replace permanent barriers is of the approved type.



4-19 Impact Attenuator (Stationary & Truck Mounted)

4-19.1 **Design** — Impact attenuator is an energy-absorbing device. This proprietary made product shall pass acceptable performance test (NCHRP Report 350 Test Level 3) and be designed for each application to ensure performance.

4-19.2 **Application** — Stationary attenuators or crash cushions shall be used only if other suitable end treatments are not appropriate as the leading terminal of a safety barrier for long duration works along expressways and other roads where the operating speed limit is ≥70km/hr. For other road environments, a crash cushion is also warranted at high risk locations such as at a road bifurcation. As crash cushions are proprietary products, they shall be designed and installed by the Manufacturer Certified Installer.

Example of a stationary attenuator system

Use of crash cushion to shield the leading terminal of the w-beam VIG.

Use of crash cushion to shield the leading terminal of the concrete safety barrier

4-19.3 Truck mounted attenuators attached to the rear of protective vehicle shall be used during short duration and mobile works to absorb the impact of the errant vehicle.

Example of a truck-mounted attenuator (TMA)

4-20 Visibility Enhancing Devices

4-20.1 They are mounted on supports, barricades, barriers or other channelling and delineation devices to warn road users/ worker/ motorists by enhancing the visibility of the temporary traffic control devices, and hazards within the work zone particularly at night.

4-21 Retro-reflective Disc

4-21.1 **Design** — It is a 200mm round disc fitted with Fluorescent Orange Wide Angle Prismatic Retro-reflective sheeting on an aluminium plate or any other suitable mounting substrate.

Example of retro-reflective disc

4-21.2 **Application** — Retro-reflective discs are to be spaced at regular intervals to provide a continuous line of sight. The interval shall be 6m c/c and 10m c/c for minor roads and expressways/ major roads respectively. It is an economical and effective visual enhancing device. It shall be mounted facing the direction of the traffic, at about 1m above the ground on the delineation devices. It shall not be used for pedestrian footpath and off-road areas. Flashing beacons are to be used instead.

4-22 Flashing Beacons

4-22.1 **Design** - It is a portable, lens-directed, and enclosed amber light device (200mm diameter). It shall be able to operate in STEADY mode or FLASHING mode complying with BS 3143 Part 2 "Low intensity battery-operated lamps" or complying with BS 3143 Part 4 "High intensity battery-operated lamps".

4-22.2 **Application** — Beacons should operate in:

(1) STEADY mode and be mounted on the delineation devices about 1m above the ground to delineate the vehicle path. They shall be spaced at regular intervals to provide a continuous line of sight.

    (a) Minor road - 6m c/c
    (b) Major road - 10m c/c
    (c) Expressway – 10m c/c

(2) Low intensity FLASHING mode and shall be used together with a temporary advance warning sign to draw road users' attention to hazards ahead. It shall be used as a danger lamp to indicate to road users the limit of a temporary obstruction of a road.

(3) High intensity FLASHING mode and shall be used 24 hours a day in extremely hazardous situations.

Example of flashing beacon

4-22.3 Flashing beacons shall not be used for delineation because of the confusing light pattern that is produced when they are placed in series. Pedestrian footpath and off-road areas shall be lined with flashing blinkers and not by retro-reflective discs.

4-23 Portable Amber Rotating Lamps

4-23.1 **Design** - It is a battery-operated device with amber enclosed light and a rotating parabolic reflector complying with BS 3143 Part 4 or approved equivalent.

Example of a portable amber rotating light

4-23.2 **Application** - These are powerful attention-seeking devices and the uses are as follows:

(1) Mounted on vehicles, plant and equipment during operation to warn road users of their presence.
(2) As a danger lamp to indicate to road users the limit of a temporary obstruction of a road 24 hrs a day in extremely hazardous situations.
(3) Placed behind channelling or delineation devices.

4-24 High Visibility Warning Cloth

4-24.1 **Design** - The design shall be lightweight and cool, and of 100 percent polyester knit fabric or woven mesh. The vest shall be fluorescent lime yellow embossed with organisation identification /logo. The retro-reflectivity of the double vertical and horizontal bands shall comply with European Standard EN 471 Class 2 for High-visibility warning clothing. The list of approved safety vests to be used may be found in the "Product Listing Scheme" (PLS) administered by the Singapore Productivity and Standards Board (PSB)

4-24.2 **Application** - All personnel working on or near the road shall put on the vest to make them more conspicuous and to warn road users of their presence. A worker with a red orange fluorescent vest could be mistaken as a temporary sign from afar. The use of the lime yellow vest can help the motorist distinguish a worker from a temporary sign. Only fluorescent lime yellow shall be used on a work zone for ease of identification.

FRONT BACK

FRONT BACK

Summary

Visibility Enhancing devices				
Type	Retro-reflective Disc	Flashing Beacon	Portable Amber Rotating Lamp	High Visibility Warning Cloth
				
Size	200mm diameter	Proprietary	Proprietary	Per requirement
Colour	Fluorescent orange	Amber	Amber	Fluorescent lime yellow
Reflectivity	Wide Angle Prismatic	Battery-operated	Battery-operated	EN 471 Class 2
Mounting height (min)	1m	1m	1m	NA
Delineation spacing	*10m c/c **10m c/c ***6m c/c	*10m c/c **10m c/c ***6m c/c	NA	NA
Material	Plastic or Aluminium plate	Plastic housing	Plastic housing	100% polyester mesh
Standard	Per this manual	BS 3143 Part 2/4	BS 3143 Part 4	EN 471 Class 2

*Expressways, **Major Roads, ***Other Roads

Other Devices

4-25 Use of Other Devices

4-25.1 The Authority may direct, when the situation and condition require, such devices and/or any other necessary devices to be used to enhance and complement the devices used in the road construction work zone.

Example of a portable traffic light

4-26 Portable Traffic Light System

4-26.1 **Design** — To refer to the guidelines for portable traffic light under Appendix III.

4-26.2 **Application** — Portable traffic light to regulate traffic for shared right of way shall be used when traffic control is required.

4-27 Flashing Arrow

4-27.1 **Design** - Flashing arrows are diesel or solar-powered lamps flashing sequentially to create a chevron pattern, indicating a move to the left or right. It is usually mounted on truck for mobile work and trailers for other works.

Example of a variable message sign (VMS) displaying flashing arrows

4-27.2 **Application** - They are used where extra assistance is required due to difficult road conditions, to warn motorists about lane closures ahead and the side where work is carried out. They shall be placed behind channelling or delineation devices.

4-28 Variable Message Sign

4-28.1 **Design** - This is a proprietary-made, battery-operated traffic sign mounted on vehicle or trailer capable of displaying real-time information.

4-28.2 **Application** - It is displayed in advance to supplement other devices to provide additional advance information to the road user. Truck-mounted signs are used for mobile works and trailer-mounted signs are for stationary works.

4-28.3 The sign can be used during one of the following scenarios:

- Construction or maintenance work zone.
- Incident management
- Advance notice of traffic scheme implementation.
- Notification of future construction or event.

4-28-4 The sign can provide a unique message that alerts the motorist and support signing for:

- Speed reduction.
- Advance notice of lane closures and shifts.
- Diversion to a different route.
- Advance notice of ramp closures.
- Changes in alignment or surface conditions.

4-29 Solar-powered Portable Changeable Flashing Arrow

4-29.1 **Design** - This is a proprietary-made, solar-powered portable changeable flashing arrow is mounted on a semi A-frame and provides advanced warning and directional information in diverting and controlling the traffic around maintenance and construction zone.

4-29.2 **Application** - It is displayed at the start of the taper to warn motorist of the lane closure.

4-30 New Devices

4-30.1 Recommendations for use of new temporary traffic control devices shall be subject to evaluation and approval by the Authority.

Chapter 5 Implementation, Operation & Maintenance and Closeout

5-1 General

5-1.1 This chapter contains guidelines and procedures on the following three phases of temporary traffic control: —

(1) Implementation — installation of traffic control devices.
(2) Operation & maintenance — inspection & maintenance of traffic control devices to ensure effectiveness and safety.
(3) Closeout — removal of temporary devices and replacement with permanent devices.

5-1.2 These three phases of traffic control are depicted in an action flowchart (fig. 5.1) which shows the complete process of planning, design, implementation, operation & maintenance and close-out. The process involves continual checks and feedback throughout the life cycle of a traffic control plan.

5-1.3 Safe implementation, operation and maintenance are important to a successful traffic control and road safety. Approved traffic control plans shall be implemented before works can commence.

5-2 Implementation Procedure

5-2.1 A full-time qualified supervisor shall be appointed to implement TCPs before works start. Implementation includes preparation and execution. The supervisor shall perform the following duties: —

(1) **Preparation Phase**

(a) Verify that the engineer has approved the TCP.
(b) Prepare a method statement and seek the engineer's approval.
(c) Set out the components of the work zone by marking the positions on the ground.
(d) Verify that the setting-out is suitable and feedback to the engineer if modification is required.
(e) Determine and prepare all devices to ensure that they are available and in good working condition.
(f) Inform the relevant authorities in advance of the day of implementation.
(g) Ensure that the personnel assigned to place the devices are aware of their duties.

(2) **Execution Stage**

(a) Place the devices following a safe system.
(b) Cover the traffic signs and devices with suitable material before they are required and remove the covers upon implementation.
(c) Cover permanent signs that have become inapplicable or misleading.
(d) Check for adequacy and clarity of the traffic control layout before work starts and seek approval to alter the plan if needed.

Implementation, O&M and Close-out flowchart

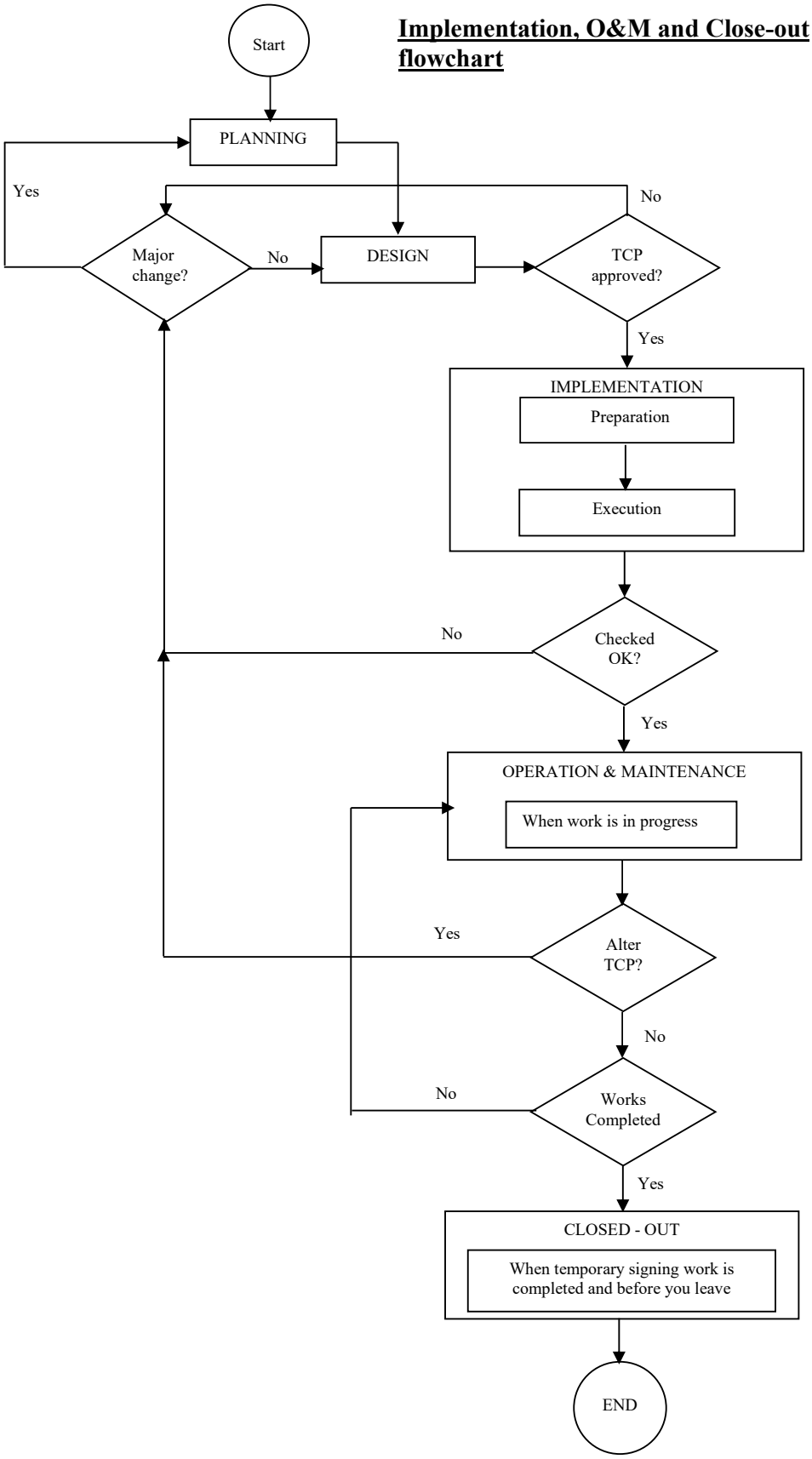


Fig 5.1

5-3 Operation Procedure

5-3.1 The same supervisor should supervise the operation. He should perform the following daily routine tasks:-

(1) **Before work starts**
- (a) Inspect and record devices that have been displaced or damaged during the night or the day before.
- (b) Deploy a protective (shadow) vehicle where needed.
- (c) Make adjustment to the devices for the day's work.
- (d) Check the safety and effectiveness of the devices through a drive.

(2) **When working**
- (a) Ensure at all times that the signing represents the prevailing conditions accurately.
- (b) Ensure that workers do not stray into adjacent live traffic lanes and safety zone.
- (c) Ensure that nothing e.g. equipment, machinery, material, vehicles, men etc is within the safety zone.
- (d) Manage parking of vehicles and the movement of work traffic in and out of the work zone (use report form for illegal parking).
- (e) Ensure that access to the work zone is properly maintained.
- (f) Assist owners to remove stalled vehicles causing congestion at the work site to a safe location.
- (g) Attend to road accidents and other problems encountered at site.
- (h) Check that the floodlight does not dazzle drivers.
- (i) Re-position devices that have been displaced by traffic.

(3) **End of workday**
- (a) Re-position devices at the end of the work.
- (b) Ensure that the signing represents the prevailing conditions.
- (c) Check the safety and effectiveness of the devices by driving through.

(4) **After the workday (inclusive of weekends and holidays)**
- (a) Assign personnel to inspect and maintain the devices.
- (b) Provide after-hours contact for replacing damaged and displaced devices.
- (c) Record all damaged or displaced devices.

(5) **Daily record keeping**

The supervisor shall keep daily records of:-
- (a) The sign arrangement and layout of devices erected on the road by reference to approved Traffic Control Plan.
- (b) The hours of operation and the surface condition of the road. Any significant departures from, or additions to, the signs and devices.

(6) **Accident reporting**

Supervisor shall record and report any road accident, whether witnessed or reported to the engineer including the following:
- (a) The actual type, size and location of signs, and devices in use at the time of accident.
- (b) The sign arrangement photographed for subsequent reporting.
- (c) Details of the actual travelled path width and condition and weather conditions.
- (d) Involvement of public or workers from which legal proceedings may arise.

The report format and procedure for road accident shall comply with traffic police requirements.

5-4 Closing out Procedure

5-4.1 The following routine should be followed when closing out a traffic control plan:-

(1) Carry out a pre-close-out inspection of the work zone.
(2) Reinstate all markings and make good all defects on road.
(3) Restore all permanent signs that were covered or removed.
(4) Clean up the site.
(5) Remove the devices by following a safe procedure.
(6) Ensure that the permanent devices are in order of original positions before leaving the site.

5-5 Inspection Procedure

5-5.1 The engineer shall plan and ensure that all inspections are carried out throughout the duration of traffic control plan. The inspections shall be carried out at the normal speed along the entire travel path by day and night.

(1) **Inspector's duties**

The inspectors shall ensure that, in conforming to the approved traffic control plan:

(a) There are no contradictory signs.
(b) There are no superfluous or distracting signs.
(c) The traffic control plan fits with other traffic control in the area.
(d) Devices are suitably placed, by considering sight distances, motorists approaching at high speed, expected queue lengths, visibility, shady or high-glare areas.
(e) Signs and devices are in place at appropriate times, and removed or covered when not needed.
(f) Damaged or defective signs are replaced or rectified as soon as practicable.
(g) Surface of travelled path is maintained in a satisfactory condition.
(h) Checklists shall be used for all inspections.

(2) **Inspection Schedule**

The engineer shall plan for the inspection schedule based on the following minimum frequencies:

(a) Day and night inspections by the supervisor and engineer on the day of implementation.
(b) At least one day and one night inspection by the engineer for short-term work.
(c) Fortnightly day inspections and monthly night inspections by the **engineer for long-term work.**
(d) Daily day inspections and weekly night inspections by the **supervisor with reports to the engineer.**
(e) Day and night inspections by the engineer and site supervisor upon completion of physical work to ensure only appropriate signs remain and to arrange for other on-going work.
(f) Day and night inspections by an independent inspector once per month.

(3) **Follow-up Action**

The inspector shall submit all results of inspections and records to the engineer for evaluation, recommendation and noting. The authorised person shall be responsible for ensuring that any corrective actions required/recommended/ approved by the engineer are followed up expeditiously. The records shall include: —

(a) Date and time of the incident.
(b) Deficiencies and changes made.
(c) Issues raised and corrective action required/recommended.

(4) **Demerit Point System**

The performance of the traffic control plan reported by the Independent inspector will be assessed using a demerit point system and appropriate actions would be taken against irresponsible parties. The details of the Demerit Point System refers to the 'Authority's Code of Practice for Road-Opening Works' (for services departments' contractors) or Demerit Point System specified in the contract such as 'Demerit Points And Administrative Charges For Safety And Housekeeping Infringements'.

5-6 Maintenance Procedure

5-6.1 A designated inspection and maintenance vehicle shall be used for routine inspection and maintenance of the temporary traffic control plan. The vehicle shall be painted with a distinctive bright colour and fitted with cab-mounted rotating amber light or amber flashing arrow panel. The vehicle shall be loaded with additional devices for immediate replacement. An adequate stock of devices used shall be kept on site.

5-6.2 The daily routine maintenance activities shall include the following: —

(1) Clean all dirty signs to ensure that they are kept clear and legible at all times.
(2) Replace and dispose off damaged or defective devices promptly so that they are not inadvertently re-used.
(3) Re-position all displaced devices to their proper locations.
(4) Clear away any debris, mud etc, on the work site daily or as soon as it is safe and practical.

5-7 Installation Procedure for Long-Term Work

5-7.1 Securing the work zone for long-term work may need more effort and longer time due to the elaborate temporary traffic control devices used. Placing and removing of devices for long-term work can be treated as normal roadwork. The work zone should be temporarily secured for the placement of the longer-term devices. The following procedure shall apply:

(1) Secure the work zone temporarily with portable devices following the procedure for short-duration work quickly.
(2) Install the actual traffic control devices for longer-term works according to the plan and method statement.
(3) Remove the portable temporary devices installed following the procedure of removal for short-duration works.

5-8 Installation Procedure for Short-Duration Work

5-8.1 Securing the work zone temporarily is a critical safety activity. When installing and removing devices on major roads (70kph or more) and expressways, a Truck-Mounted Attenuator (TMA) shall be deployed. The TMA attached to the protective truck plays a very important role in keeping the road environment safe. The operation procedure for the TMA is included in **Appendix II** under specifications for TMA.

5-9 Mobile Operation

5-9.1 The procedure for closing a lane for mobile work is similar to that for the short-duration work except that no devices will be placed on the road. The qualified supervisor shall conduct the following activities: —

(1) Brief all persons involved of the removal procedure and ensure that they are properly attired with reflective vests. Appoint and equip a lookout with red warning flag or traffic baton, hand phone or radio set.
(2) Move the works vehicle and protective vehicle installed with a TMA in the same manner

described above for the short-duration work into the works zone. Reduce speed, well in advance, as the vehicles move closer to the starting point of the mobile work.

(3) The operator shall activate the arrow panel to warn motorists. The operator shall ensure that the arrow panel is displaying the correct signal i.e. right arrow for work on the slow lane etc.

(4) Deploy the lookout at a safe distance upstream of the vehicles. Move the protective vehicle and works vehicle slowly forward to close the lane. DO NOT REVERSE THE PROTECTIVE VEHICLE IN THE TRAFFIC LANE ON EXPRESSWAY.

(5) The works vehicles and the protective vehicle shall move forward only with the lookout following behind. The lookout shall use a warning flag to alert motorists to slow down.

(6) The supervisor shall signal to the worker to start work when it is safe to do so. The vehicle moves gradually forward, keeping a safe distance(25m), behind until completion of work.

(7) Once all the equipment and workers are on the works vehicle, allow it to accelerate & merge with the traffic. Once it is safely on its way, the protective vehicle should join the flow of traffic with the TMA down and the flashing arrow and rotating lights on.

(8) The protective vehicle shall exit the expressway and high-speed road at the first instance. Drive to the nearest safe place to stop. Raise the TMA until it is in a vertical upright position. Switch off the flashing lights before returning to the office.

5-10 Removal Procedure

5-10.1 **Short-Duration Work -** The qualified supervisor shall supervise the removal of the devices when the work has been completed and the road needs to be re-opened to the traffic. The procedure to remove the devices for short-duration work is similar to that for mobile operation. The qualified supervisor shall conduct the following activities: —

(1) Brief all persons involved of the removal procedure and ensure that they are properly attired with reflective vests. Appoint and equip a lookout with red warning flag or traffic baton, hand phone or radio set.

(2) Move the works vehicle and protective vehicle in the same manner described above for the short-duration work into the works zone.

(3) Deploy the lookout at a safe distance upstream of the advance warning zone. DO NOT REVERSE THE PROTECTIVE VEHICLE IN THE TRAFFIC LANE ON EXPRESSWAY.

(4) The works vehicles and the protective vehicle shall move forward only with the lookout following behind. The lookout shall use a warning flag to alert motorists to slow down.

(5) Remove the devices starting with the upstream end while the vehicle moves gradually forward until completion. Always keep a safe distance while worker is removing the devices.

(6) Clean the work zone simultaneously while removing the devices upon completion. Be sure that the lookout uses the warning flag to signal and warn oncoming traffic of the works vehicle at all times.

(7) Depart from the work zone as described above.

5-10.2 **Short and Long-Term Work –** When the work has been completed and the road needs to be re-opened to the traffic, the following procedure shall apply: —

(1) Secure the work zone temporarily with portable devices following the procedure for short duration work as fast as possible.

(2) Remove the devices according to the plan and method statement.
(3) Remove the portable temporary devices installed in Phase I following the procedure for short-duration work.

5-11 Safe Operation Procedure for Truck Mounted Attenuator

5-11.1 Only a trained driver/operator is allowed to operate the TMA. The operator shall carry out daily routine checks on all items contained in the inspection checklist provided by the manufacturer and maintain the TMA in tip-top condition. The procedure is detailed in **Appendix II** under specifications for TMA.

5-12 Road Safety Precautions

5-12.1 **A qualified safety supervisor** shall brief all workers and supervisors of the following road safety precautions which they have to observe prior to working on the road:

(1) Park your vehicle safely before unloading.
(2) If possible, park your vehicle off the road.
(3) Make sure the vehicle can be clearly seen by other drivers.
(4) Turn on the roof mounted amber beacons.
(5) Set up a “Keep Right” sign at the outside corner of the vehicle.
(6) Always face the on-coming traffic when placing devices.
(7) Stay on the verge/shoulder as far as possible.
(8) Walk behind the Vehicle Impact Guardrail (VIG) on expressways.
(9) Do not use your arm to control traffic.
(10) Do not cross in front of a stationary vehicle.
(11) Do not cross in between stationary vehicles.
(12) Do not dash across the road without regard for on-coming vehicles.
(13) Do not jay walk.
(14) Ensure that workers are wearing reflective vests.

5-13 Method Statement Format

5-13.1 A good method statement will assist the qualified supervisor to implement the temporary traffic control plan successfully. The qualified supervisor shall prepare and submit to the qualified engineer a method statement with the basic information given below. The Authority may require method statement to be submitted prior to the implementation of a traffic control plan.

PROJECT: (Title)

(Method Statement on the implementation of traffic control plan should include the following)

a) Scope of Works
Type of work
Dimension: length & width etc.
Designs drawing

b) Location and Access
The proposed work is located at.....
The works can be accessed from.....
Access will be restricted by .....
Material will be transported in by.....

c) Preparation Works
List of temporary traffic devices.
Hoisting of the devices.
Preparation of the temporary traffic control devices.

d) Machinery and manpower
TMA
Transportation
Lifting facilities
Number of workers
Duties etc.,

e) Works Sequence and schedule
Starting time and ending time
Activity sequence
Contingency plan

5-14 Co-ordination with Relevant Authorities

5-14.1 Co-ordination with other relevant agencies is essential in the planning as well as later stages of the work. The agencies shall be consulted if the temporary traffic control e.g. Road closure affects their operation: —

(1) **Traffic Police**: It is important to inform the Traffic Police, the enforcer of traffic rules and regulations of the change in traffic scheme on work zone and duration. At times, traffic police's assistance will be needed to control the traffic.

(2) **Fire Safety Bureau**: It is important to inform the Civil Defence Force about the change of the site condition or any obstruction. Fire Safety Bureau can then update their routine plan and the emergency plan and avoid passing by the construction site.

(3) **Public Transit Companies**: All the affected public transport companies such as Taxi, Singapore Bus Service (SBS), City Shuttle Bus, TIBS etc. must be informed. This will allow them to make proper arrangement to their operation to minimise inconveniences to the commuters.

(4) **Land Transport Authority**: Other departments of the Authority must also be consulted about the temporary traffic control plans in areas such as traffic signal, works in road tunnel and underpasses. The plan must be submitted to them for comment and approval before actual execution.

(5) **Hospitals**: The major government and private hospitals, such as Singapore General Hospital (SGH), National University Hospital (NUH), Mount Elizabeth Hospital, Kandang Kerbau Woman & Children Hospital (KKH), have to be informed as the temporary traffic control may affect the movement of the ambulance during an emergency. It is necessary for the hospitals to choose the appropriate road for their ambulance.

(6) **LTA (RF Dept)**: The Authority's Road & Facilities Department needs to be informed when public lighting posts are affected by temporary traffic diversion, so that temporary street light can be provided and existing street light re-sited.

(7) **SingTel**: When Traffic light and control box are affected by traffic diversion, SingTel must be informed to re-connect the traffic light control box in conjunction with PowerGrid power supply work. It is to ensure that traffic signal is properly set to its order.

APPENDIX I - Acts & Regulations

1) Regulation 4 of BOWEC

BOWEC, Regulation 4 of FACTORIES (BUILDING OPERATIONS AND WORKS OF ENGINEERING CONSTRUCTION) REGULATIONS, FACTORIES ACT (Chapter 104).

Obligations

4 (1) It shall be the duty of every contractor and every employer, who is undertaking any of the operations or works to which these Regulations apply —

(a) to comply with such of the requirements of these Regulations as affect him or any person employed, except that such requirements shall be deemed not to affect any employee if and so long as his presence in any place is not in the course of performing any work on behalf of his employer and is not expressly or impliedly authorised or permitted by his employer; and

(b) to comply with such of the requirements of these Regulations as relate to any work, act or operation performed or about to be performed by any such contractor or employer.

4 (2) It shall be the duty of every contractor and every employer who erects or alters any scaffold to comply with such of the requirements of these Regulations as relate to the erection or alteration of scaffolds having regard to the purpose or purposes for which the scaffold is designed at the time of erection or alteration.

4 (3) Every contractor and every employer, who erects, installs, works or uses any plant or equipment to which any of the provisions of these Regulations applies shall erect, install, work or use such plant or equipment in a manner which complies with those provisions.

4 (4) Where a contractor, who is undertaking any of the operations or works to which these Regulations apply, appoints any artisan, tradesman or other person to perform any work or service under a contract for services, it shall be the duty of the contractor to comply with such of the requirements of these Regulations as affect that artisan, tradesman or other person.

4 (5) For the purpose of paragraph (4), any reference in these Regulations to an employee shall include a reference to such artisan, tradesman or other person and the contractor shall be deemed to be his employer.

4 (6) It shall be the duty of every employee to comply with the requirements of such of these Regulations as relate to the performance of or the refraining from an act by him to co-operate in carrying out these Regulations.

4 (7) No employer or contractor shall permit an employee to do anything not in accordance with the generally accepted principles of sound and safe practice.

4 (8) No employee shall do anything not in accordance with the generally accepted principles of sound and safe practice.

4 (9) No person shall wilfully do any unsafe act which may cause injury to himself or to others.

2) Section 119 of Road Traffic Act (Chapter 276)

PART VI - PROVISIONS AS TO USE OF HIGHWAYS

Power to place traffic signs.

i) 119 (1) The Minister may cause or permit traffic signs to be drawn, placed or erected and maintained on or near any road, and any signs so drawn, placed or erected shall be subjected to and be in conformity with such general or special directions as he may give.

ii) Traffic signs shall be of the prescribed size, colour and type except where the Minister authorises the placing or retention of a sign of another character.

iii) No traffic signs shall be drawn or placed on or near any road except under and in accordance with subsections (1) and (2).

iv) The Minister shall by notice in writing, require the owner or occupier of any land on which there is any traffic sign or any object which so closely resembles a traffic sign that it might reasonably be taken to be such a sign to remove it and if any person fails to comply with such a notice, the Minister may cause the removal to be effected with as little damage as may be and the expense incurred in doing so may be recovered as a civil debt from the person so in default:

Provided that this subsection shall not apply in the case of any sign or object which complies with subsection (2) and the retention of which is expressly authorised by the Minister.

v) The Minister may authorise the entry upon any land and the exercise of such other powers as may be necessary for the purpose of the exercise and performance of his powers and duties under this section.

vi) In this Part, "traffic sign" includes all signals, warning sign posts, directional posts, signs, lines or other devices for the guidance or direction of persons using roads, but shall not include warning signs or other devices temporarily set up by any Government department to indicate that road work is in progress.

vii) Any person wilfully and unlawfully damaging, moving, defacing, altering or otherwise interfering with any traffic sign shall be guilty of an offence, and any police officer or the Registrar or any officer authorised in writing in that behalf by the Registrar on production of his authority may without warrant arrest any person found committing such offence.

viii) The Minister may make rules to prescribe the size, colour and type of traffic signs to be drawn or placed on or near roads.

3) Section 115 of Road Traffic Act (Chapter 276)

PART VI -
PROVISIONS AS TO USE OF HIGHWAYS

Power of Minister temporarily to prohibit or restrict traffic on roads.

i) Subject to this section, if the Minister is satisfied that traffic on any road in Singapore should, by reason of works of repair or reconstruction being required or being in progress on or under the road, be restricted or prohibited, he may restrict or prohibit the use of that road or any part thereof by vehicles or by vehicles of any particular class or descriptions to such an extent and subject to such conditions or exceptions as he may consider necessary.

ii) Subject to this section, the Minister shall, not less than 7 days before prohibiting the use of a road or part thereof under this section, cause notice thereof to be published in one or more newspapers circulating in Singapore. Every such notice shall contain a statement of the effect of the prohibition and a description of the alternative route or routes, if any, available for traffic.

iii) So long as any restriction or prohibition made under this section is in force, a notice stating the effect thereof and describing any alternative route or routes available for traffic shall be kept posted in a conspicuous manner at each end of the part of the road to which the restriction or prohibition relates and at the points at which it will be

necessary for vehicles to diverge from the road.

iv) Any person, authorised by name or office in writing in that behalf by the Minister, may at any time by notice restrict or prohibit temporarily the use of any road or part thereof by vehicles or by vehicles of any particular class or descriptions where, owning to the likelihood of danger to the public or of serious damage to the highway, it appears to him necessary that such restriction or prohibition should come into force without delay. Any such notice shall describe the alternative route or routes, if any, available for traffic and shall be kept posted in accordance with subsection (3) and shall not continue in force for a period longer than 7 days from the date thereof; but where such a notice has been posted the Minister may, before the expiration of that period, proceed to make restriction or prohibition under subsection (1) with respect to the same road or part thereof.

v) Any person who uses or causes or permits the use of a vehicle in contravention of any restriction or prohibition imposed under this section shall be guilty of an offence.

4) Rule 2 of Road Traffic (Traffic Signs) Rules

Rule 2 of ROAD TRAFFIC (TRAFFIC SIGNS) RULES [1S T November 1991], ROAD TRAFFIC ACT (Chapter 276, Sections 119 and 140).

Prescribed traffic signs.

i) Subject to any directions which the Minister may give under Section 19 of the Act, the traffic signs authorised to be drawn or placed on or near any road shall —

(a) Be at least of the size, and conform to the colour and type as prescribed in the diagrams set out in the Schedule; and

(b) Conform to the descriptions set out in these Rules.

ii) The dimension of the traffic signs as given in the diagrams set out in the Schedule denotes the dimension in millimetres unless otherwise stated.

iii) A traffic sign drawn or placed on or near a road shall be deemed to be a prescribed traffic sign and to have been so lawfully drawn unless the contrary is proved, and the fact that a traffic sign differs slightly in size, colour or type from that prescribed in these Rules shall not prevent the traffic sign from being a regular or lawful sign so long as the sign is not thereby misleading or its general appearance materially altered or its effectiveness impaired.

5) Section 17 of Street Works Act 1995

PART II -PUBLIC STREETS

Power to control works on public streets.

i) No person shall carry out any works on any public street, public bridge or on any street which is to be declared public unless he has obtained the prior approval of the Authority.

ii) An application to the Authority for its approval under subsection (1);

(a) shall be made in writing and shall be accompanied by a plan in duplicate, showing the location affected by the works; and

(b) may be granted by the Authority subject to such directions as may be given by the Authority under subsection (3).

iii) The Authority may give written directions to the person submitting the application with regard to all or any of the following particulars:
- (a) compliance with this Act and any regulations made thereunder;
- (b) the location and extent of the work and other related apparatus to be laid or erected;
- (c) the provision of footways and diversion roads and the size and specifications of such footways and diversion roads;
- (d) the design and construction method;
- (e) the period of the works;
- (f) the provision of temporary traffic signs and other road related facilities; and
- (g) the reinstatement of any affected public street or public bridge or any street which is to be declared public.

iv) Where in the opinion of the Authority any works have been carried out in contravention of the provisions of this Act or any regulations made thereunder, the Authority may by order in writing require —
- (a) the cessation of the works;
- (b) the removal of any installations;
- (c) the reinstatement of any affected public street or public bridge or any street which is to be declared public; or
- (d) such work or alteration to be carried out as may be necessary to cause the works to comply with the provisions of this section and in every case, the order shall specify —
  - (1) the manner in which the removal, work or alteration specified in the order is to be carried out;
  - (2) the time within which the removal, work or alteration shall commence;
  - (3) the time within which the removal, work or alteration shall be completed; and
  - (4) that the removal, work or alteration shall be carried out with due diligence to the satisfaction of the Authority.
- (e) An order made under subsection (4) shall be served on the owner of the works and the person carrying out the works.
- (f) If an order made under subsection (4) is not complied with, the Authority may —
  - (1) demolish, remove or alter the works or cause the works to be demolished, removed or altered, or take such other steps as appear to the Authority to be necessary or expedient; and
  - (2) recover all costs and expenses reasonably incurred by the Authority in the exercise of its powers under this section from the person in default.
- (g) Neither the Authority nor the Government shall be liable to make good any damage caused to or any loss of goods or property as a result of any work carried out under subsection (6).

(h) Without prejudice to the rights of the Authority to exercise its power under subsection (6), if any person on whom an order made under subsection (4) is served fails to comply with the order, that person shall be guilty of an offence and shall be liable on conviction to a fine not exceeding $100,000 and, in the case of a continuing offence, to a further fine not exceeding $1,000 for every day during which the offence continues after conviction.

(i) The Authority may levy a charge on the person who carries out works on public streets or public bridges or any street which is to be declared public.

(j) The charge shall be determined in accordance with such rate and method of calculation as may be prescribed.

(k) The Authority may require the person who made the application under subsection (1) to make a deposit before commencing any work.

(l) If the works are not executed to the satisfaction of the Authority in any case where a deposit has been made under subsection (11), the Authority may, at any time after the service of a notice, execute or cause any works to be properly carried out and the costs and expenses of any works executed or caused to be carried out by the Authority shall be recovered from the deposit made under that subsection.

6) Regulation 4 of Street Works (Works on Public Streets) Regulations 1996

Part II - AUTHORITY'S APPROVAL FOR WORKS ON PUBLIC STREET

No person shall commence or carry out, or permit or authorise the commencement or carrying out of any works on a public street unless he has obtained the approval of the Authority for the works to be carried out.

APPENDIX II - Specifications

Specifications for Reflective Sheeting

1. Scope

This specification covers flexible, non-exposed glass bead lens and microprismatic retro-reflective sheeting designed for use on traffic control signs, delineators, barricades and other devices.

2. Description

The sheeting shall be classified as follows :

2.1 High Intensity Sheeting

The sheeting shall consist of encapsulated glass bead elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface.

This retro-reflective sheeting or any other approved equivalent shall conform to Type III sheeting classification specified in ASTM D4956-2001 Standard Specification for Retro-reflective Sheeting for Traffic Control.

Typical applications for this material are:

- bands of traffic cones (white colour bands)
- bands of barricades (alternate orange and white colour bands)
- bands of traffic cylinders (white colour bands)

2.2 Wide angle Prismatic or Un-metallized Microprismatic Retro-reflective Sheeting

Super high intensity retro-reflective sheeting having very high retro-reflectivity characteristics at long and medium road distances as determined by R_A values of Table 10. This sheeting is typically an un-metallized microprismatic retro-reflective element material.

Typical applications for this material are:

- regulatory signs
- work zone warning signs
- information signs
- lateral shift markers
- reflective discs
- pedestrian walkway sign

The background colours of the wide-angle prismatic reflective sheeting or un-metallized microprismatic retro-reflective are:

Table 1 : Types of Signs and Colour Used

DEVICE	COLOUR
Work zone warning signs	Fluorescent orange background
Information signs	Fluorescent orange background White colour background on upper band of all information signs for the legend name of services departments. Fluorescent yellow colour is used for the 'smiling face icon' in the “End of Work Zone” sign.
Lateral shift markers	Fluorescent orange background
Reflective discs	Fluorescent orange background
Pedestrian walkway sign	Fluorescent orange background

3. Non-Fluorescent Colours

3.1 Daytime Colour

The colour of the sheeting shall conform to requirements of Table 1 and one of the following Table 2 or Table 3 when tested in accordance with 3.3. Daytime and night-time colour shall have substantially the same hue.

Table 2 : Colour Specification Limits (Daytime)[A]

Colour	1		2		3		4	
	x	y	x	y	x	y	X	y
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404

Source: ASTM D4956 - 05, Table 17

[A] *The four pairs of chromaticity co-ordinates determine the acceptable colour in terms of the CIE 1931 Standard Colourimetric System measured with CIE Standard Illuminant D65*

Table 3 : Daytime Luminance Factor (Y %)[A]

Colour	Minimum	Maximum
White	27	---
Orange	14	30

Source: ASTM D4956 - 05 Table 6

[A] *For High Intensity sheeting*

Table 4 : Daytime Luminance Factor (Y %)[A]

Colour	Minimum	Maximum
White	40	---
Orange	12	30

Source: ASTM D4956 - 05 Table 10

[A] *Typically Non-Metalized Microprismatic except fluorescent orange*

3.2 Colourfastness

After the specified outdoor weathering (in accordance to Clause 3.4), the specimen shall conform to the requirement of Table 1 and one of the following: Table 2 or Table 3 when tested in accordance with 3.3.

3.3 Colour - Test for daytime colour

3.3.1 Determine the chromaticity and luminance factor Y(%) in accordance with Practice E 308, Test Method E 1347 and E 1349 and Practice E 991 and E 1164.

3.3.2 For rotationally non symmetrical materials, make a series of eight measurements. After each of these measurements, rotate the specimen 45^{0} in the same direction about the axis, normal to the specimen surface and average the data. Make additional measurements until such further measurements do not result in a change in Y value in excess of 1% of the average to that point

3.3.3 Instruments (spectrophotometers, colourimeters) used to measure daytime colour should have 45/0 or 0/45 illumination and viewing geometry. The illumination angle should not vary from 0^{0} by more than $\pm$ 15^{0} for 45/0 condition. For the 0/45 condition, the requirements for illumination are interchanged.

3.4 Outdoor Weathering

Conduct outdoor exposures in accordance with Practice G 7. During exposure, test panels shall be open backed and oriented at an angle of 45^{0} from the horizontal and facing the equator in accordance with Practice G 7. Expose two panels per location for thirty six (36) months. Conduct exposures in locations with the climate types shown in Table 4. Panel labelling, conditioning and handling of panels prior to exposure and during evaluation period shall be in accordance with Practice G 147.

Table 5 : Climate Types for use in Outdoor Exposures of Retroreflective Sheetings

Mean Monthly Temperature ^{0}C			
Climate Type	**Warmest Month**	**Coldest Month**	**Representative Example of a Typical Location**
Tropical summer rain	28 to 34	18 to 22	Miami, FL

Source: ASTM D4956 - 05, Table 16

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4. Fluorescent Colours

4.1. Daytime Chromaticity Limits

The material shall plot within boundaries described by the four corner points listed in Table 6 below when measured in accordance with the test Methods in Clause 5 of this Specification. (The saturation limit shall be considered to extend to the boundary of the chromaticity locus of spectral colors.)

Table 6 : Daytime Colour Specification Limits

Colour	1		2		3		4	
	X	y	X	Y	x	y	x	y
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442

Source: ASTM D4956 - 05, Table 17

[A] *The four pairs of chromaticity co-ordinates determine the acceptable colour in terms of the CIE 1931 Standard Colourimetric System measured with CIE Standard Illuminant D65*

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4.2. Total Luminance Factor and Fluorescence Luminance Factor

The material shall meet the following minimum requirements when measured in accordance with the test Methods in Clause 5 of this Specificatons.

Table 7: Total Luminance and Fluorescent Luminance Factor

Material Color Name	Y		Y_F
	Minimum	Maximum*	Minimum
Fluorescent Orange	20	None	10
Fluorescent Yellow	35	None	15

Total luminance factor (Y) and fluorescence luminance factor (Y_F).

* Applies only for materials intended for use with a white legend.

4.2.1 Luminance Factors.

It is the existence of fluorescent luminance that differentiates fluorescent specimens from their non-fluorescent counterparts. The luminance of a fluorescent specimen is the sum of two quantities, the luminance due to reflectance and the luminance due to fluorescence. Similarly, the luminance factor Y of a fluorescent specimen is the sum of two quantities, the reflectance luminance factor YR and the fluorescence luminance factor YF : Y = YR + YF. A YF value greater than zero establishes that the specimen is fluorescent (For non-fluorescent specimens YF = 0, so Y = Y_R). The fluorescence luminance factor determined under a set of standard measurement conditions provides a metric that both verifies the presence of fluorescence and quantifies the fluorescent efficiency of an object-color specimen.

4.3. Night time Chromaticity Limit

The material shall plot within the following boundaries described by the four corner points listed in Table 8 below when measured in accordance with ASTM test method E811and evaluated using the CIE system in ASTM E-308. (The saturation limit shall be considered to extend to the boundary of the chromaticity locus of spectral colors.)

Table 8: Chromaticity Coordinates (x,y) of the corners of the regions for the colours of Fluorescent Retroreflective Materials

[CIE Illuminant A, Observation angle of 0.33 degrees and entrance angle of 5 degrees; CIE 1931 Standard Observer]

Material Colour Name	1		2		3		4	
	x	y	x	Y	x	y	x	y
Fluorescent Orange	0.625	0.375	0.669	0.331	0.636	0.330	0.589	0.376
Fluorescent Yellow	0.554	0.445	0.610	0.390	0.569	0.394	0.526	0.437

5. Testing of Chromaticity

5.1 Specimen Preparation

The test specimen shall be measured mounted on the material they will be used on in service.

5.2 Cleaning

Exposed specimens should be cleaned prior to testing.

5.3 Daytime Test Methods

5.3.1 The measurement of chromaticity and luminance factors shall be in accordance to test methods in ASTM E-991, using the two monochromator procedure.

5.3.2 Test Geometry – The geometry for 45/0 (0/45) measurements is described in ASTM E1164 and E-1349.

5.3.3 For rotationally non-uniform materials, make a series of eight measurements. Make each measurement by rotating the specimen 45º in the same direction about an axis normal to the specimen surface and average the data.

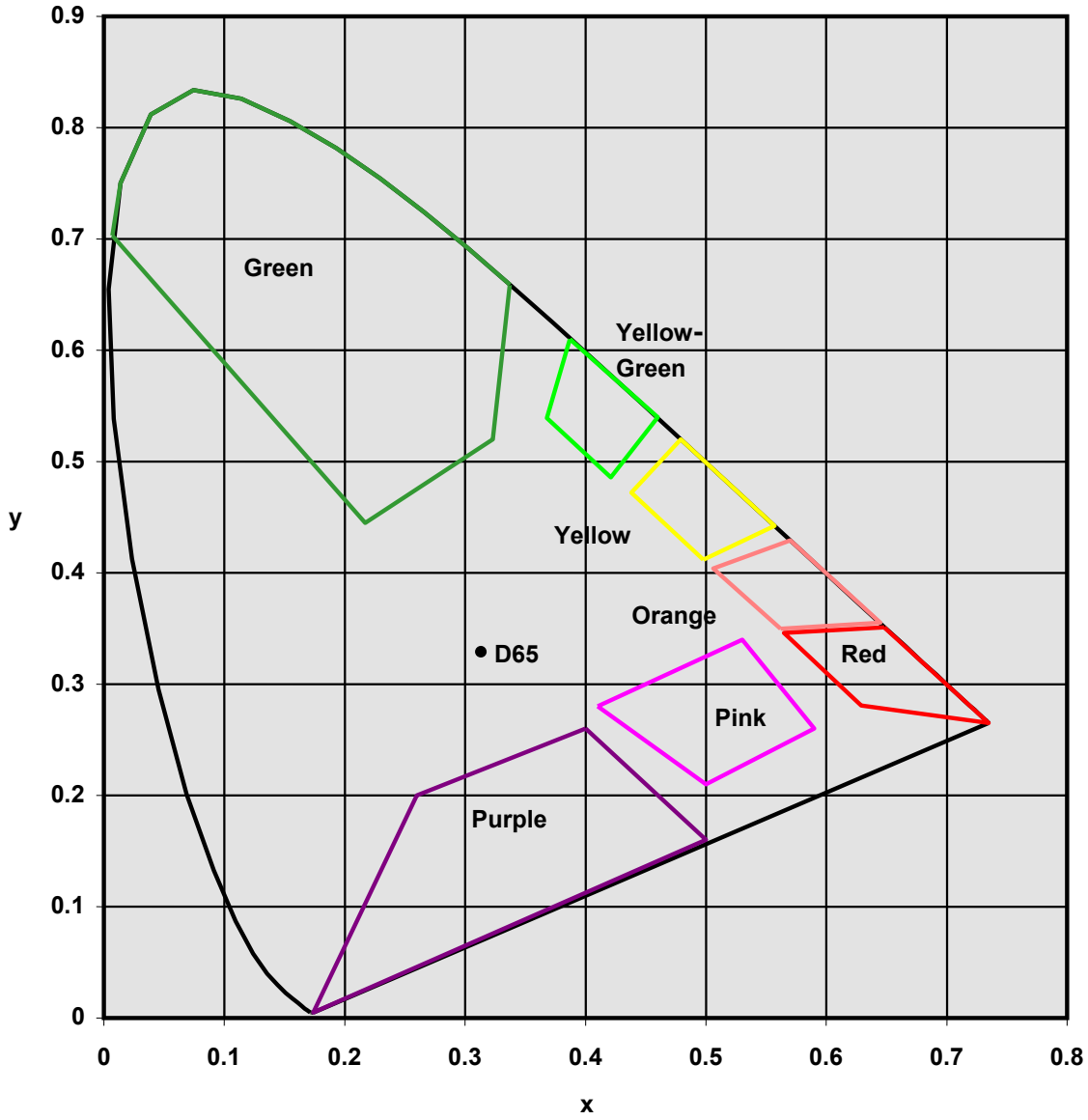
5.3.4 Instrument used to measure daytime colour should have 45/0 or 0/45 illumination and viewing geometry as described in ASTM E-1164. For referee purposes on microprismatic materials, the illumination and viewing geometry shall be the uniform illumination of a 10 degree illuminating (viewing) cone angle centred at 0 degrees and a uniform response pf a 10 degree annular ring viewing (illuminating) cone centred at the 45 degree angle.

5.4 Night Time Test Method

The measurement of night time chromaticity shall be in accordance with test methods of ASTM E-811. The Observation Angle shall be 0.33 degrees. The Entrance Angle shall be $\beta_1 = 5$ degrees and $\beta_2 = 0$ degrees. The rotation angle shall be 0 degree. The source aperture shall illuminate uniformly from a cone angle of 10 minutes of arc and the receptor aperture shall be a uniformly sensitive within a cone angle of 10 minutes of arc.

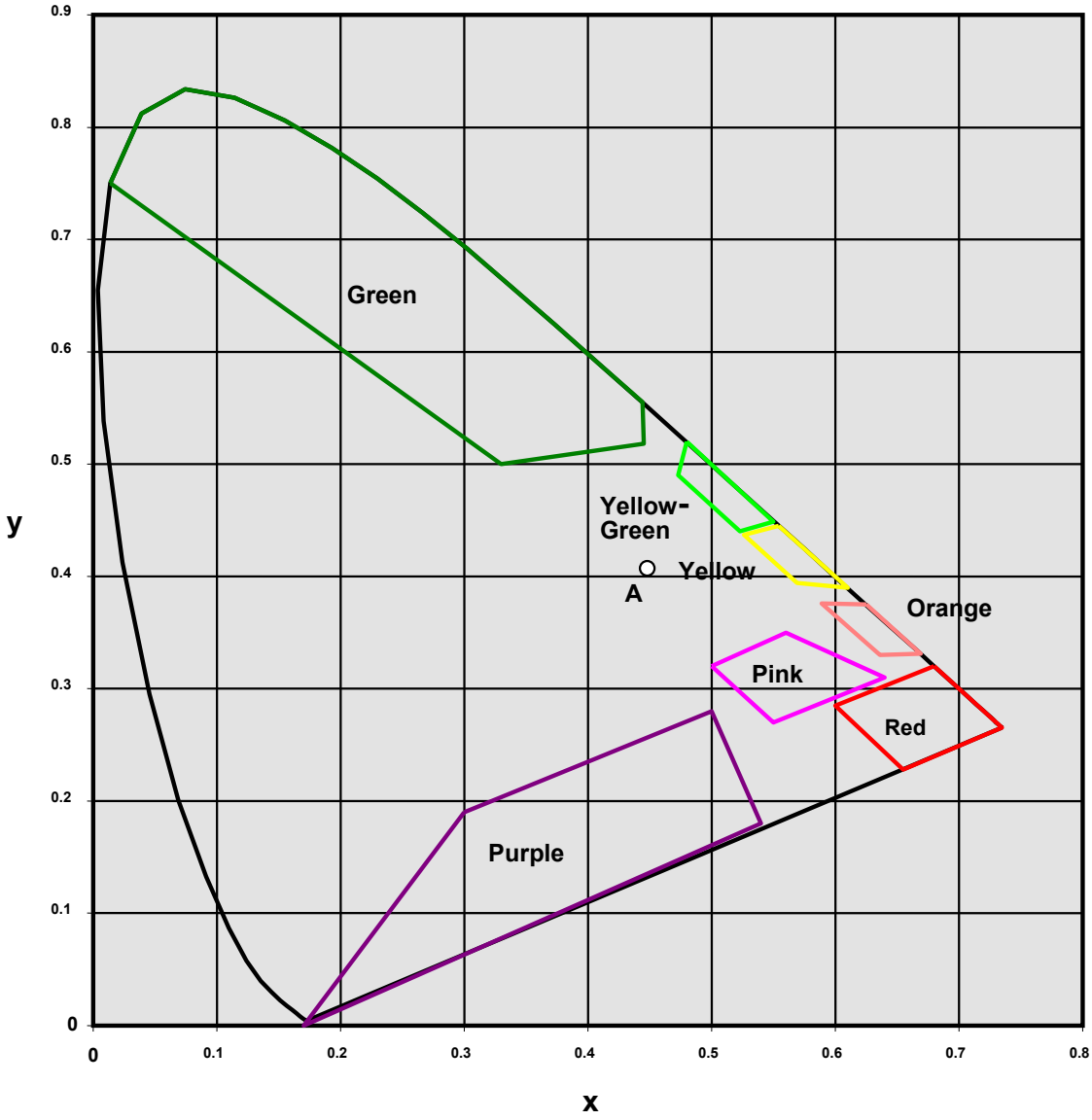
Daytime Color of Fluorescent Retroreflective Materials

CIE Illuminant D65 / CIE 2º Obs / 45/0(0/45)



Nighttime Color of Fluorescent Retroreflective Materials

CIE illumination A / CIE 2º obs / 0.33 obs angle and 5º entrance



6. Coefficient Of Retro-reflection

The coefficient of retro-reflection shall be determined in accordance with ASTM E-810 for the following minimum requirements.

6.1 High Intensity - The coefficient of retro-reflection R_A of the sheeting shall meet the following minimum initial readings as stated in ASTM D4956-05 for High Intensity sheeting.

Table 9 : Initial reading (when brand new)

Minimum coefficient of retroreflection : (Candelas per footcandle per m^2)

Observation Angle	Entrance Angle	White	Orange
0.2°	- 4°	250	100
0.2°	+ 30°	150	60
0.5°	- 4°	95	30
0.5°	+ 30°	65	25

ASTM D495 -05, Table 8

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6.2 Wide angle prismatic or Un-metallised microprismatic - The coefficient of retro-reflection R_A of the wide angle retro-reflective sheeting shall meet the following minimum initial readings as shown in the table.

Table 10 : Initial reading (when brand new)

Minimum coefficient of retro-reflection : (Candelas per footcandle per m^2)

Observation Angle	Entrance Angle	Fluorescent Yellow	Fluorescent Orange	White
0.2°	- 4°	230	115	380
0.2°	+ 30°	130	65	215
0.5°	- 4°	145	72	240
0.5°	+ 30°	81	41	135
1.0°	-4°	48	24	80
1.0°	+30°	27	14	45

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7. Field performance requirement

The retro-reflective sheeting is acceptable to be reused or recycled for a minimum of 3 years provided it meets the minimum readings in the following table. Notwithstanding this, if the surface is defaced, scratched, stained, damaged or in the opinion of LTA that the sheeting is ineffective for its intended purpose, it shall be deemed unsatisfactory for use and shall be replaced with a new sheeting

7.1 Field performance requirement – High Intensity

Table 11 : At 3rd year performance life, minimum coefficient of retroreflection (candelas/footcandle/m^2) at 0.2° observation angle and –4° entrance angle

White	200
Orange	80

Source: ASTM D4956 -05, (Figures computed and interpolated from Table 9)
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7.2 Field performance requirement – Wide angle prismatic or Un-metallised microprismatic

Table 12 : Minimum coefficient of retro-reflection (candelas/footcandle/m^2) 90 degree rotation, at 0.2° observation angle and -4° entrance angle.

Fluorescent Orange	100	At 3rd year	*State of Connecticut DOT recommendations*
Fluorescent Yellow	165	At 7th year	*State of West Virginia Division of Highways Specifications*
White	304	At 3rd year	*ASTM D4956:2001 Table 3 & 14*

The above figures depicts the minimum reading the sheeting must achieved for continual usage, and
The minimum readings the sheeting must achieved under accelerated testing

8. Screening Equipment

8.1 The reflective sheeting shall be processed into traffic signs by screen processing, using approved transparent process coloured inks. For screen processing, screen mesh of high-grade polyester or nylon microfilament screen fabric and stencil film or photo film shall be used in accordance with the manufacturer's recommendations.

8.2 The screen frame shall be of rigid wood or metal frame which is well enough to provide a well area between the frame and open design. The screen fabric must be tightly and uniformly stretched and fastened onto the frame.

8.3 The squeegee for screen processing shall be sharp, medium to hard rubber or plastic blade. The squeegee must be long enough to cover the area to be screened with a 50 mm or greater overlap on each end.

8.4 A vacuum printing table shall be used for screen processing and it shall be perfectly flat with no nicks or scratches. The minimum size of the vacuum printing table shall be 610 mm X 915 mm.

9. Screen Processing

9.1 It is important that the transparent processed colour ink and reflective sheeting shall be brought to normal ambient room temperature and humidity before screen processing.

9.2 Before screen processing, the surface of the reflective sheeting ad screen shall be wiped to remove any dust or foreign matter and they shall be completely clean.

9.3 The screen processing shall be carried out using off contact screening method. Direct contact screening method shall not be used because the uneven contact with the sheeting by the screen may cause variations in colour layer thickness which may appear as swirls or shadows, particularly when the transparent colours on the reflective sheeting are viewed under reflective light.

9.4 Screen errors shall be rectified immediately before the colour dries, otherwise hidden damage to the sheeting may leave a visible outline or shadow where the colours have been applied. After removing errors, the suitability of the refurbished sheeting shall be determined for the intended use.

10. Curing and Drying

The reflective sheeting processed into traffic signs shall be air dried and individually racked on open racks or shelves to allow adequate air circulation. Fans directed through the racks or shelves may be used and are not mandatory. Air-drying shall be done at relative humidity of 20% - 50%. The processed signs shall be air dried for a minimum of 16 hours between colours and a minimum of 24 hours after the final colour.

11. Application for Reflective Sheeting

The application of the reflective sheeting processed into traffic signs shall be made on the treated aluminium sheet with a manually or mechanically operated 1200 mm wide squeegee roller application to crate a permanent long-life bond with the application surface and eliminate air bubbles and wriggles. The fabricated traffic signs shall be air dried for about 3 hours. No hand application is allowed.

12. Submission for approval for retro-reflective sheeting

12.1 Retro-reflective sheeting manufacturer shall perform periodical checks on their products to ensure compliance.

12.2 Submission for approval shall include valid test reports and illustrative pamphlets/technical information leaflets/catalogues, etc together with 0.3 m^2 sample for each colour of sheetings and/or materials. The test reports shall cover:

Table 13 : Lists of Tests Reports for Sheeting Approval

Test Requirements	Type of Material	Test Standards	Specifications
Colour Specifications Limits – non-fluorescent colours	All	ASTM 4956 Types VII and IX	Clause 3.1
Colour Fastness	All	ASTM Practice G7 and Practice G147	Clause 3.4
Chromaticity and Luminance Factor	All	ASTM Practice E308, Test Method E1347, E1349, Practice E991 and E 1164	Clause 3.3.1
Colour Specifications Limits – fluorescent colours	All	ASTM E 1164 and ASTM E308	Clause 4.1 and 4.2
Night time colour – fluorescent colours	All	ASTM E811 and ASTM E 308	Clause 4.3
Coefficient of retro-reflection	High Intensity	ASTM D4956-01	Clause 5.1
	Wide angle prismatic or Unmetallized microprismatic retro-reflective sheeting	State of Connecticut DOT Memorandum Item #1220002A dated 22 Jun 1994	Clause 5.2

12.3 All tests shall be performed by accredited laboratory by Singapore Productivity and Standards Board (PSB) or any approved Engineering Testing Laboratory.

Specification for Letterings

1. Alphabet and Numeral Template

The alphabet and numerals shall be die-cut of rounded block script. The font type, thickness, height and width of the alphabet and numerals shall be as shown in the attached diagrams which is also similar to that shown in the LTA Standard Details Of Road Elements, drawings nos. LTA/RD/SD99/DIR/1 to 5.
The size of the lettering shall be enlarged by the following factors as specified in Part 1 Section III of the Code Of Practice For Traffic Control At Work Zone:

Expressways : Minimum 6 times enlargement factor
Other roads : Minimum 4 times enlargement factor

The spacing between the lettering shall comply with the relevant tables specified in the LTA Standard Details Of Road Elements, drawing nos: LTA/RD/SD99/DIR/7 & 8.

2. Durable Black Cast Film

Durable, dimensionally stable, glossy vinyl film should be used as legends / letters on the work zone signs. The film shall be a 2 μ Cast Vinyl, with a pre-coated pressure activated adhesive protected by an easily removable liner. The film shall be carefully applied to achieve maximum adhesion and eliminate air bubbles and wriggles.

They should withstand severe weather and handling conditions. Should incompatible products be used, the contractor shall be liable to the Authority for any defects and make good such defects such as discolouration, peeling, cracking, shrinking or any other causes due to the manufacturing defects.

3. Transparent Process Inks

3.1 Compatible inks are to be used in conjunction with the manufacturing of road signs.
3.2 The inks shall be transparent in nature so that light can pass and be reflected through it when screen printed on the surface of the reflective sheeting.
3.3 It shall be comparable reflectivity to that of the reflective sheeting and good reflection shall be cast back to the light source in similar range of angles of that sheeting.
3.4 It shall have high durability to weather condition, normal heat and humidity. It shall not crack, delaminate and peel after being applied on the reflective sheeting and used on the roads. The life expectancy of the inks shall not be less than warranted period of the sheeting.
3.5 It shall have high stability in colour. Colour shall not easily fade when exposed to local weather conditions.

4. Process Coloured Ink

4.1 The transparent process coloured inks shall be used within one year after the date of purchase. The cans of inks shall be tightly sealed and if not, the inks may skin over which must be removed and disposed off before thinning and mixing.

4.2 Thinner specially designed to work with the inks shall be used. Extenders drying agents or other materials shall not be added because the effective performance life of colours will be reduced.

5. Thinning and Mixing

The transparent process coloured inks shall be mixed thoroughly either manually or mechanically. Generally, up to 10% thinner by volume may be added depending on the screen mesh and climatic condition. Thorough mixing shall be required after adding thinner and then the inks shall be strained through a standard paint strainer. The inks shall be allowed to stand for one hour to eliminate bubbles and re-stirred before use.

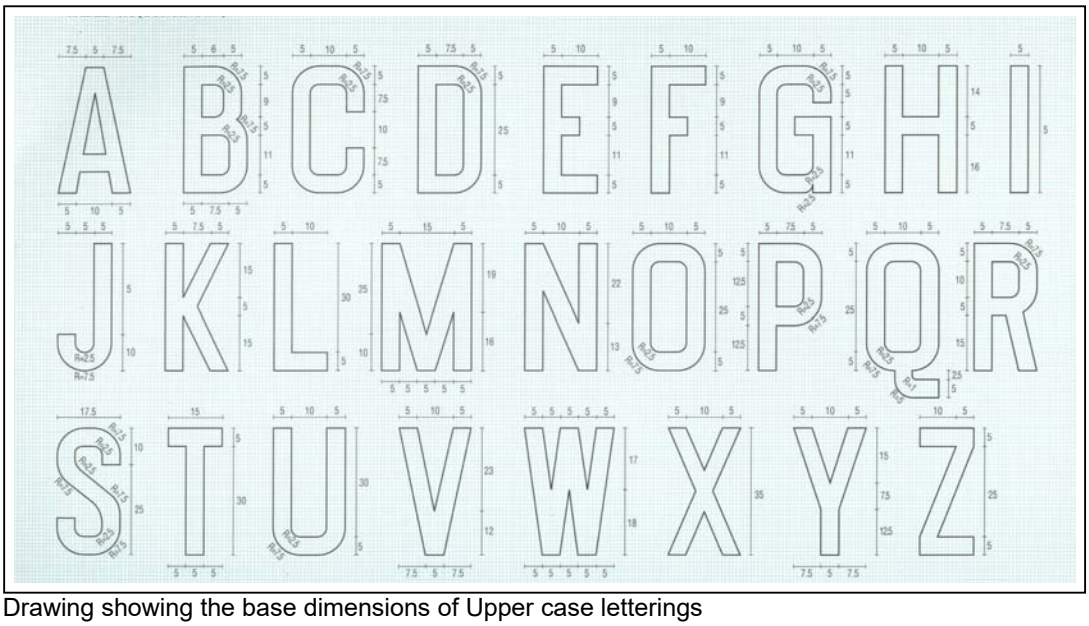
6. Alphabets and Numerals

6.1 The alphabet and numerals shall be of approved cast opaque black vinyl film. They shall be die-cast of rounded block script.

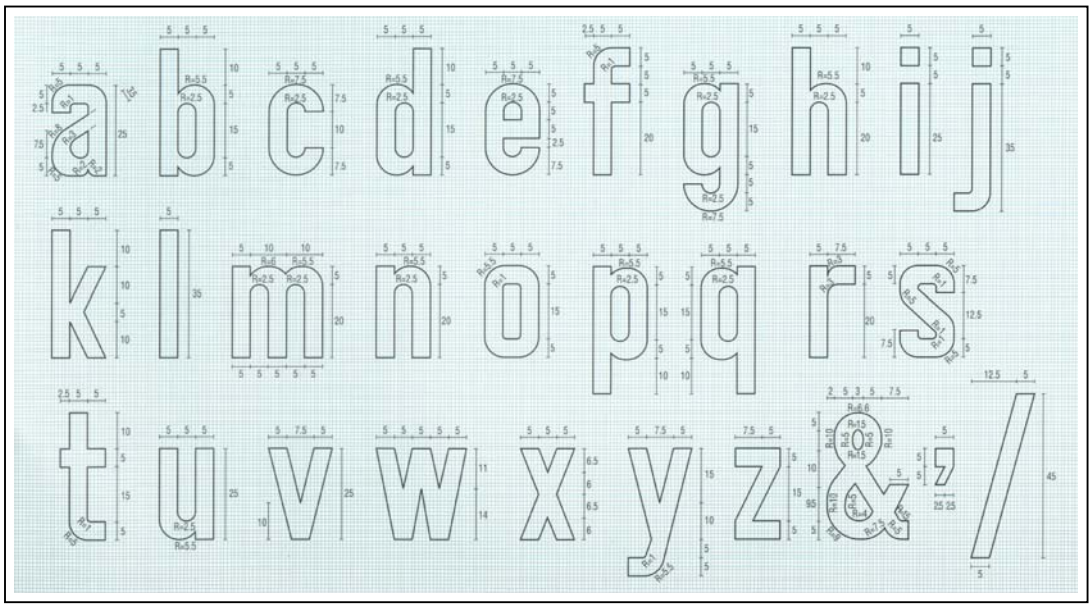
6.2 Only one type of letter is used in all the information signs. The letter type to be adopted is the rounded block script. Letters script and numerals used are as shown in the Standard Drawings, Drawing No.: HB 96-CE-30567 B-1 to B-4

6.3 All signs shall be manufactured according to Part 2, Section 2 of this Code of Practice.

6.4 Alphabet and numerals for non-standard signs shall comply with the latest Design Manual from Traffic Management Department of LTA.

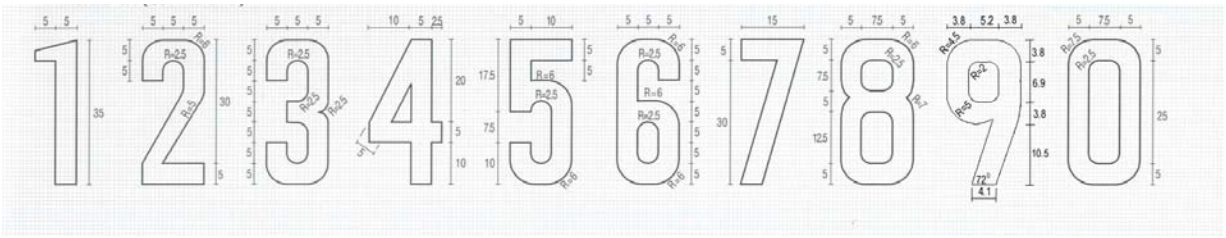


Drawing showing the base dimensions of Upper case letterings



Drawing showing the base dimensions of lower case letterings

Drawing showing the base dimensions of numerals



Note:

All dimensions are in mm.

The size of the lettering shall be enlarged to the following enlargement factors;

Expressways : Minimum 6 times enlargement factor

Other roads : Minimum 4 times enlargement factor

The spacing between the letterings shall comply with the relevant tables specified in the LTA Standard Details Of Road Elements, drawing nos: LTA/RD/SD99/DIR/7 & 8.

Specification for Aluminium Sheet

1. Aluminium Sheet

1.1 The material shall comply with the relevant specification of BS 1470:1972.

1.2 The material shall be free from defects prejudicial to its use.

1.3 Chemical Composition

The chemical composition shall comply with the following requirements:

Material Designation	1200
Silicon + Iron	1.0%
Copper	0.05 - 0.2%
Manganese	0.05%
Zinc	0.10%
Others	Each 0.05% (Total 0.15%)
Aluminium	99.00%

1.4 Typical Physical and Mechanical Properties

The typical physical and mechanical properties shall comply with the following requirements:

Material Designation	6063
Temper	T5
Density	2.7 X 10^3 kg / m^3
Mean Coefficient of Linear	23.4 X 10^{-6} per ºC
Expansion	615 - 650 ºC
Melting Range	Min 113 N / mm^2
Tensile Strength	Max 155 N / mm^2

1.5 Sizes and Tolerances

1.5.1 The sizes and tolerances of the aluminium sheet shall comply with the requirements of BS 1470:1972.

1.5.2 All edges of the aluminium sheet shall be rounded and smoothened.

2. Surface Preparation

2.1 Either - scrub the aluminium sheet and extrusion surface thoroughly, using cleaning and finishing pad or medium to fine steel wool and abrasive cleaner in water. Rinse thoroughly with clean water and dry immediately following rinse.

2.2 Or - Wipe the aluminium sheet and extrusion surface with a rag saturated with lacquer thinner or similar solvent, wipe dry with a clean rag, then the surface with a rag saturated with 6% - 8% phosphoric acid solution. Rinse the surface thoroughly with clean water and dry immediately following rinse. All

provisions that come under the Factories Act governing the handling of industrial and toxic chemicals shall be strictly adhered to.

3. Solvent Wiping

3.1 The following test shall be carried out to detect surface contamination on the properly treated aluminium sheet and I-extrusion:

3.1.1 Tape Snap Test - A strip of transplant tape shall be applied firmly on the surface of the aluminium sheet. After the tape has been pressed firmly onto the surface, the tape shall be snapped up at a right angle to the surface. Any loose material on the tape or visual change in colour of the sheet where the tape has been applied indicates a heavy, loosely coated or otherwise contaminated surface that may be unsatisfactory for the sheeting application.

3.1.2 Water Break Test - Test for oil or wax contamination shall be carried out by pouring water onto the surface, the water should not bead up but should flow out to form a uniform film on the surface.

4. Joints for Signs

Joints normally shall not be permitted. Where the size of the sign requires joints, they shall be positioned horizontally at the dividing line between the legends and these joints should divide the signs into equal area. Backing strip is required when the sign is made up of separate sheets. Joints shall be riveted with proper backing strip. The rivets shall be 4.8 mm minimum diameter and not more than 150 mm apart.

5. Signs Securing

The sign shall be secured to the post using an adequate number of bolts and nuts. The bolt and nut shall be approved stainless steel and of the round head type.

6. Other Signs Specifications References

Technical specifications from Road and Traffic Management Departments of LTA.

Specification for Traffic Cones

1. Definitions

All part of the cones and cylinders except the retro-reflective portion.

2. Colour

The colour of traffic cones and cylinders shall be red and comply to BS 873: Part 8: 1985.

Table 14 : Chromaticity co-ordinates and Luminance Factor for the red portions of Traffic Cones and Cylinders (Ordinary and Fluorescent Portions

Colour		Chromaticity co-ordinates of corner points. (CIE Standards Illuminant D65, CIE 45/0 Geometry)				Minimum Luminance Factor
		1	2	3	4	
Red	x	0.690	0.575	0.521	0.610	0.11
	y	0.310	0.316	0.371	0.390	

3. Specifications for traffic cones

The traffic cone shall also conform to the following specific requirements:

Dimensions : Minimum height 700mm
Minimum base 0.75 H or 400mm, where H is the height of the cone
Minimum thickness 3mm
Sides shall make an angle of 10 ± 2.5º
Diameter of the top shall be 60 ± 10 mm

Weight : Minimum weight 4.4 kg. Ballast shall not be used. The traffic cone shall not overturn when it is tilted up to an angle of 49° from its vertical axis.

Body Material : PVC type or medium density polyethylene (PE) type. The design of the cones shall allow stacking within each other without binding and without causing damage to the retro-reflective surfaces.

Sleeve : Upper band width of 150mm.
Lower band width of 100mm.
Gap from top of cone to upper band shall be 100mm.
Gap between the upper and lower band shall be 60mm.

Sleeve material : White colour High Intensity grade retroreflective sheeting conforming to Type III sheeting classification in ASTM D4956-2000. Adhesive of sheeting shall be compatible with the substrate material of the cone.

Logos : Identification logo of the services departments to be placed on the lower band. 2 numbers of the logo shall be placed diametrically opposite each other on the lower band. The size of the logo shall be max of 100mm by 100mm to fit into the width of the lower band. The logos shall be silk-screened into lower band.

Tests	:	All tests stipulated in Appendices in BS 873: Part 8 : 1985: 1. Low temperature impact test 2. Stability (for traffic cones only) 3. Drop Test (for traffic cones only)
Drawing	:	See diagram

4. Additional Specifications for Traffic Cylinders

The traffic cylinders shall also conform to the following specific requirements:

Dimensions	:	Proprietary-made subject to the approval of Land Transport Authority
Body Material	:	PVC type or medium density polyethylene (PE) type.
Installation	:	Inserting and removal of cylinders shall be done at the base without the aid of special tools.
Characteristics	:	Cylinders into which water can enter at the top shall have a drainage at the bottom. A circular hole of 33 ± 3 mm shall be provided at the top of the cylinder except where the inclusion of any internal mechanism makes it impracticable to provide such an hole. It shall be constructed so that in the event of being run over, the air will exhaust without the cylinder bursting
Retro-reflective portion	:	White colour High Intensity grade retroreflective sheeting conforming to Type III sheeting classification in ASTM D4956-2000. Adhesive of sheeting shall be compatible with the substrate material of the cone.
Testing	:	All tests stipulated in Appendices in BS 873: Part 8 : 1985: 1. Low temperature impact test 2. Bending test 3. Fatigue test The test specimen shall not crack, fracture or split and return to its original shape after test.

Suppliers shall be able to produce test reports on the compliances of traffic cones and cylinders.

Drawing showing Dimensions and Details of Traffic Cone

Cone Sleeves
Retroreflective bands to be High Intensity Grade, white colour.

The adhesive of the sheeting must be compatible with the substrate material.

Agency Logo:
2 nos of logo placed diametrically opposite each other on the lower band.

logo size is 100mm x 100mm size. Logos are to be silk-screened into sheeting.

Body material:
PVC type or Medium density polyethylene (PE) type.

Min weight 4.4 kg
Min thk 3mm

Body colour:
Fluorescent orange red.

Specification for Supports used for Signs

1. Post for Signs

Material	:	Mild steel square hollow section to ASTM A500-74 and hot dipped galvanised to BS 729.
Size	:	75mm x 75mm x 3.2mm thick SHS post shall be used to support signs not exceeding 1.44 m^2 in area. 100mm x 100mm x 3.2mm thick SHS post shall be used to support sign exceeding 1.44 m^2 in area. 50mm x 50mm x 2.3mm thick SHS post shall be used to support lateral shift marker.

2. Proprietary Post Systems

Foldable/collapsible spring-loaded portable standing post, reusable post-socket system and other proprietary post system may be used with the approval of LTA. Such systems shall be manufactured according to the design and performance requirements recommended by the manufacturer.

3. Portable A-frame

Material	:	Extruded aluminium hollow section of alloy 6063-T5 to BS 1474 or other material to LTA's approval.
Dimension	:	Designed by manufacturer and to be approved by LTA.

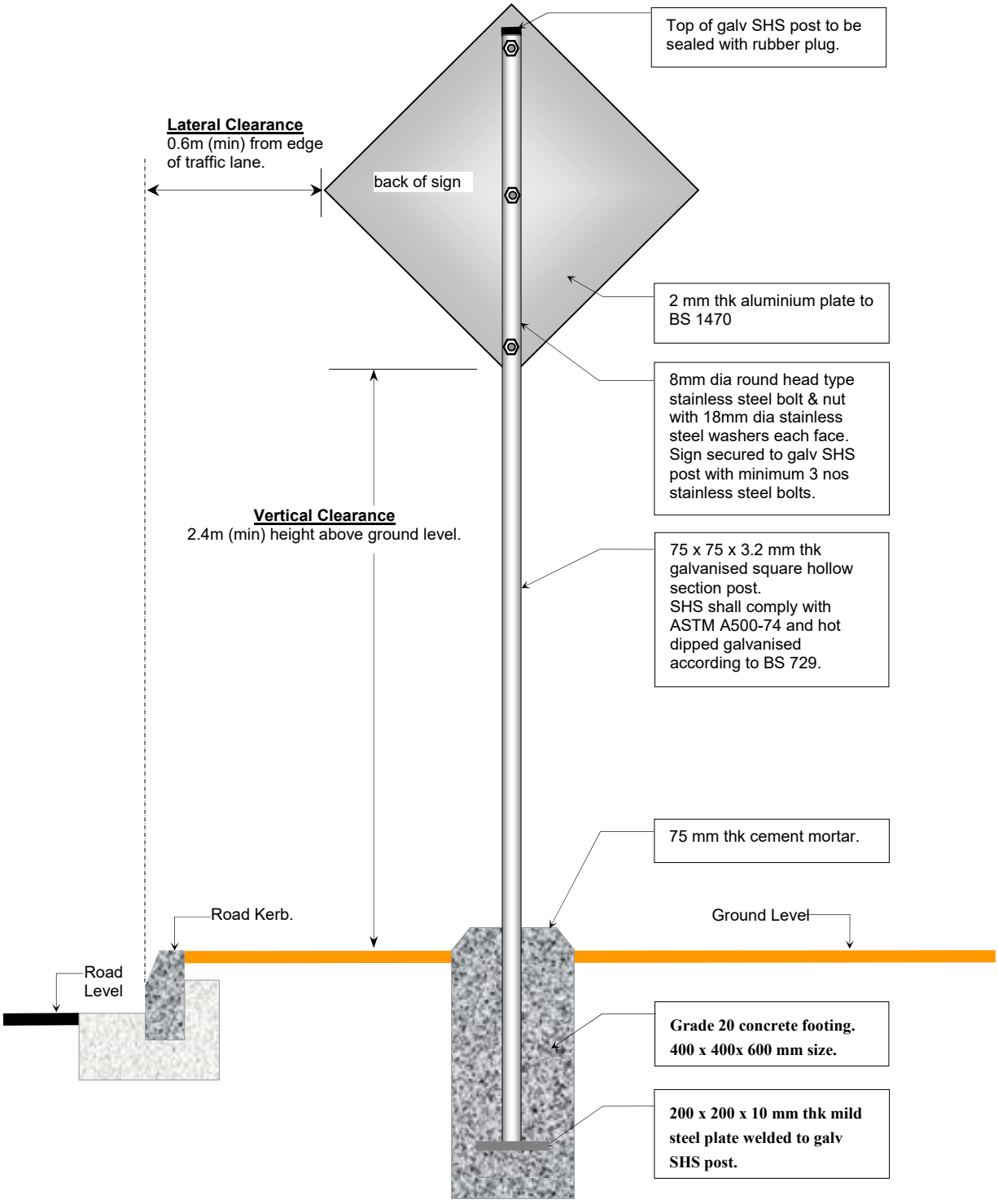
4. Stainless Steel Bands, Buckles Etc

4.1 Stainless steel bands with buckles approved by LTA shall be used to install the signs onto street lamp posts or traffic light posts. For signs which are to be installed onto building walls, concrete structures etc, high tensile steel threaded studs with cartridges or its equivalent shall be used according to manufacturer's specifications.

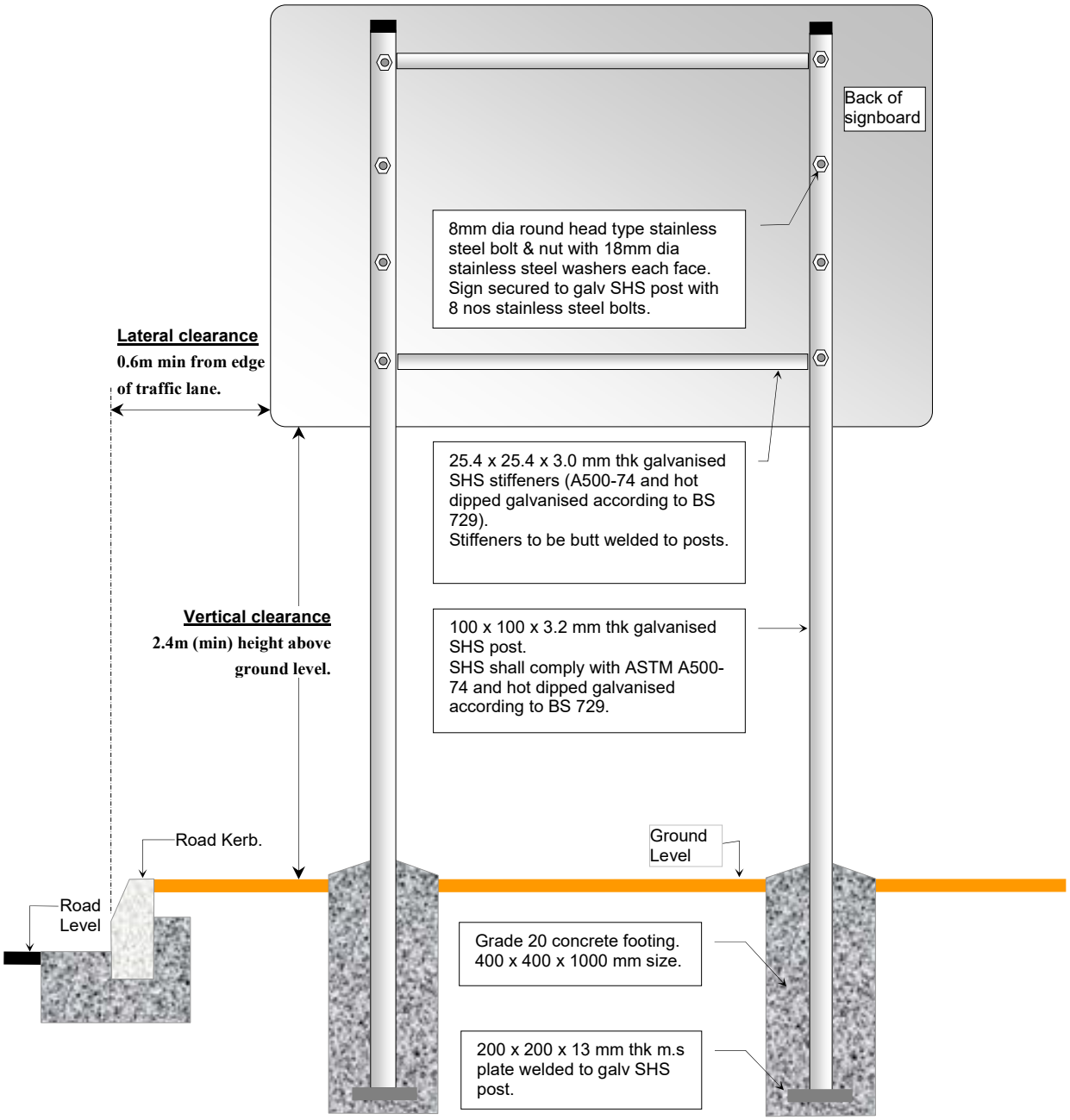
4.2 The stainless steel bands, buckles, high tensile steel threaded studs and cartridges including the fastening tools shall be handled by competent and experienced person and used in accordance with the manufacturer's recommendations and instruction.

4.3 Every precautionary and safety measures must be taken to safeguard the safety of the public when these materials and fastening tools are used in the installation of signs. All safety rules and regulations enforced from time to time by the relevant authorities on their usage and handling must be strictly complied with.

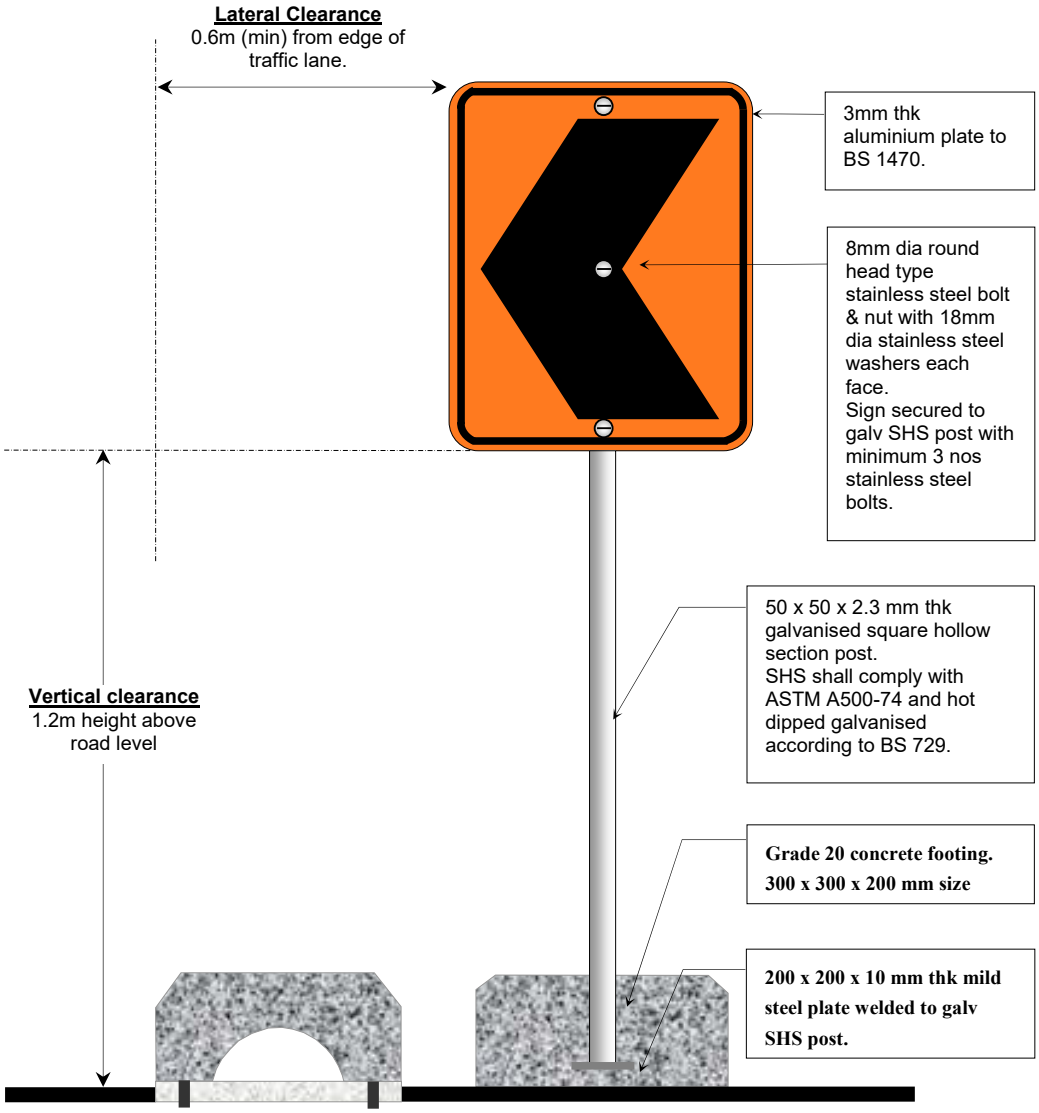
Recommended Support for Sign Not Exceeding 1.44m^2 In Area.



Recommended Support for Sign Exceeding 1.44m^2 In Area.



Recommended Support for Lateral Shift Marker.



Specification for Collision Attenuator or Truck Mounted Attenuator (TMA)

1. Definitions.

"TMA" used refers to truck-mounted attenuator.

"User" used hereinafter is defined as the contractor/agencies who are using the TMA (regardless of self-ownership or rental) on public roads of posted speed of 70 kph or more.

"Operator" used hereinafter is defined as the person that will be operating the TMA. He may also double up as the shadow vehicle driver.

"Shadow Vehicle" is defined as the LTA-approved truck where the TMA is mounted on.

"NCHRP" refers to National Co-operative for Highway Research Program commissioned by American Association of State Highway and Transportation Officials and US Federal Highway Administration.

2. Compliance to Standards.

The collision attenuator or TMA shall meet US NCHRP Report 350 Test Level 3 (TL-3).

The collision attenuator or TMA shall be of a commercially available design having a proven record for satisfactory performance. The system proposed shall have documentary evidence to prove that it has been successfully crash tested following the procedures set forth in the NCHRP Report 350, Tests 50, 51, 52 & 53. Test 52 shall be optional. Such evidence shall demonstrate that on expressways with speed limit of 100 kph and above, the collision attenuator or TMA shall be able to protect a stationary vehicle and safely decelerate errant vehicles weighing between 820 kg to 2000 kg travelling at speeds up to 100 kph according to NCHRP Report 350 Guidelines.

The energy-absorbing element of the collision attenuator or TMA shall have a lightweight modular design. The collision attenuator or TMA system shall be suitable for use in the typical climatic conditions found in Singapore and the energy absorbing elements and other components of the system shall not be liable to damage or deterioration due to high temperatures or prolonged exposure to direct sunlight. Accordingly, the system proposed shall have documentary evidence to indicate that it has been vibration-tested. The proposed collision attenuator or TMA system shall have been successfully subjected to complete moisture test.

3. Assembly.

The collision attenuator or TMA shall consist of three basic components;

- a modular design
- a back-up structure
- an energy-absorbing support frame specifically designed to fit the required vehicle.

The collision attenuator or TMA shall be designed to provide a minimum road clearance of 28 cm when in use. It is a specific requirement that the system shall feature a design which will minimise repair cost after 30 kph to 55 kph impacts as well as a durable nosing to protect the unit from nuisance damage. The system shall also have an integral standard trailer lighting system including brake lights, taillights and turning signals.

The collision attenuator or TMA shall be designed so as to feature easy attachment and detachment from the required vehicle through the use of disconnect pins. The system will also include front- and rear-mounted retractable jacks to allow for ease of handling and storage when not in use.

4. Approval of Attenuator.

The User is to ensure that the shadow vehicle and the assembly for TMA is approved by Vehicle and Transit Licensing Division of LTA.

To allow the use of collision attenuator or TMA on the public roads, manufacturers shall submit the relevant test reports of their product to the Manager, Road Asset Regulation & Licensing Department for approval.

5. Availability of TMA and Training.

The User shall have a spare TMA unit available for immediate replacement in the event of an accident. In the event of an accident, the User shall stop all works and fully clear the roadway until the replacement unit is properly installed.

The User's desired supplier of the collision attenuator or TMA shall send a manufacturer's representative to Singapore to provide a minimum two hours training course on the efficient and safe use of the collision attenuator or TMA. The manufacturer's representative shall provide certifications of training to all in attendance. The User shall have a duly trained and certified employee full time on site throughout the duration when the TMA is in used. Operator shall must be able to produce documentation proof of training upon verifications by the Authority.

6. Operation Procedure for TMA

(a) Before leaving for the work site

The qualified supervisor shall conduct the following activities before leaving for the meeting point (only when a protective safety vehicle will be deployed) or the work site: —

(i) Brief all persons involved of the installation procedure and their duties.
(ii) Remind the workers to take safety precautions and ensure that they are properly attired.
(iii) Appoint a look out and equip him with a red warning flag or traffic baton, hand phone or radio set.
(iv) Load all temporary traffic control devices and persons on a work vehicle. The vehicle shall be painted with a distinctive bright colour and fitted with cab-mounted rotating amber light or amber flashing arrow panel.
(v) *Ensure that the operator/driver of the TMA completed the walk around inspection.
(vi) *Brief the drivers on the route to be taken to the safe meeting point.
(vii) *Ensure that the TMA is in 90º vertical upright position and the twin-rotating beacon lights are on before moving.
(viii) *Leave for the meeting point with the works vehicle leading the way.
(ix) *The driver of the protective vehicle shall keep a safe distance from the works vehicle.

* apply only to TMA

(b) At the meeting point

A safe meeting point is a pre-arranged location close to the work zone where the works vehicle and the safety vehicle can meet and stop without blocking traffic. The drivers can safely get down from the trucks and walk on the road. The qualified supervisor and operator of the TMA shall carry out the following works when the vehicles arrive at the meeting point: —

(i) Ensure that the handbrakes are engaged.
(ii) Get down and walk to the rear of the vehicle along the far side from any traffic.
(iii) Lower the TMA following the manufacturer instructions until it is in a horizontal DOWN position. Engage the caution mode of the arrow panel.
(iv) When the vehicles are ready, move to the work zone with the work vehicle leading the way. The vehicles shall maintain a safe distance.

(c) Arriving at the work zone

The vehicles shall begin to reduce speed gradually well before the work zone. This is to allow other motorists to overtake the vehicles and leave an open gap behind.

The driver shall engage the arrow panel (keep-left mode for right lane closure and keep- right mode for left lane closure) as the vehicle slows down. Use hand signal to tell other road users that you are preparing to stop.

(d) **Placing the devices**

When the protective vehicle mounted with TMA has been deployed upstream at a safe distance from the advance warning zone (for work on expressway or major road >70 km/hr), placing of the devices shall proceed in the following sequence: —

(i) Move the work vehicle forward, unload and post the temporary **warning signs —** beginning with the warning signs upstream.
(ii) Move the protective vehicle and keep it at a safe distance behind the work vehicle.
(iii) Deploy the lookout at a safe distance upstream of the transition zone. Signal to the worker that it is safe to start work. Unload and line the traffic cones in a tapered fashion by the side of the road. Keep an opening for the protective vehicle to drive through safely.
(iv) Drive the protective vehicle past the traffic cone and signal to the worker to "close" the taper quickly.
(v) The lookout shall wave the warning flag to draw the attention of the motorists to the workers' presence. He shall alert the workers with the warning whistle (or loudhailer) when he sees vehicle approaching in a dangerous manner.
(vi) Continue to place the remaining devices at the activities zone and termination zone.
(vii) Always re-deploy the protective vehicle to protect the personnel as the work progresses.
(viii) Recall the lookout after the work zone has been completely secured.
(ix) Reverse the protective vehicle within the secured area and position it to protect the workers when work is in progress. DO NOT LEAVE THE CLOSED LANE AND REVERSE IN THE TRAFFIC LANE.
(x) If signs are needed on both sides of the road, devices should be placed first on the side where the lane is to be occupied by the works.
(xi) If work occupies the intermediate lane, devices should be placed on the slow lane first.

(e) **At the yard**

Check all items contained in the inspection checklist provided by the manufacturer of the protective vehicle and TMA before leaving for the meeting point. This is to ensure that the TMA and vehicle are in good working condition i.e. TMA cartridges are not damaged and all tyre pressures are in order. The TMA must be locked in the 900 vertical upright position and the twin-rotating lights are on.

(i) **Before leaving**: Before starting the engine, ensure that you have buckled up. It can minimise the injury during an accident. Adjust the headrest until it suits you i.e. approximately 5cm from the top of the head. The headrest shall never be positioned to hit the neck. FAILURE TO PROPERLY ADJUST THE HEADREST WILL RESULT IN SERIOUS SPINAL INJURY, PARALYSIS OR EVEN DEATH IN THE EVENT OF AN ACCIDENT.
(ii) **At the meeting point**: Stop the vehicle and engage the brake before getting down. Walk along the side away from the traffic. Lower the TMA in the proper sequence until it is in a horizontal DOWN position.
(iii) **Arriving at the site**: Slow down the vehicle prior to reaching the work zone. Engage the turn signal to inform other motorists that you are stopping. Always keep a safe distance from the works vehicle and worker.
(iv) **Before work starts**: Engage the hand brake and activate the arrow panel when you are in the position that protects the worker when work is in progress. Double check that the flashing arrow is correct for the lane closure.

Keep the engine running and signal to the supervisor when you are ready so that the supervisor knows that it is safe to start work.

(v) **During work**: Monitor the works if you need to re-position your vehicle at a safe distance as recommended by the manufacturer in order to protect the worker. Direct all workers out of the safety zone, i.e. behind the TMA or within 8m in front of the vehicle. Always keep a safe distance of at least 8m and 24m for stationary and mobile works respectively.

(vi) **During after close out**: No one should travel with you. Ensure that the flashing lights are switched on. Exit the high-speed road at the nearest exit. Raise the TMA at a safe place before returning home.

6. Impact Performance.

For any vehicle weighing between 820 kg to 2000 kg impacting straight into the rear of a test vehicle weighing 9000 kg ± 450 kg that is equipped with a collision attenuator or TMA and is parked in second gear with the emergency brake engaged, or at a 10 degrees impact angle with a w/4 offset from centre, the deceleration shall be less than 12 g's. The calculated 60 cm flair space will be less than 12 metre/second and the 10 millisecond average ride-down deceleration shall not exceed 20 g's.

Test reports shall be made available to the Authority for approval before using the collision attenuator or TMA on the road.

7. Shadow Vehicle.

The shadow vehicle mounted with the collision attenuator or TMA to be used in Singapore shall have a minimum gross weight of 8500 kg. The lighting system of the TMA shall be fully compatible with that of the shadow vehicle.

The arrow panel which is fixed /attached to the rear of the shadow vehicle shall be of such size and brightness that it is clearly visible for a distance of up to 2000 metres. The arrow panel shall remain operational at all times. In the event of a mechanical failure in the arrow panel, the User shall stop all works and fully clear the roadway until the arrow panel is properly repaired and operational.

For mobile operations, the driver of the shadow vehicle shall remain in the vehicle at all times. The shadow vehicle shall be properly spaced behind the working vehicle. The shadow vehicle shall maintain a longitudinal buffer distance of 25 m behind the working vehicle. This distance shall remain constant as the work progresses down the road / expressway.

For stationary operations, the driver of the shadow vehicle shall not be in the vehicle. He shall pre be in a safe location off the road / expressway, preferably behind the vehicle-impact guardrail or other form of safety device. He must remain on site throughout the operations of the works and to monitor the safety with respect to the pedestrian workers. The stationary vehicle shall be properly spaced behind the work crew and maintain a longitudinal buffer of 10 m behind the start of work area. This spacing shall remain constant as the work area progresses down the road / expressway.

Specification for High Visibility Warning Clothing

1. Definitions

High –visibility warning cloth –	warning clothing intended to provide conspicuity at all times
Fluorescent Material –	Material that emits optical radiation at wavelengths longer than absorbed.
Background Material –	Fluorescent yellow material intended to be highly conspicuous, but not to comply with the requirements of retro-reflective material.
Retro-reflective Material –	Material which is a retro-reflector but which is not intended to comply with the requirements of the background material.

2. Garment Design:

The high visibility safety vest shall conform to Class 2 garment design of the BS EN471:1994.

It shall incorporate a minimum of $0.5m^2$ of background material and $0.13m^2$ of retro-reflective material. The retro-reflective material photometric performance shall comply with requirements of Table 5 in EN471. Bands of retro-reflective material shall not be less than 50mm wide. The torso shall have two horizontal bands of retro-reflective material at least 50mm apart, the lower horizontal band at 50mm away from the garments bottom edge with bands over each shoulder joining the upper body band front and crossing at the back

Note: Some sizes will need bands wider than 50mm in order to meet Class 2 requirements. For example, a garment circumference of 107cm (42”) will require approximately 62mm wide reflective material.

3. Garment Material :

Background materials shall comprise either a robust woven or knitted fabric of cotton, linen or equivalent synthetic fibre which contains a fluorescent pigment or material using a mesh style construction made from cotton, linen or equivalent synthetic fibre which contains a fluorescent pigment. Materials to which a fluorescent plastic coating has been applied is not acceptable.

4. Colour

The chromaticity shall lie within one of the areas defined in the table below and the luminance factor shall exceed the corresponding minimum values in the table.

Table 15 : Chromaticity Chart for Background Material

Background material colour	Chromaticity coordinates		Min luminance
	X	Y	βmin
Fluorescent yellow / Lime Yellow	0.387	0.610	0.76
	0.356	0.494	
	0.398	0.452	
	0.460	0.540	

Source: BS EN 471:1994, Table 3

Background materials shall conform to the requirements as set in Section 5, BS EN471:1994.

a. Daylight colour and luminance factor test.

b. Colour fastness to light test.

c. Colour fastness to washing.

d. Colour fastness to perspiration.

Subject to the approval from LTA, colour like yellow-green or lime-green may be used.

5. Requirements of Retro-reflective Material.

The retro-reflective material shall comprise a flexible fabric, plastic film or film system incorporating retro-reflective elements and shall comply with the requirements of Table 5 BS EN471.

Table 16 : Requirements for Retro-reflective Material of Vest

Observation angle	Entrance angle			
	5°	20°	30°	40°
12'	330	290	180	65
20'	250	200	170	60
1°	25	15	12	10
1°30'	10	7	5	4

Source: BS EN 471:1994, Table 5

The retro-reflective material when tested in accordance with the following test exposures as specified in BS EN471:1994 shall comply with the photometric and physical requirements for the retro-reflective material as stated in Section 6, BS EN471:1994.

Table 17 : Photometric and Physical Requirements

Test Exposure	Section
Abrasion	7.4.1
Flexing	7.4.2
Temperature variation	7.4.4
Washing	7.4.5.1
Influence of rainfall	7.5

Source: BS EN 471:1994, Table 8

6. Labelling

The high visibility garment shall include label(s) sewn inside the garment stating the following information; fabric content, name of manufacturer and care instructions.

7. Conformance to Standards

Suppliers of reflective vest shall make available the relevant test reports on the garment and retro-reflective element for proof of compliance.

APPENDIX III - Guidelines

Guidelines for Portable Traffic Light

1. Definitions.

Portable traffic light is a device deployed to direct traffic whilst road works are being carried out. It is required to meet both the physical display and operational requirements of conventional traffic signals.

"Applicant" used hereinafter is defined as any person who makes or has made an application under Regulation 5 of the Regulations and includes a person whose application has been granted by the Authority. The Applicant is responsible for all temporary traffic management, planning the work and risk assessments. The Applicant shall engage qualified traffic consultant to assess site-specific factors such as schools, zebra-crossings, permanent traffic signals, road geometry, length of road works, commercial and industrial activities and etc., and determine timings for the portable traffic lights. During deployment, they shall also monitor vehicular flow at intervals and adjust the timing if necessary.

"User" used hereinafter is defined as the contractor/agencies who deploy portable traffic signals for road works, do not need the authority's permission to use them but should notify and/or consult the authority when planning the works.

2. Compliance to Standards.

The portable traffic light shall conform to the requirements for traffic signals and traffic signal equipment specified in BS 505 Road Traffic Signals, Road Traffic (Traffic Signs) Rules or equivalent.

3. Assembly.

The portable traffic light signals for vehicles shall be a 3-colour system consists of red, amber and green lights arranged vertically with the red light placed above the amber light and the green light placed below the amber light.

The effective diameter of the lens of each light shall be at least 200mm.

The minimum luminous intensity of the lights shall be as follows:

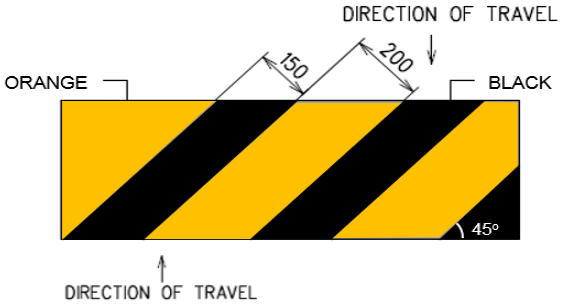
Type	Minimum Intensity (Candela/cd)
Red light (200mm)	236
Amber light (200mm)	295
Green light (200mm)	295

The portable traffic lights shall operate under the hot and humid temperature in Singapore.

To ensure all equipment function without any detriment under external environment.

To ensure no sharp edges in the mounting brackets or panel casing which might cause injury to commuters or pedestrians.

The base of portable traffic light shall be painted in alternate orange and black colour (see colour scheme).



COLOUR SCHEME FOR BASE

4. Traffic Control Signals Requirements

In order not to confuse motorists, portable traffic lights cannot be deployed where motorists' straight line-of-sight could be distracted by permanent traffic lights along the same road. Alternative traffic control arrangements such as authorised traffic marshals to regulate traffic could be deployed for such cases.

The minimum height clearance of the traffic light signals from the ground surface shall be 2,290 mm with adjustable provision to suit the geometry of the approach and site condition.

The traffic signal control operation shall be operated using the master and slave concept where the traffic lights at both end must communicate with each other at all times. No two traffic lights shall have all-green at the same time for different traffic approaches. If the controller detects some faults, causing lack of communication between the 2 traffic lights, it shall shut down and a warning signal shall be generated and alert the user accordingly.

Depending on the road works area (length), the portable traffic light system shall allow the user to program and set the red, amber, green and all-red lights timings.

The timings for the red signal (assessed and determined by qualified traffic consultant) shall be programmed such that the last vehicle is able to clear the length of the road works area at any time. Thereafter, an all-red phase shall be provided for an extra three seconds (minimum) to hold signals on red to both approaches. The determining factors in all red timing are the length of work zone and prevailing speed limit of the road. This is to allow vehicles to safely clear the shared lane to avoid head-on traffic movements.

The portable traffic lights shall be designed to allow manual intervention by user in overriding the control of traffic signal in any event that required the user to do so.

Power and signal cable routes should avoid areas where there is pedestrian traffic. If this is unavoidable the cable route, as a minimum, should be covered with a ramp suitable for wheelchair use.

If power and signal cables cross a carriageway, User to cut slots in the road surface so that the cables can be buried temporarily. This area is to be resurfaced after the removal of portable traffic light system.

For wireless communication systems, there shall be no interference to the wireless transmission.

To alert motorists and increase prominence to the presence of the portable traffic lights, an advance warning sign showing traffic lights in operation ahead will be required. In addition, a *"Stop Here on Red Light"* sign will also be required to guide motorists on where to stop their vehicles when the traffic light is red for their bound. Please refer to Appendix V for details of the traffic control arrangements.

5. Maintenance

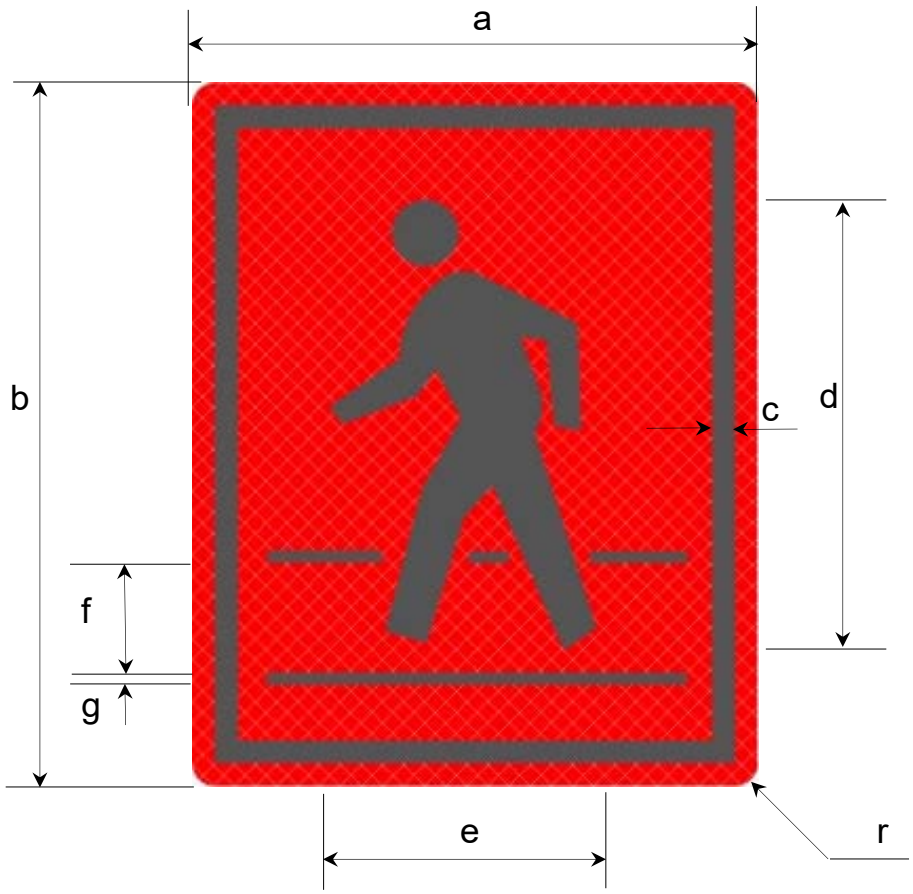
Access to the signal control panel must be restricted to prevent unauthorised changes to timings. Information on maintenance arrangements and fault reporting; i.e. contact numbers for Project Owner and contractor should be available at all times.

User shall perform daily site checks to ensure the deployed portable traffic lights are in proper working conditions. These checks shall include but not limited to the following:

- Safety and reliability of signals and lamp integrity.
- Power and signal cables, for security and damage.
- Timings, to correspond with traffic condition.
- Power supply, to ensure continuous operation.
- Signal head lenses, to be cleaned.

APPENDIX IV - SIGN DIMENSIONS

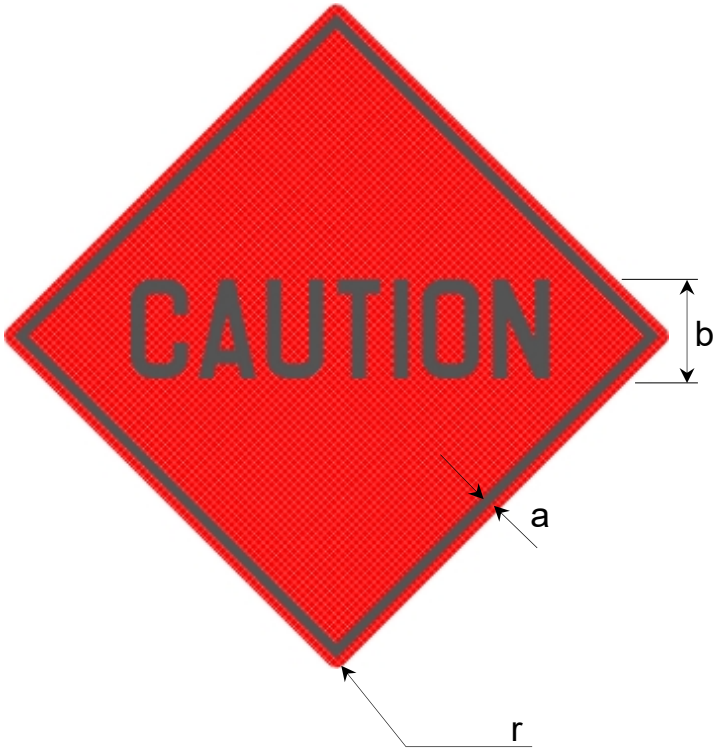
Sign P 1: Pedestrian Walkway



Sign P1
Pedestrian Walkway Sign

r	a	b	c	d	e	f	G
30	600	750	24	480	285	120	12

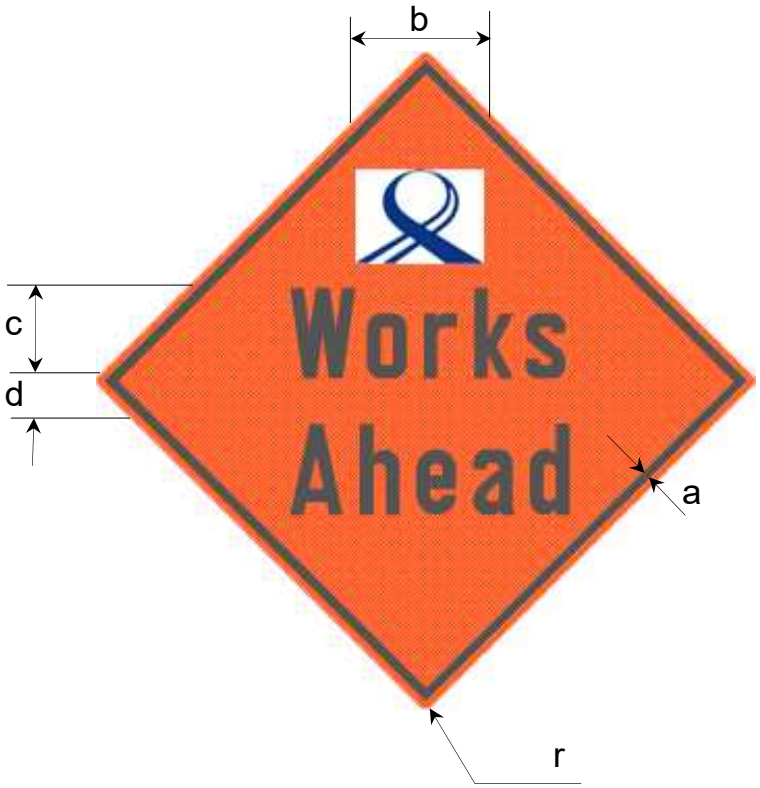
Sign W 1: Caution



Sign W1
Caution Sign

Size	R	a	B
900 X 900	30	24	200
1200 X 1200	30	24	250

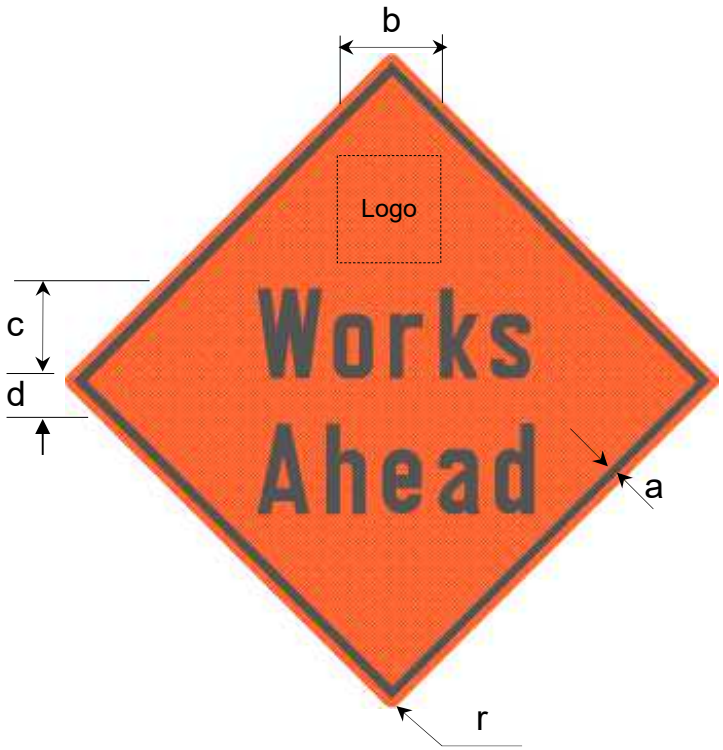
Sign W 2: Works Ahead – Land Transport Authority



Sign W 2
Works Ahead Sign (Land Transport Authority)

Size	r	A	b	c	D
900 X 900	30	24	200	210	80
1200 X 1200	30	24	260	250	125

Sign W 3 to 13: Works Ahead – Services Department



Sign W 3 to 13
Works Ahead Sign (Typical Sign for Services Department)

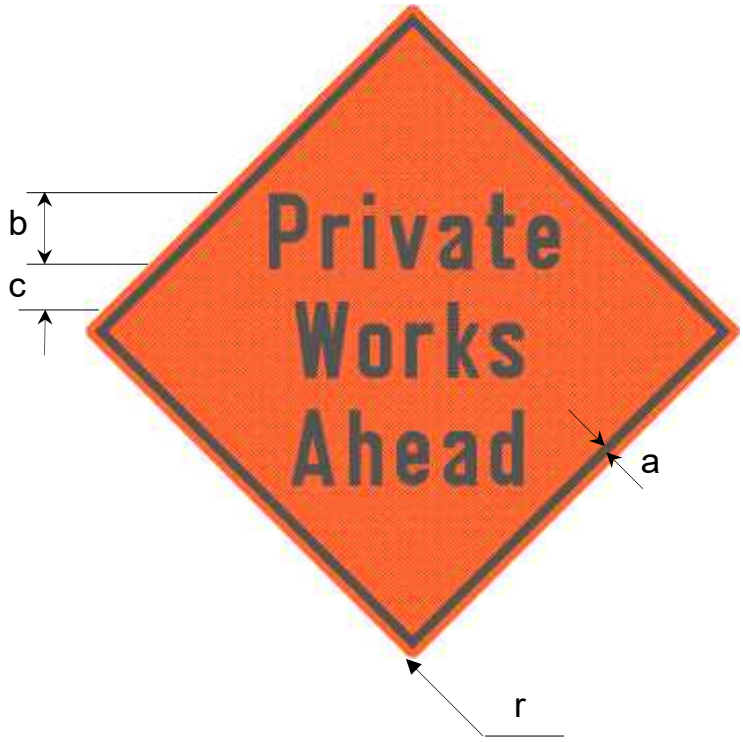
Size	r	A	b	c	D
900 X 900	30	24	200	210	80
1200 X 1200	30	24	260	250	125

1. Recommended sizes of logo for the best effect are:

Size of Signs	Size of Logo
Expressways (1200 X 1200):	260 X 260
Other Roads (900 X 900):	200 X 200

2. Relevant Authorities and Departments may design their own layout for their logo to fit into the space.
3. A white background of the same size may be used when necessary to bring out the logo. However it must be of wide-angled prismatic retro-reflective sheeting with the logo silk-screened on this white sheeting.
4. The logo may be of any shapes but preferred to be within the square size defined above.
5. If there are more than one department within the organisation that will be working on the road, the relevant authorities may choose to include their Departmental Name within the logo for identification.
6. Relevant Authorities and Departments should advise Road Asset Regulation & Licensing Department of Land Transport Authority on their preferred layout.

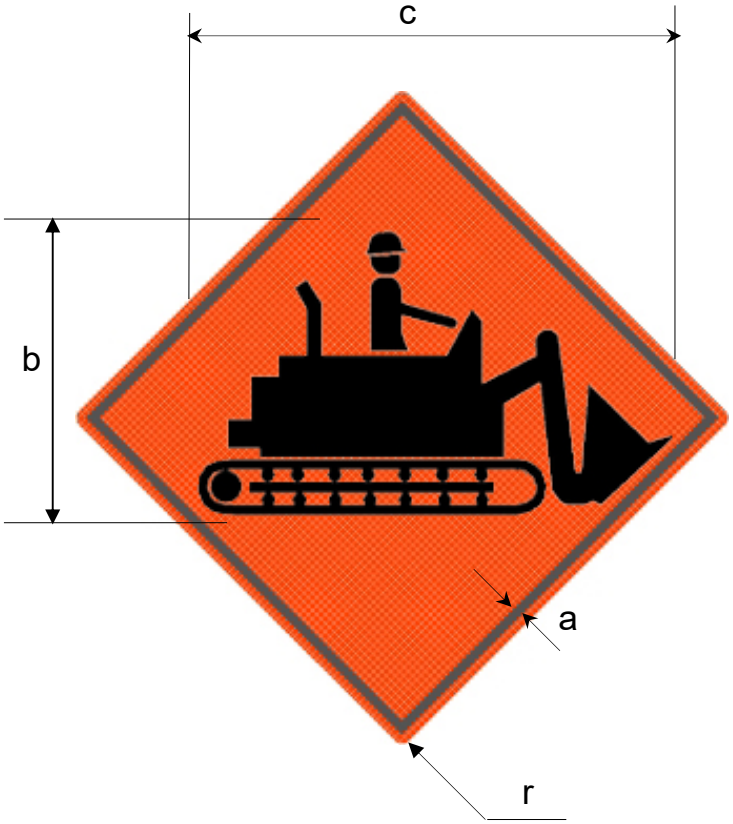
Sign W 14: Works Ahead – Private Developments



Sign W 14
Works Ahead Sign (Private Development Works)

Size	r	A	b	c
900 X 900	30	24	165	70
1200 X 1200	30	24	210	90

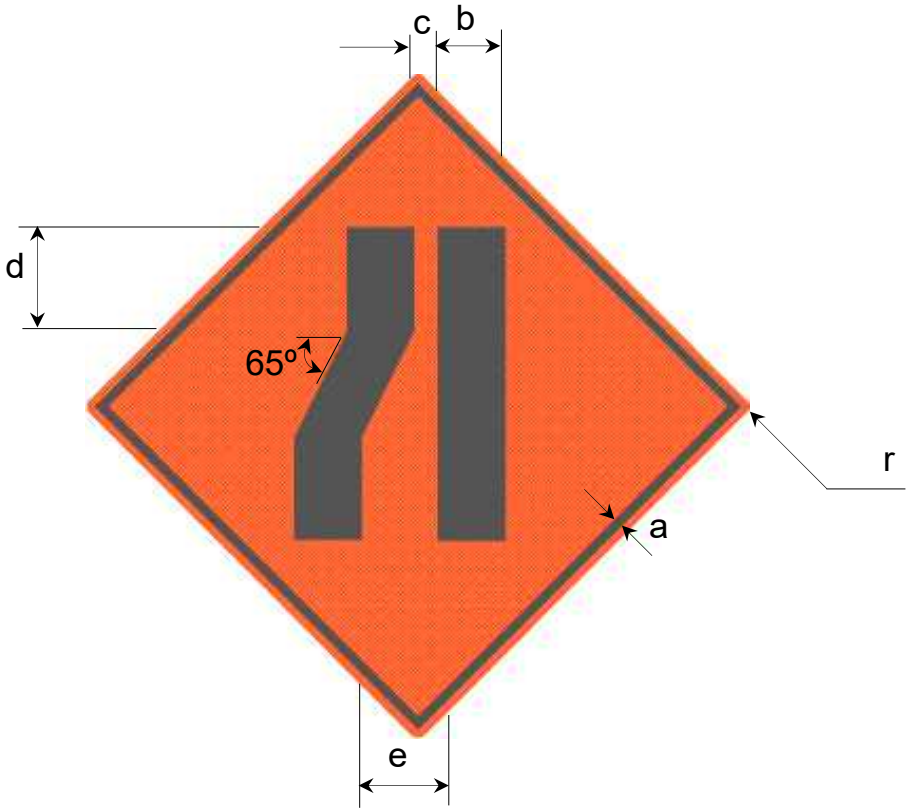
Sign W 15: Man-at-Work



Sign W 15
Man-at-Work Sign

Size	r	a	b	c
900 X 900	30	24	520	895
1200 X 1200	30	24	700	1200

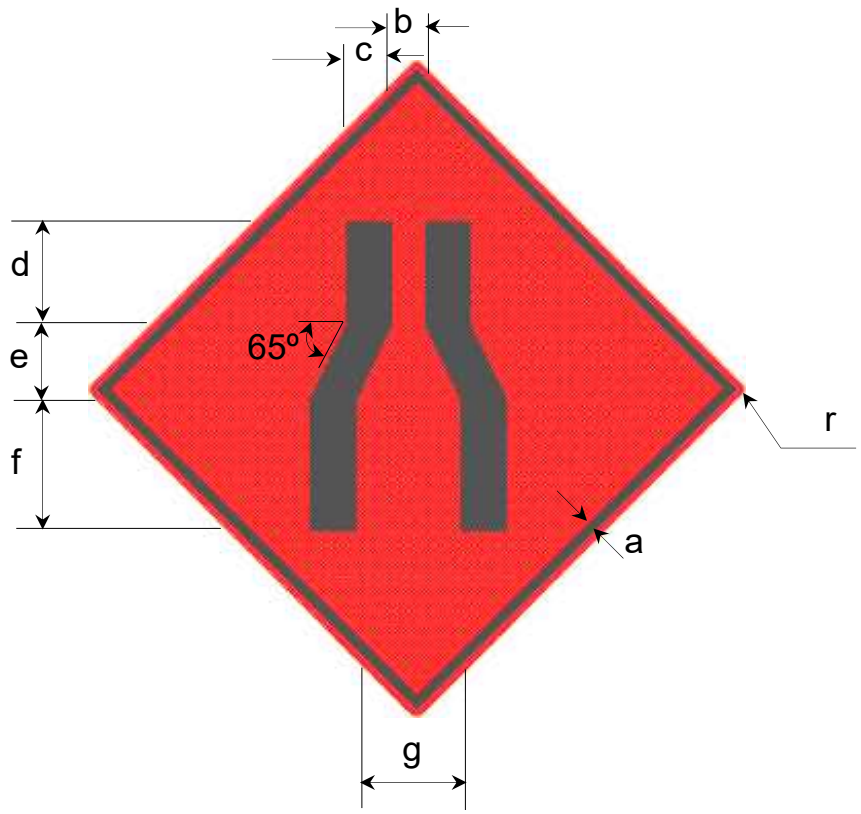
Sign W 16: Road Narrow on Left Ahead



Sign W 16
Road Narrow on Left Ahead Sign

Size	r	a	b	c	D	e
900 X 900	30	24	140	50	3 X 215	104
1200 X 1200	30	24	185	65	3 x 285	141

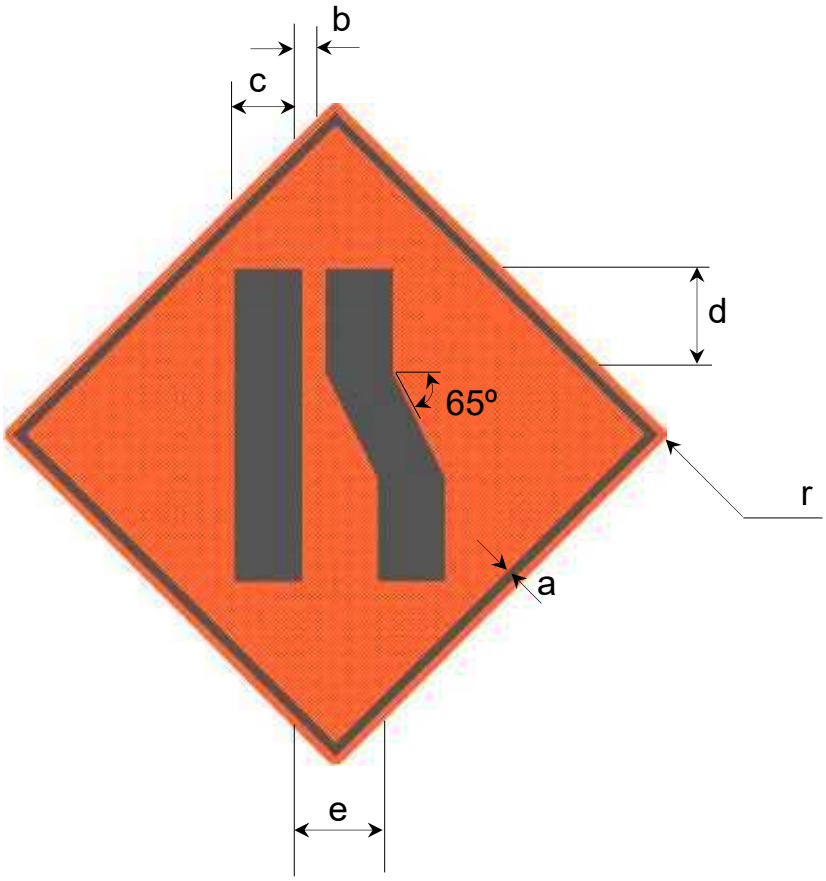
Sign W 17: Road Narrow on Both Sides Ahead



Sign W 17
Road Narrow on Both Sides Ahead Sign

Size	r	a	b	c	d	E	f	g
900 X 900	30	24	95	70	215	155	275	151
1200 X 1200	30	24	125	95	285	205	365	200

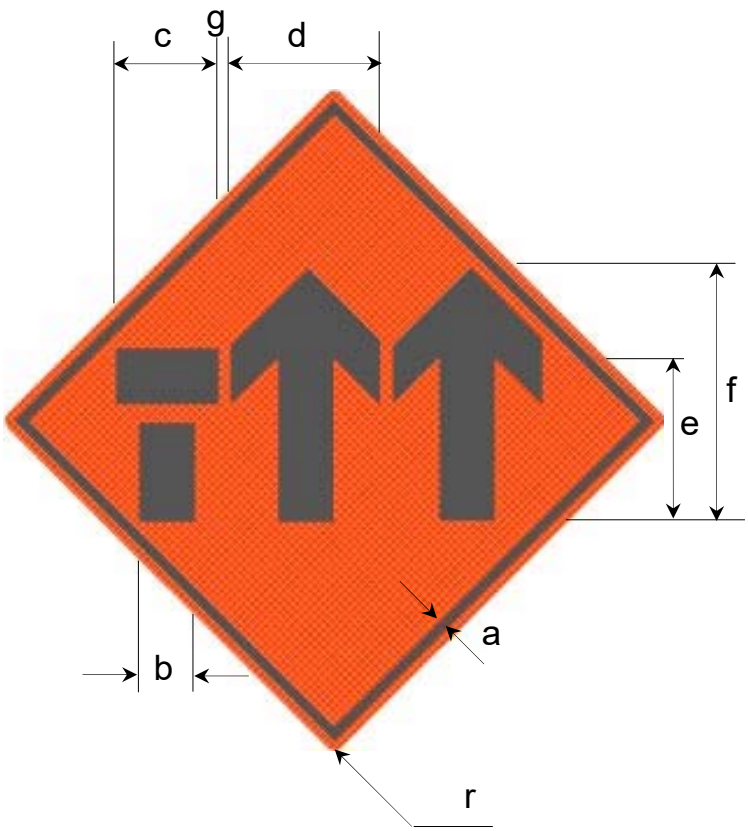
Sign W 18: Road Narrow on Right Ahead



Sign W 18
Road Narrow on Right Ahead Sign

Size	r	a	b	c	D	e
900 X 900	30	24	140	50	3 X 215	104
1200 X 1200	30	24	185	65	3 x 285	141

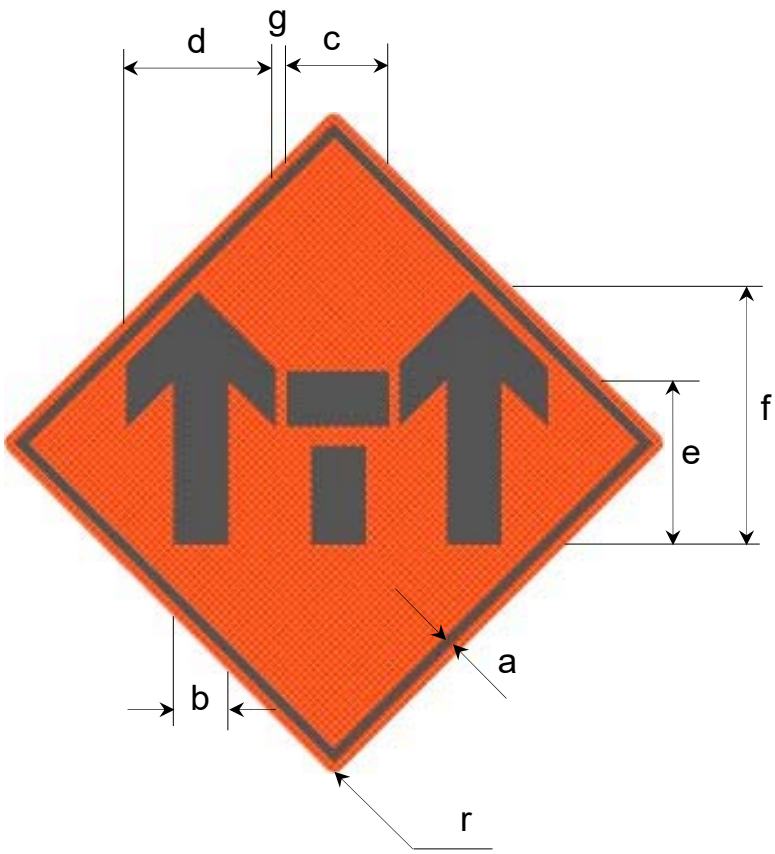
Sign W 19: Left Lane Closed Ahead



Ahead Sign

Size	r	a	b	c	d	e	f	g
900 X 900	30	24	95	200	235	355	470	28
1200 X 1200	30	24	140	260	380	440	645	32

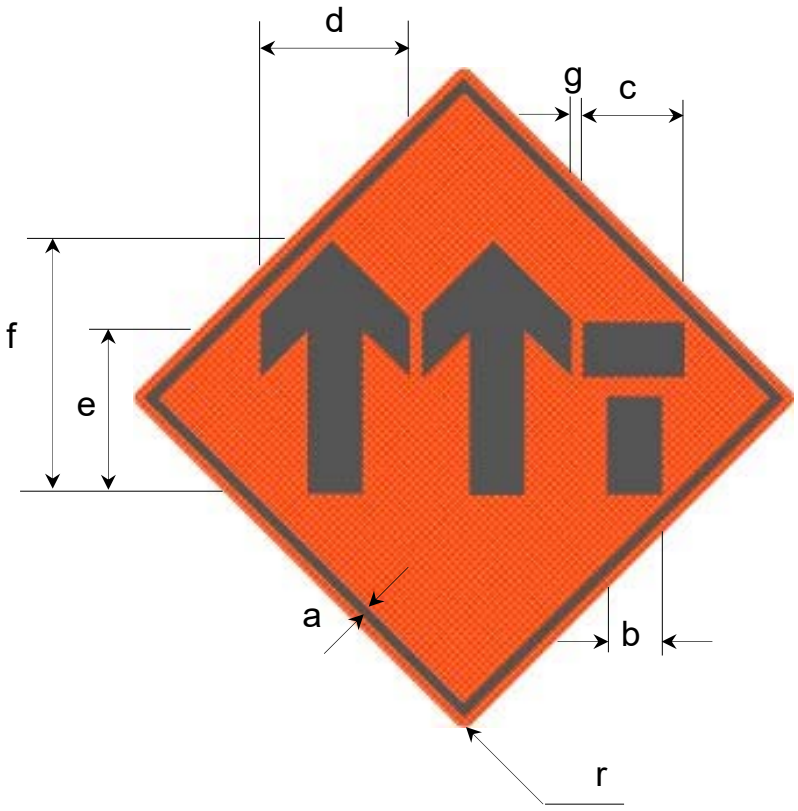
Sign W 20: Centre Lane Closed Ahead



Sign W 20
Centre Lane Closed Ahead Sign

Size	r	a	B	c	d	E	f	g
900 X 900	30	24	95	200	235	355	470	28
1200 X 1200	30	24	140	260	380	440	645	32

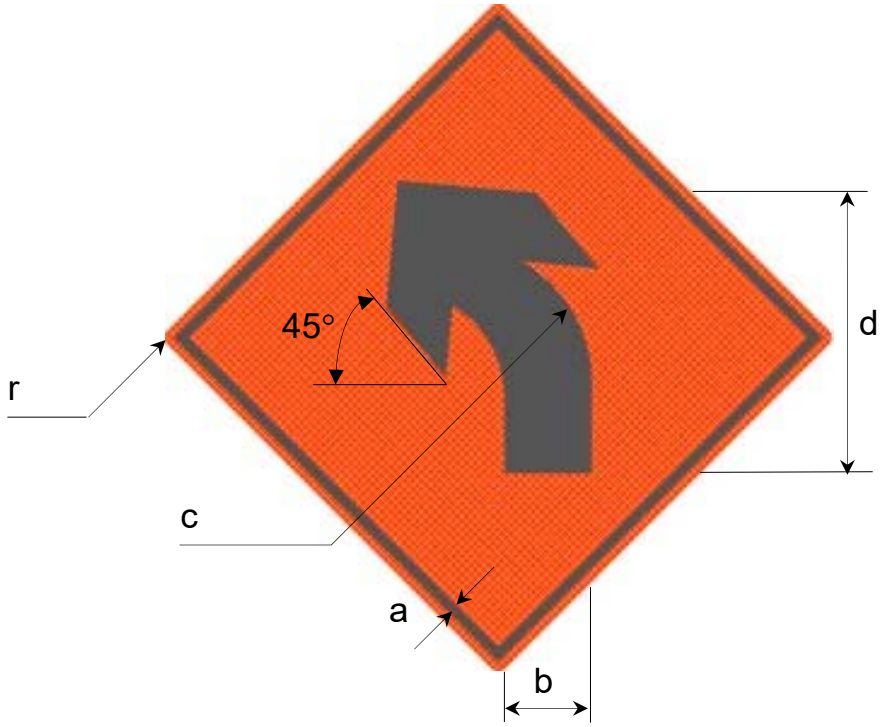
Sign W 21: Right Lane Closed Ahead



Sign W 21
Right Lane Closed Ahead Sign

Size	r	a	b	c	d	e	f	g
900 X 900	30	24	95	200	235	355	470	28
1200 X 1200	30	24	140	260	380	440	645	32

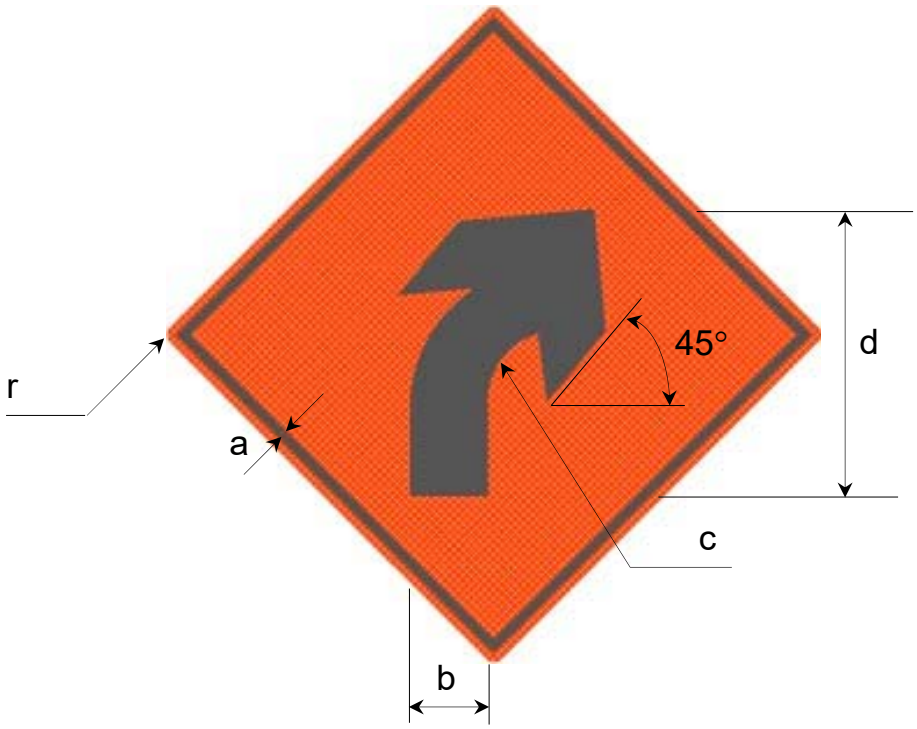
Sign W 22: Left Bend Ahead



Sign W 22
Left Bend Ahead Sign

Size	r	a	b	c (R)	d
900 X 900	30	24	150	245	560
1200 X 1200	30	24	200	325	735

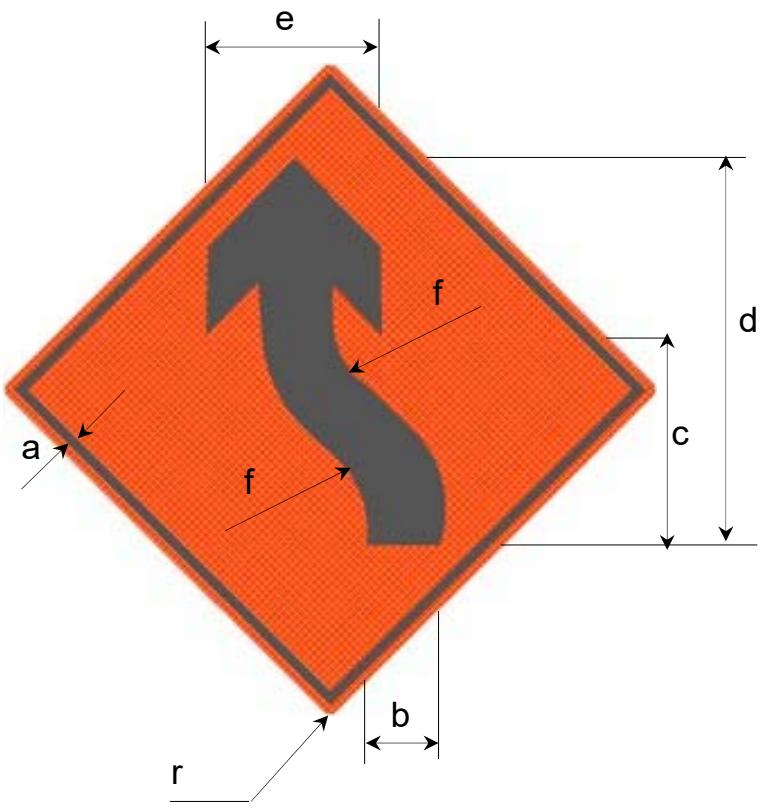
Sign W 23: Right Bend Ahead



Sign W 23
Right Bend Ahead Sign

Size	r	a	b	c (R)	d
900 X 900	30	24	150	245	560
1200 X 1200	30	24	200	325	735

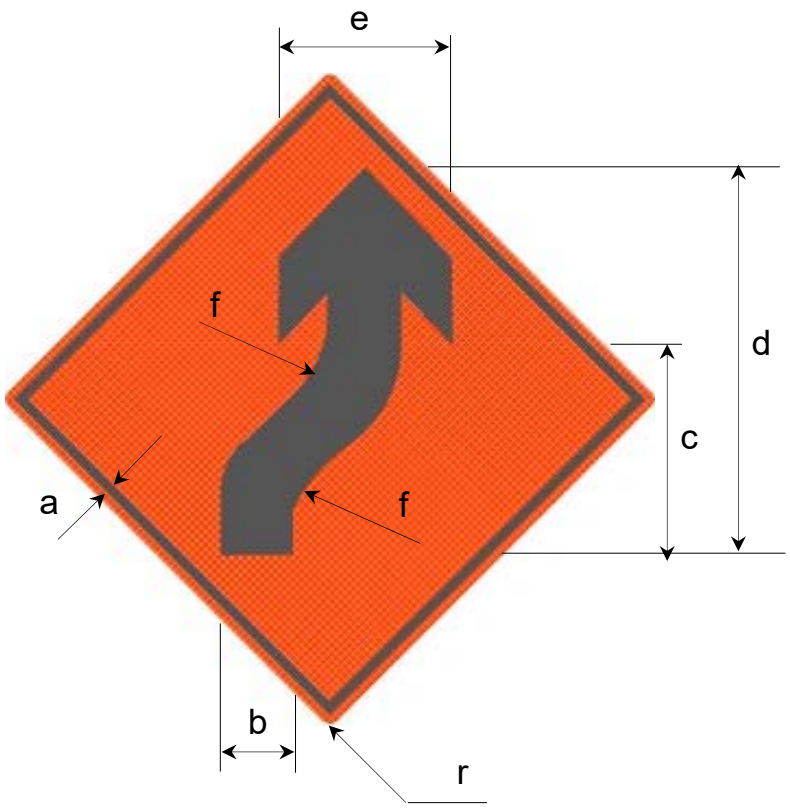
Sign W 24: Series of Bend Ahead - Left First



Sign W 24
Series of Bends Ahead – Left First Sign

Size	r	a	b	c	d	e	f (R)
900 X 900	30	24	140	380	710	450	193
1200 X 1200	30	24	200	530	1000	610	193

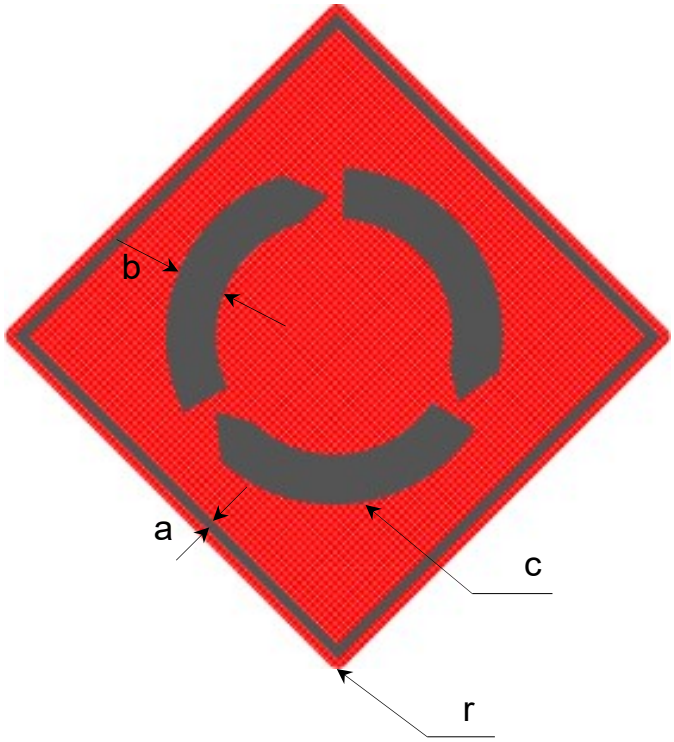
Sign W 25: Series of Bend Ahead - Right First



Sign W 25
Series of Bend Ahead – Right First Sign

Size	r	A	b	c	D	e	f (R)
900 X 900	30	24	140	380	710	450	193
1200 X 1200	30	24	200	530	1000	610	193

Sign W 26: Roundabout Ahead

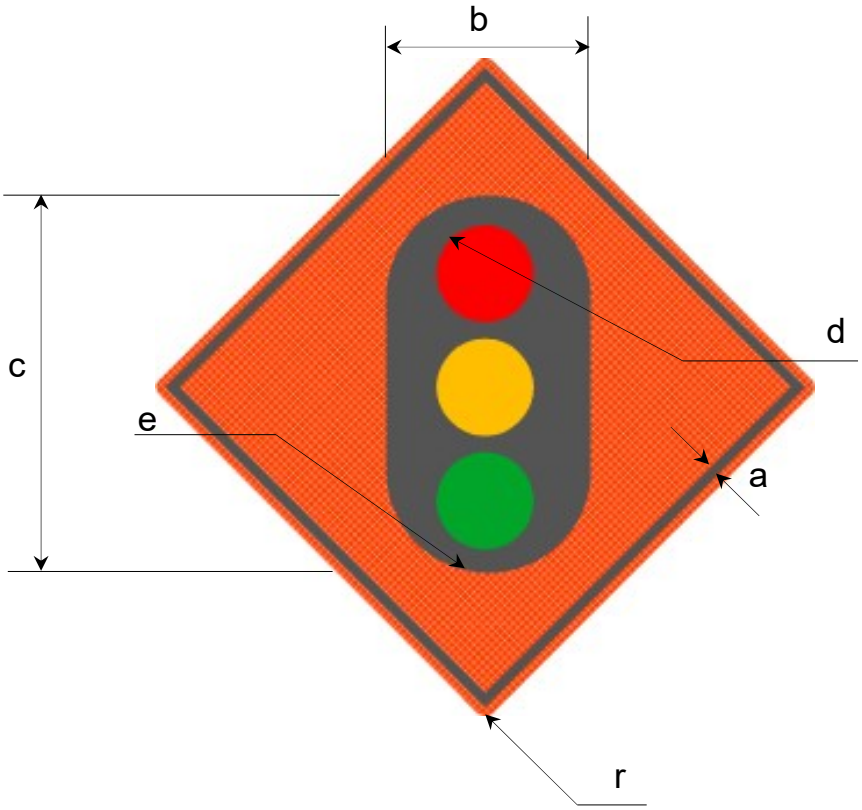


Sign W26

Roundabout Ahead Sign

Size	R	a	b	C
900 X 900	30	24	80	275
1200 X 1200	30	24	130	425

Sign W 27: Traffic Lights Ahead



Sign W 27
Traffic Lights Ahead Sign

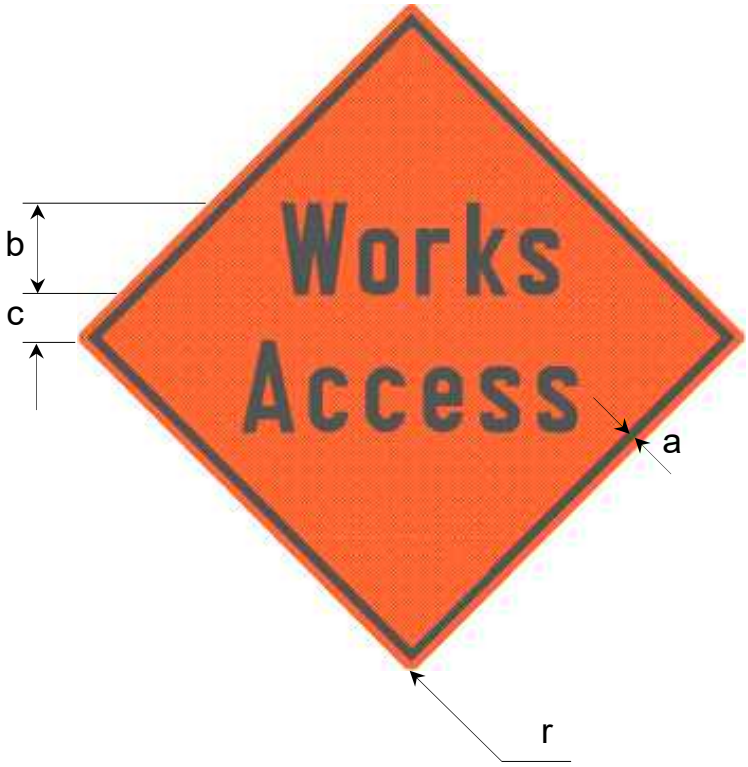
Size	r	A	b	c	D	e
900 X 900	30	24	200	680	90	160
1200 X 1200	30	24	250	900	125	230

Sign W 28: Shoulder Lane Closed Ahead

Sign W 28
Shoulder Lane Closed Ahead Sign

Size	R	a	b	C
900 X 900	30	24	165	80
1200 X 1200	30	24	210	105

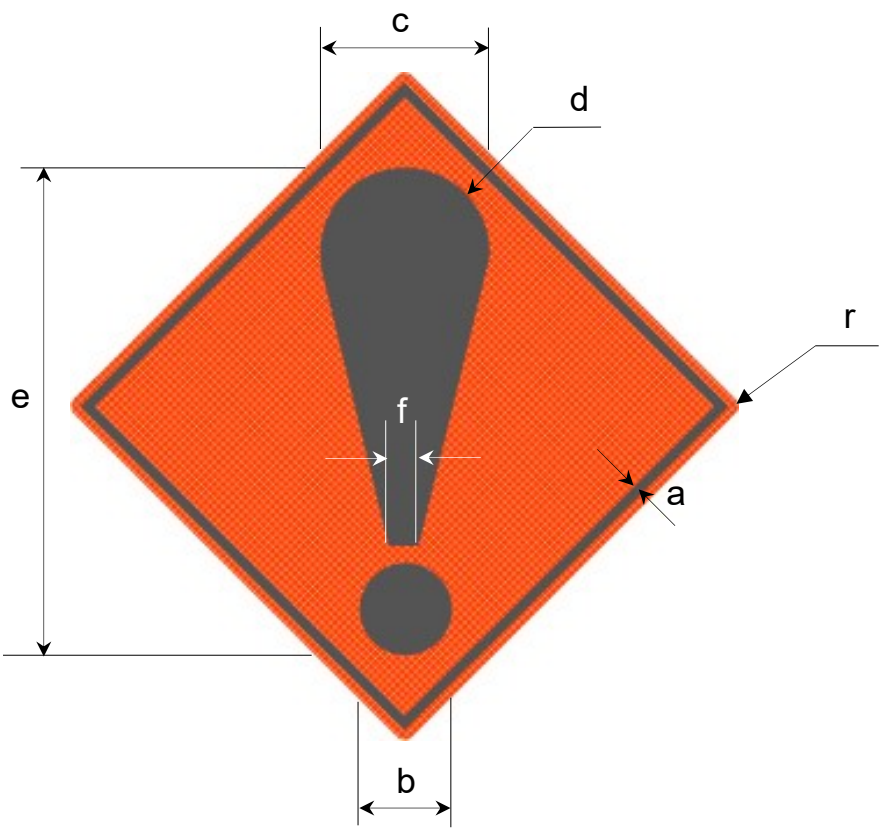
Sign W 29: Work Access Ahead



Sign W 29
Works Access Ahead Sign

Size	r	a	b	c
900 X 900	30	24	210	90
1200 X 1200	30	24	250	125

Sign W 30: Other Hazards Ahead

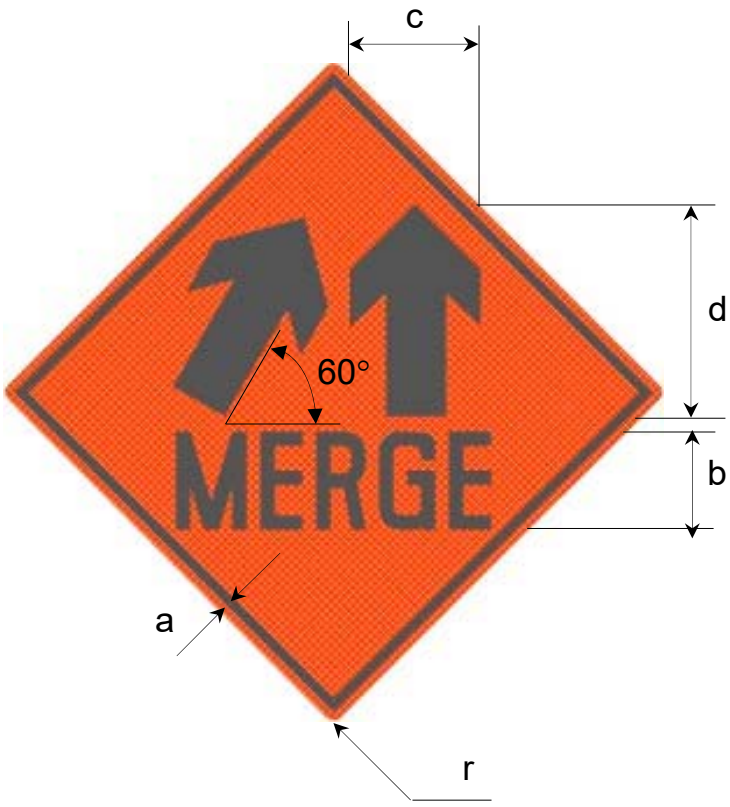


Sign W30

Other Hazards Ahead Sign

Size	r	a	b	c	d	e	f
900 X 900	30	24	160	308	150	900	50
1200 X 1200	30	24	230	425	200	1200	75

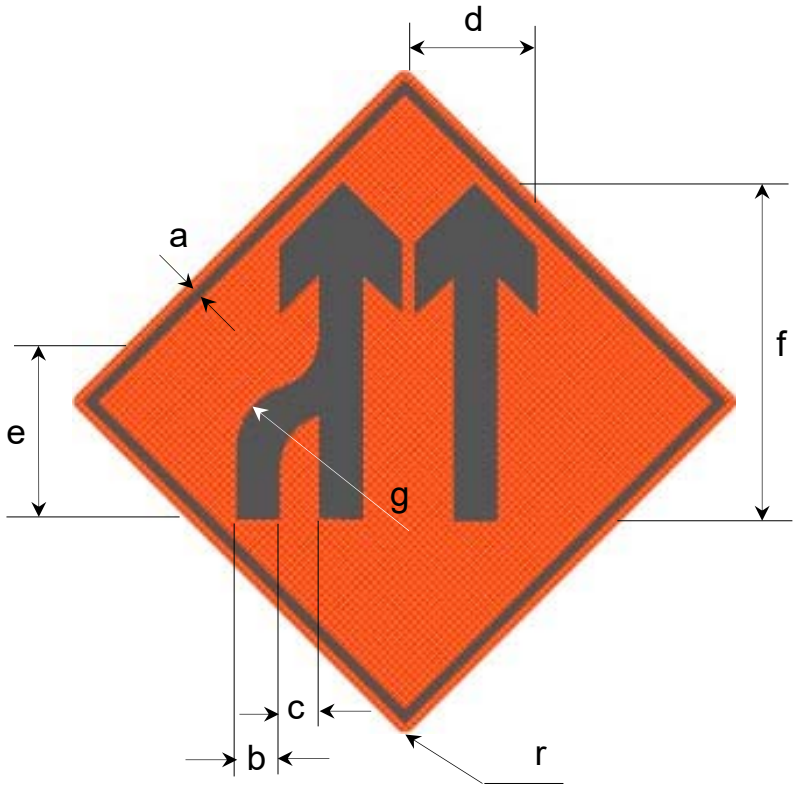
Sign W 31: Merge Ahead



Sign W 31
Merge Ahead Sign

Size	r	a	b	C	d
900 X 900	30	24	210	210	345
1200 X 1200	30	24	250	335	540

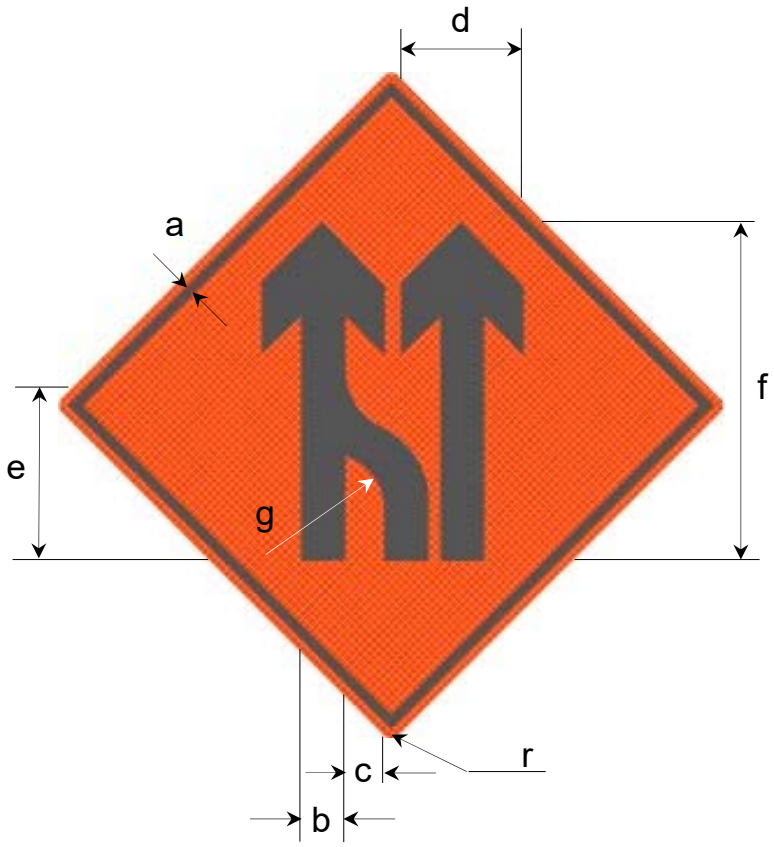
Sign W 32: Left Lane Merged with Centre Lane Ahead



Sign W 32
Left Lane Merged with Centre Lane Ahead Sign

Size	r	a	b	c	d	e	f	g (R)
900 X 900	30	24	80	75	235	365	600	208
1200 X 1200	30	24	110	100	310	480	855	208

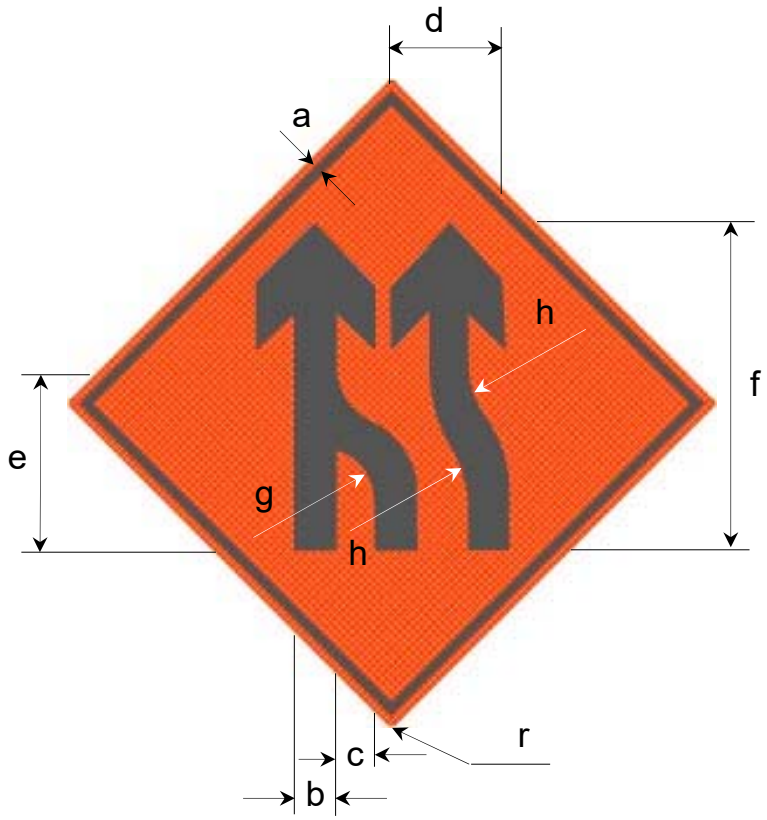
Sign W 33: Centre Lane Merged with Left Lane Ahead



Sign W 33
Centre Lane Merged with Left Lane Ahead Sign

Size	r	a	b	c	d	e	f	g (R)
900 X 900	30	24	80	75	235	365	600	208
1200 X 1200	30	24	110	100	310	480	855	208

Sign W 34: Centre Lane Merged with Left Lane and Right Lane Shifted Ahead



Sign W 34
Middle Lane Merged with Left Lane, Right Lane Shift Ahead Sign

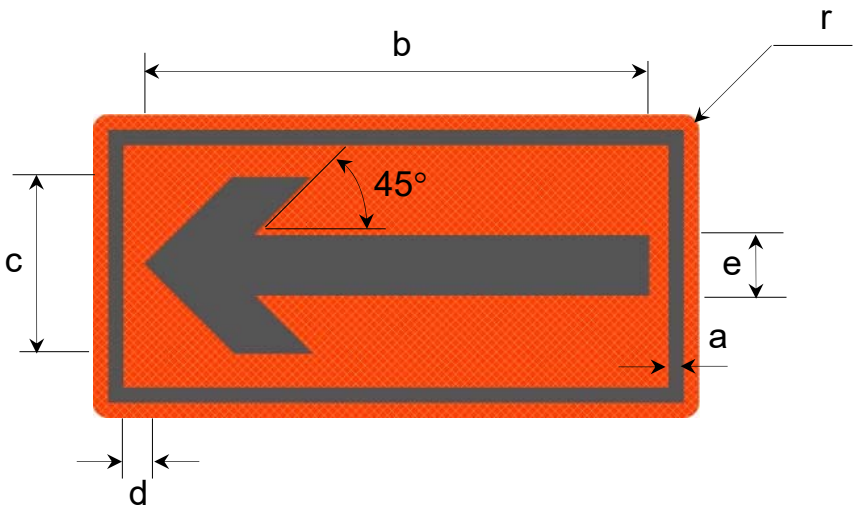
Size	r	a	b	C	d	e	F	g (R)	f (R)
900 X 900	30	24	75	70	230	340	605	208	271
1200 X 1200	30	24	110	100	320	480	855	208	271

Sign W 35: Distance Supplementary Plate

Sign W 35
Distance Supplementary Plate

Size	r	a	b
600 X 300	15	15	170
900 X 350	15	15	230

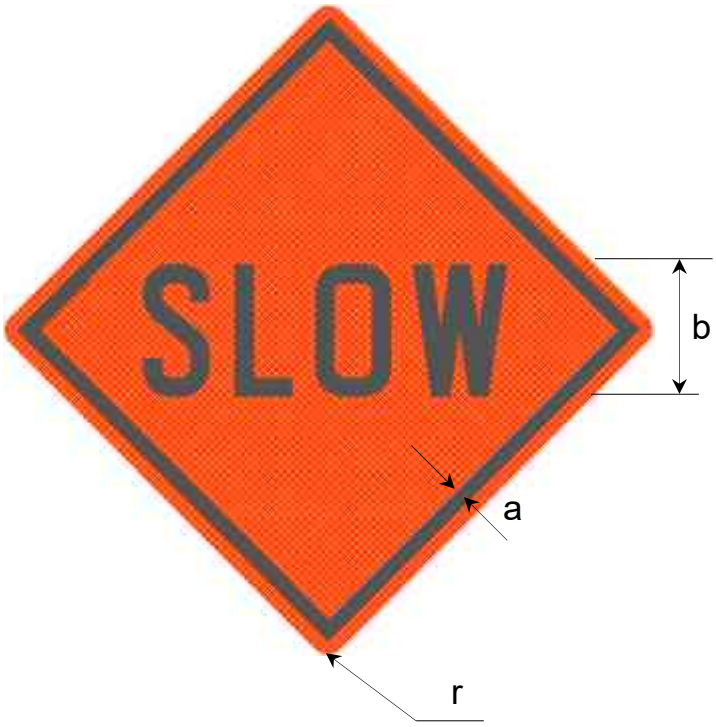
Sign W 36: Arrow Direction Supplementary Plate



Sign W 36
Arrow Direction Supplementary Plate

Size	r	A	b	c	D	e
600 X 300	15	15	500	175	20	60
900 X 350	15	15	700	240	70	80

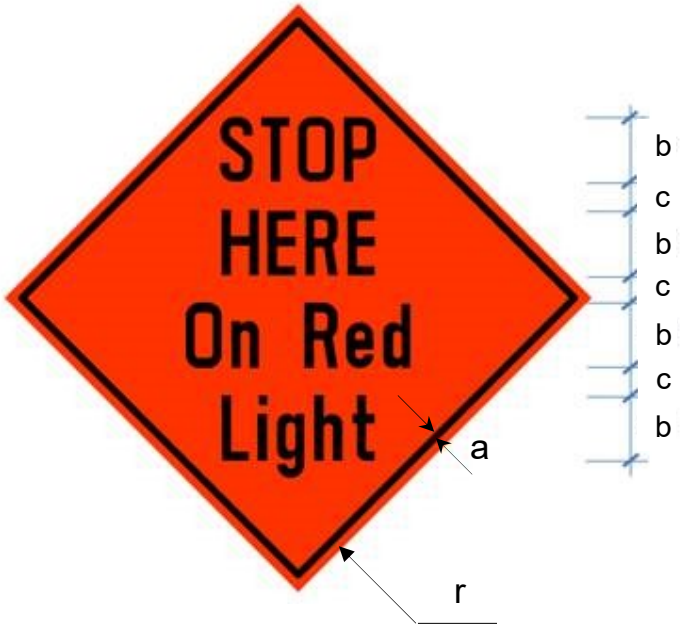
Sign W 37: Slow



Sign W37
Slow Sign

Size	r	a	B
900 X 900	30	24	200
1200 X 1200	30	24	250

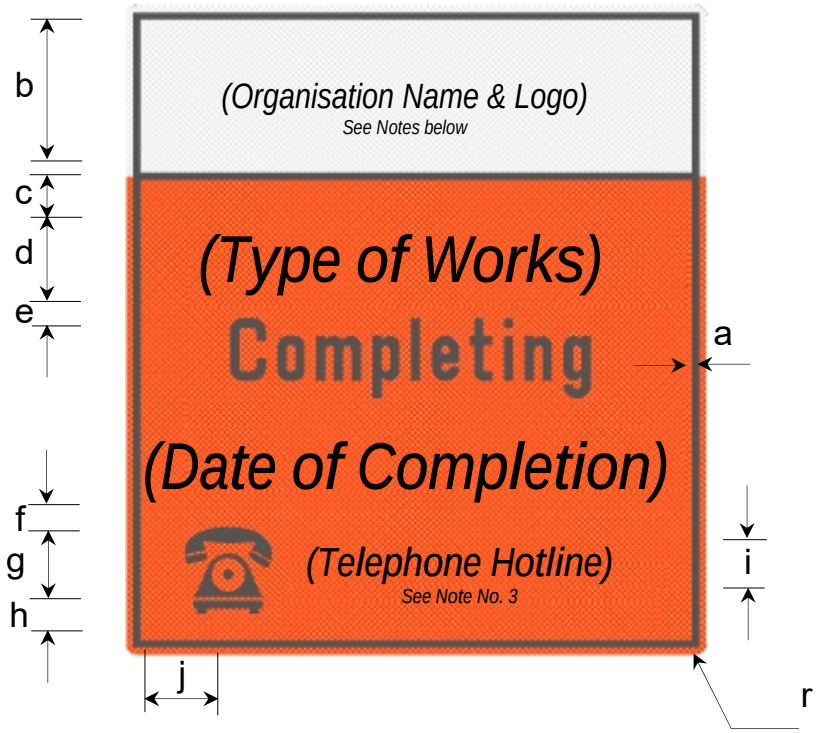
Sign W 38: Stop Here on Red Light



Sign W 38
Stop Here on Red Light

Size	r	A	b	c
900 X 900	30	24	140	60

Sign I 1: Project Information



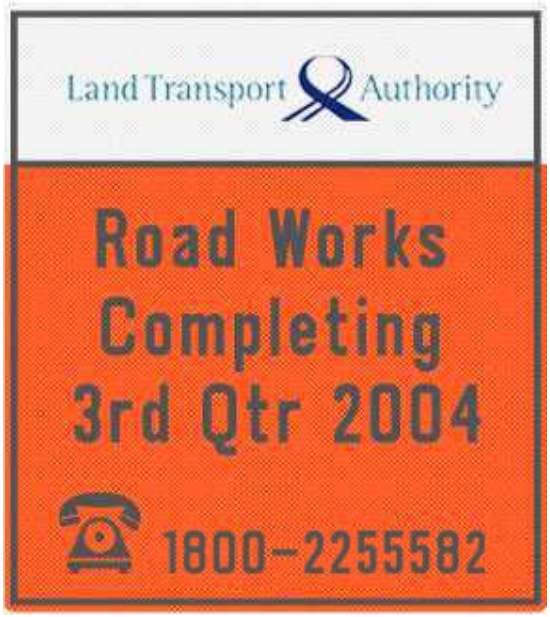
Sign I 1
Project Information (Generic) Sign

Size	r	a	b	c	D	e	f	g	h	i	j
1300 X 1500	30	16	345	100	140	70	90	195	60	100	195
2000 X 2200	30	24	515	150	210	105	135	305	90	150	305

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. Respective departments and boards shall also be indicated their telephone hotline at the bottom of the sign.

Sign I 2: Project Information – Land Transport Authority

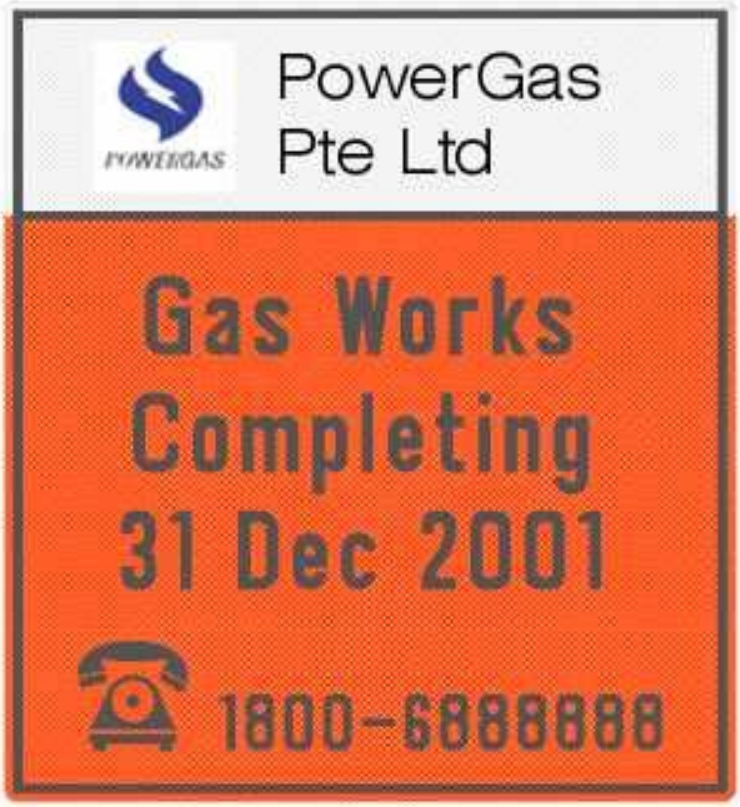


Sign I 2
Sample of Project Information Sign of Land Transport Authority

Note:

1. This is the preferred layout of this sign.for Land Transport Authority.
2. The dimensions for this sign is as sign I1described earlier.

Sign I 3: Project Information - Services Department

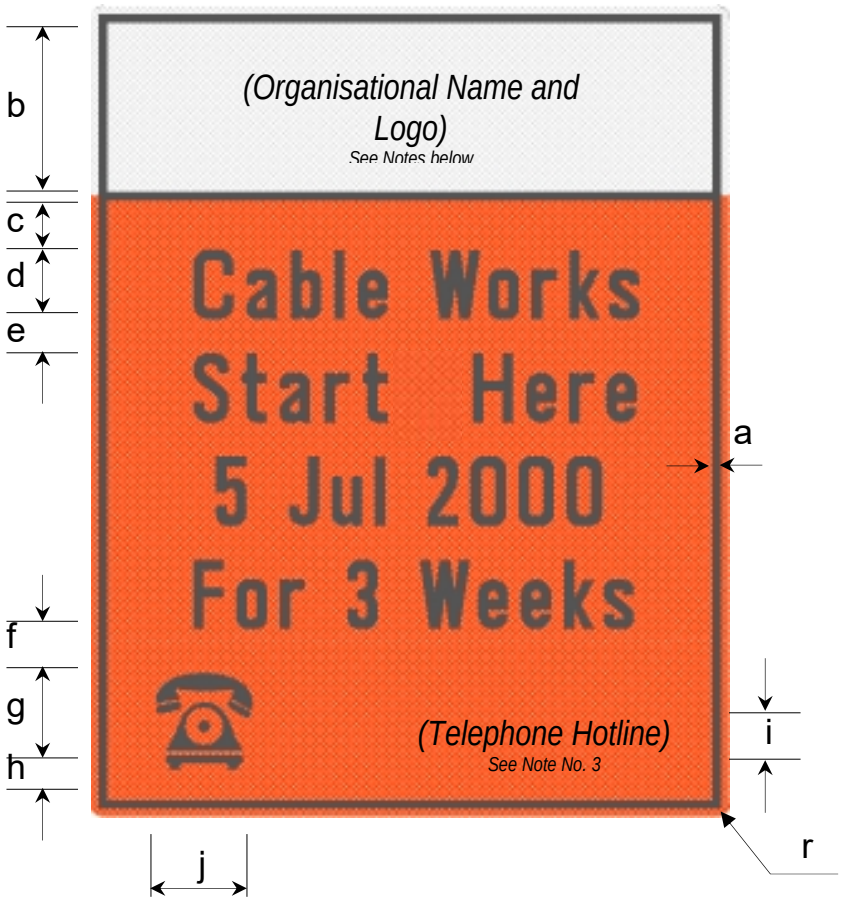


Sign I 3
Suggested Project Information Sign for Services Departments

Note:

1. This is a suggested project signboard for organisations working on public road.
2. The dimensions and requirements is as sign I1 described earlier.

Sign I 4: Coming Your Way



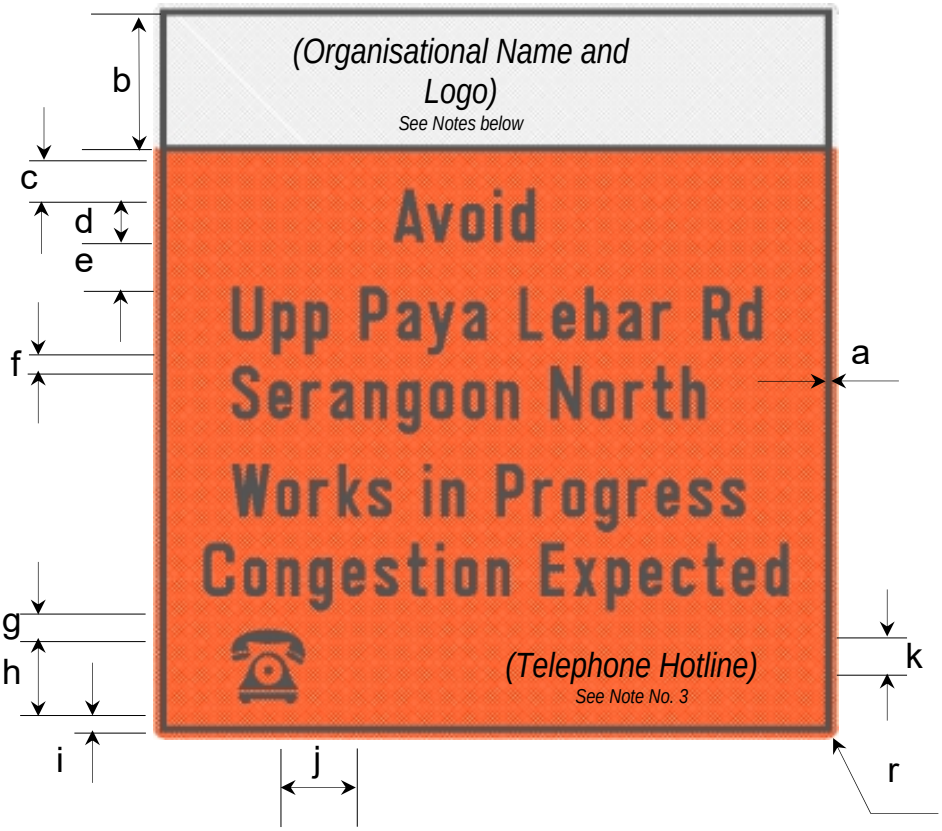
Sign I 4
"Coming Your Way" Sign

Size	r	a	b	c	d	e	f	g	h	i	j
1300 X 1700	30	16	400	100	140	70	90	195	60	100	195
2000 X 2500	30	24	542	150	210	105	135	305	90	150	305

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. Respective departments and boards shall also be indicated their telephone hotline at the bottom of the sign.

Sign I 5: Avoid Congested Road



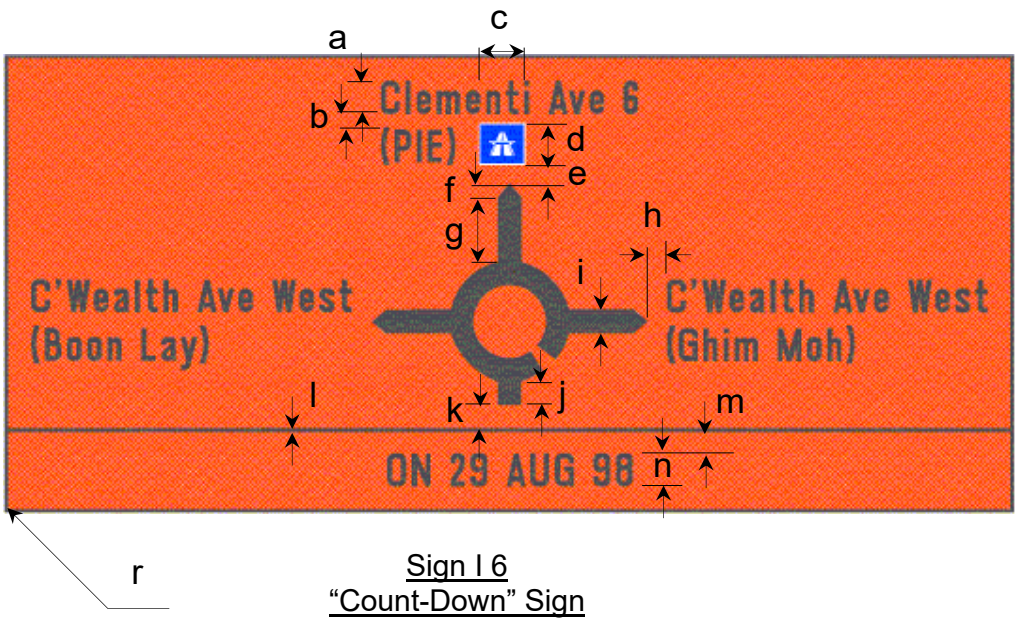
Sign I 5
"Avoid Congested Road" Sign

Size	r	a	b	c	D	e	f	g	h	i	j	k
1700 X 2000	30	16	397	100	140	120	70	90	195	60	195	100
2600 X 3000	30	24	584	150	210	180	105	135	305	90	305	150

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. Respective departments and boards shall also be indicated their telephone hotline at the bottom of the sign.

Sign I 6: Count Down on Implementing of Temporary Traffic Arrangement



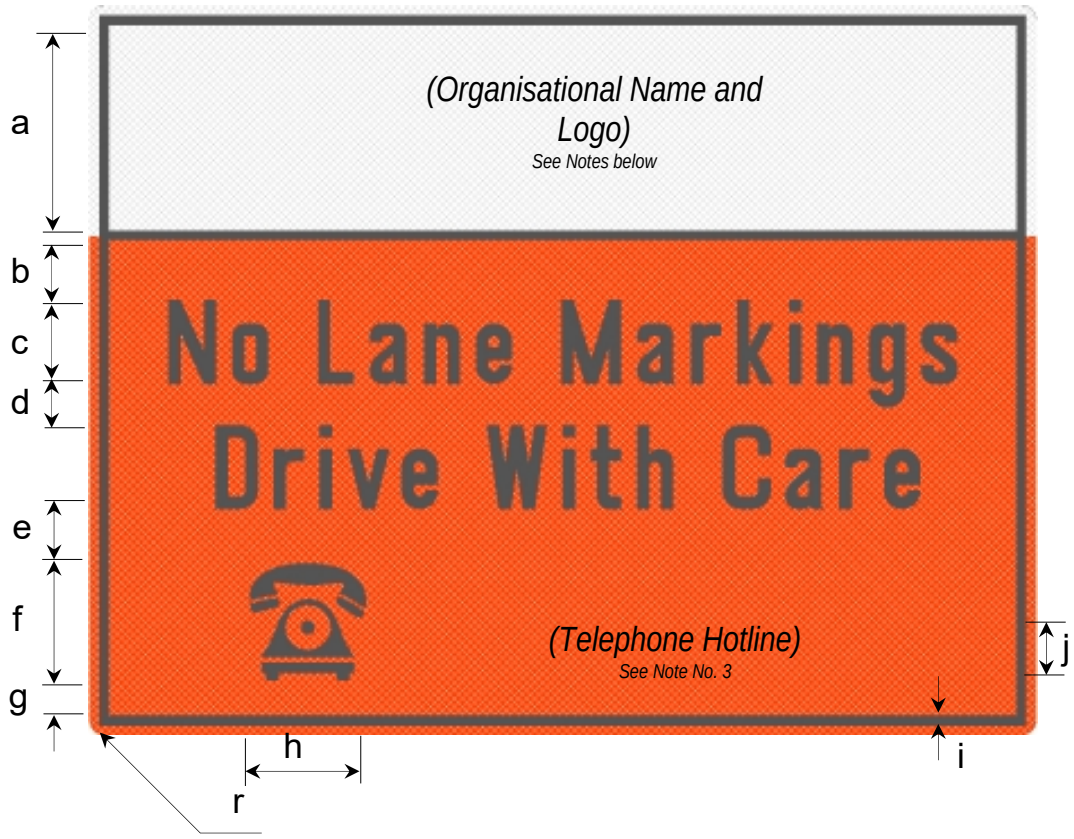
Sign I 6
"Count-Down" Sign

Size	r	a	b	c	d	e	F	g	h	i	j	k	l	m	n
4378 X 1985	30	140	70	200	180	80	60	280	90	100	100	100	16	100	140
6542 X 2985	30	210	105	300	270	120	90	420	135	150	150	150	24	150	210

Note:

1. This sign shall be used to supplement other information signs, e.g. I8 or I18, for a day-to-day countdown of the implementation of temporary traffic arrangement.
2. The overall layout of this sign, together with the information sign it is supplementing, shall be approved by LTA.

Sign I 7: No Lane Markings



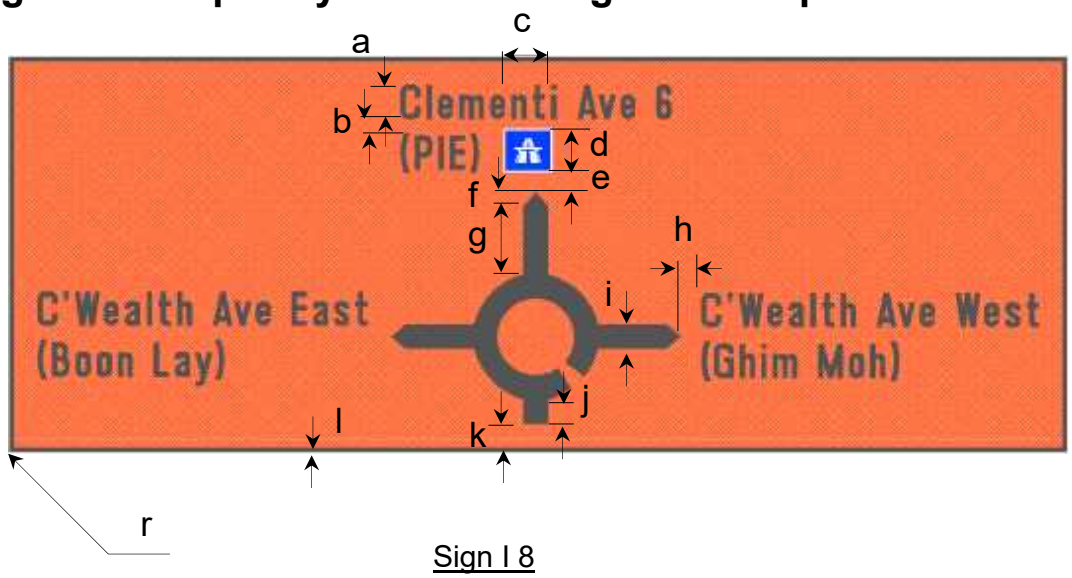
Sign I 7
"No Lane Markings" Sign

Size	r	a	b	c	d	e	f	g	h	i	j
1600 X 1300	30	424	100	140	70	90	195	60	195	16	100
2400 X 1900	30	577	150	210	105	135	305	90	305	24	150

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. Respective departments and boards shall also be indicated their telephone hotline at the bottom of the sign.

Sign I 8: Temporary Traffic Arrangement Map

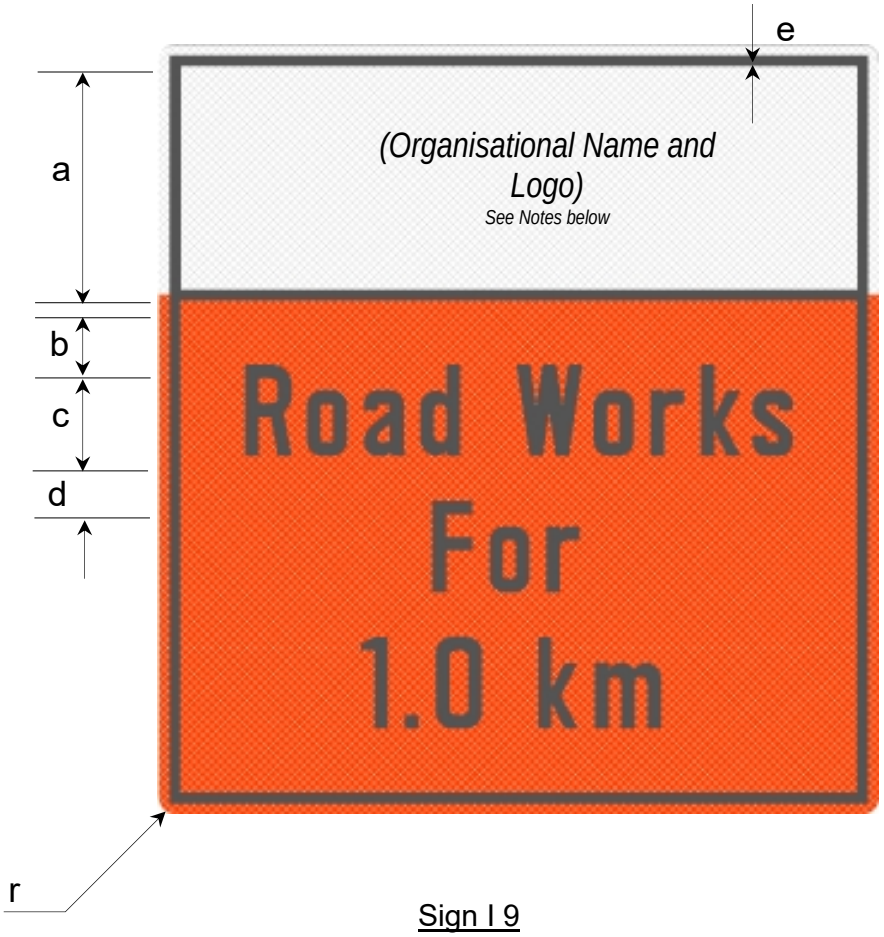


Sign I 8
Temporary Traffic Arrangement Map

Size	r	a	b	c	D	e	f	g	h	i	j	k	l
4354 X 1631	30	140	70	200	180	80	60	280	90	100	100	100	16
6505 X 2451	30	210	105	300	270	120	90	420	135	150	150	150	24

Note:
1. This sign is to inform the motorist of a new but temporary traffic scheme ahead and shall not be treated as a directional sign.
2. This sign shall be manufactured according to the latest specifications from the Traffic Management Department of Land Transport Authority.
3. The layout of the sign shall be approved by Land Transport Authority together with the proposed traffic scheme.

Sign I 9: Start of Work Zone - Roadworks



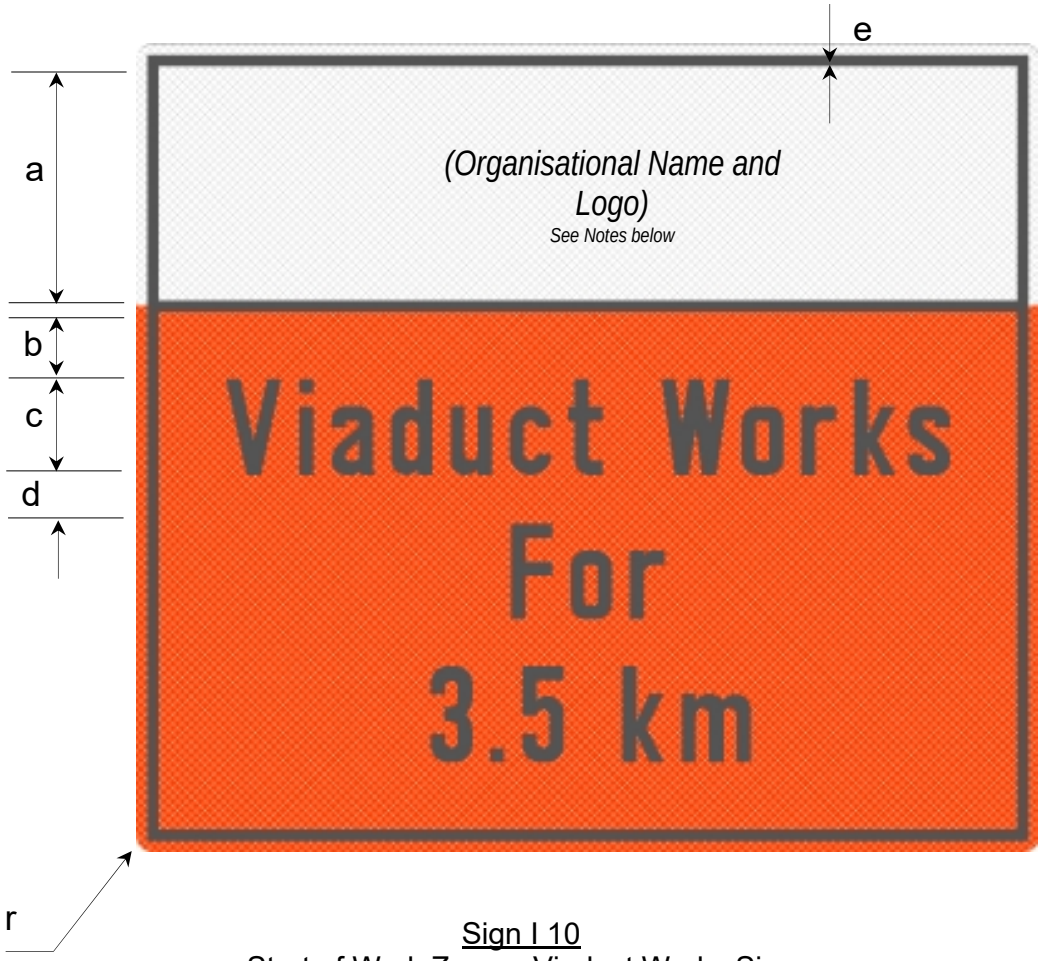
Sign I 9
Start of Work Zone – Road Works Sign

Size	r	a	B	c	d	e
1100 X 1200	30	360	100	140	70	16
1700 X 1800	30	540	150	210	105	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 10: Start of Work Zone – Viaduct Works



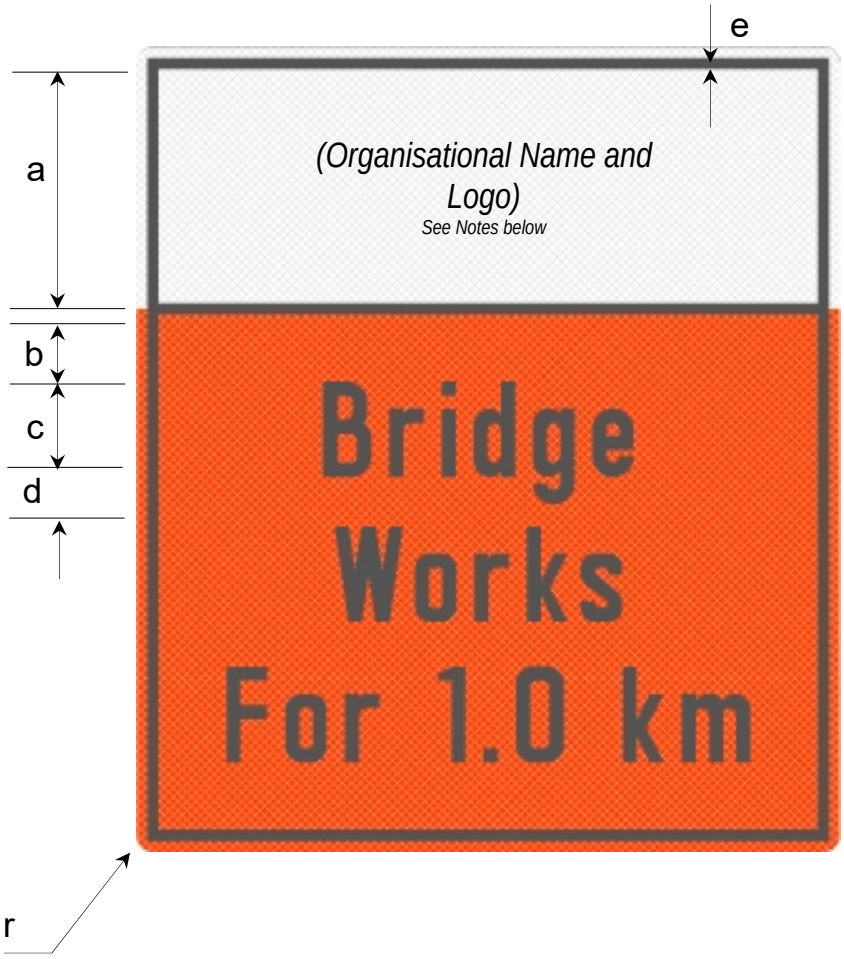
Sign I 10
Start of Work Zone – Viaduct Works Sign

Size	r	A	b	c	d	e
1400 X 1200	30	355	100	140	70	16
2000 X 1800	30	540	150	210	105	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 11: Start of Work Zone – Bridge Works



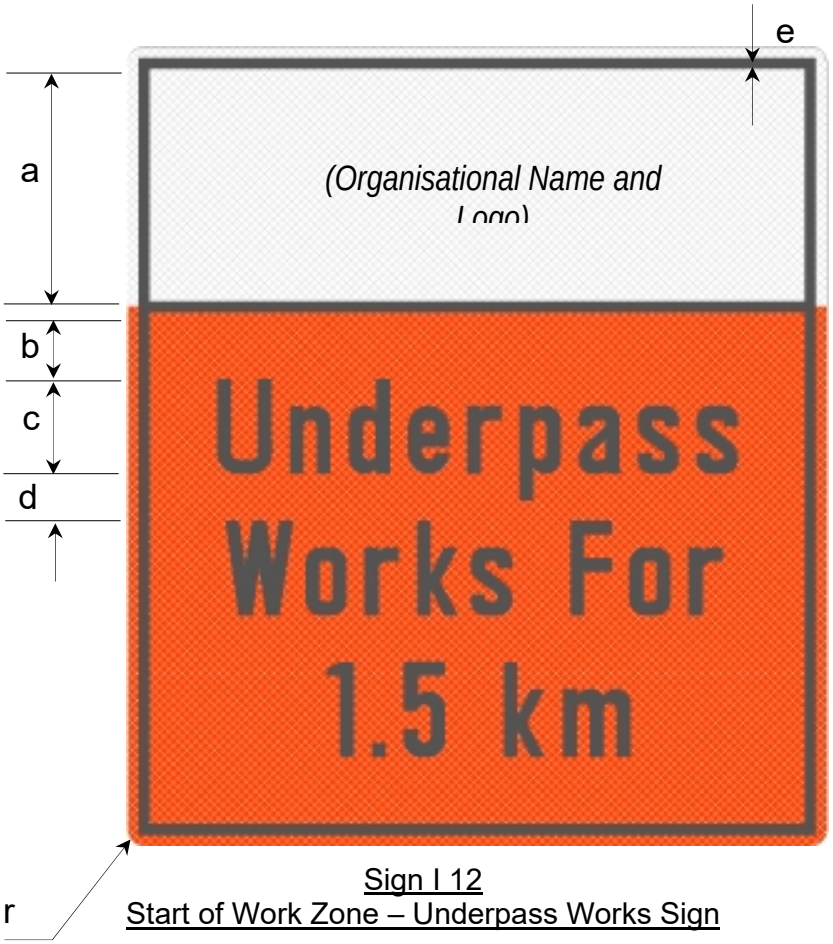
Sign I 11
Start of Work Zone – Bridge Works Sign

Size	r	A	b	c	d	e
1100 X 1200	30	360	100	140	70	16
1600 X 1800	30	540	150	210	105	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 12: Start of Work Zone – Underpass Works



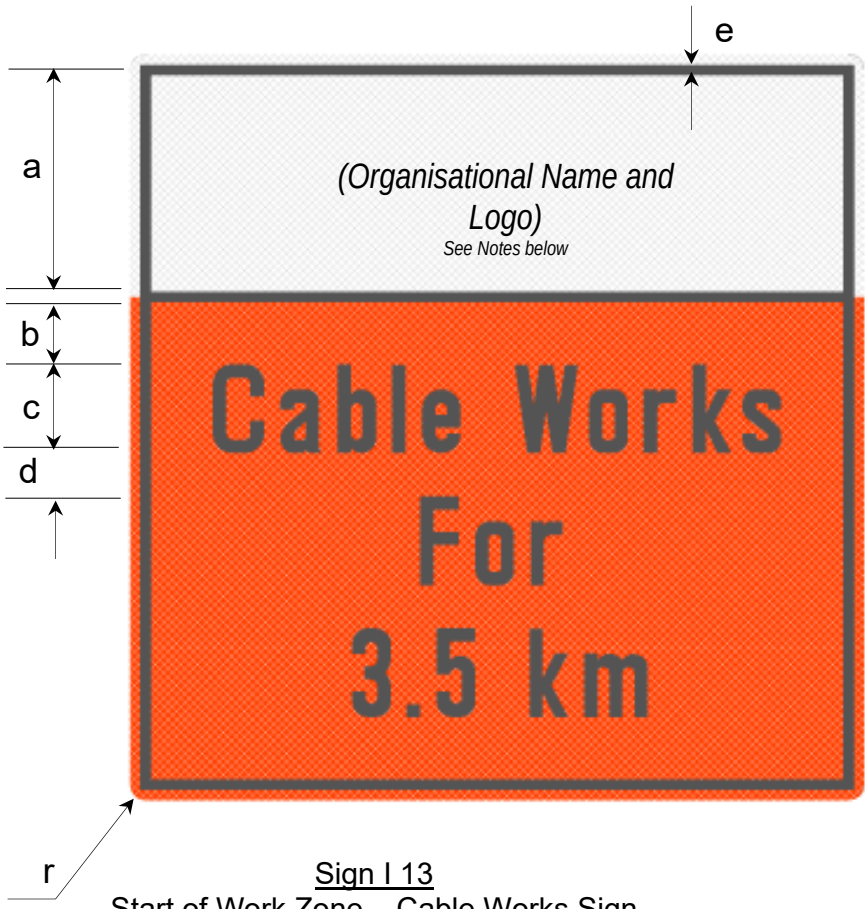
Sign I 12
Start of Work Zone – Underpass Works Sign

Size	r	A	b	c	d	e
1100 X 1200	30	360	100	140	70	16
1600 x 1800	30	540	150	210	105	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 13: Start of Work Zone – Cable Works



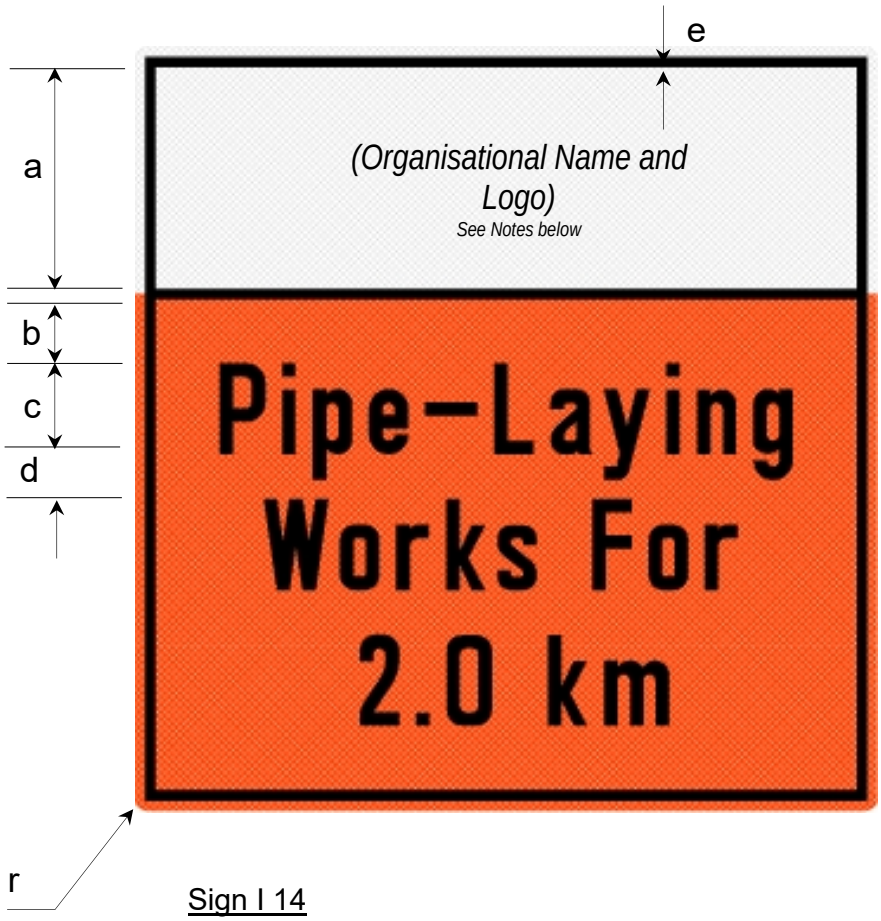
Sign I 13
Start of Work Zone – Cable Works Sign

Size	r	a	b	c	d	e
1200 X 1200	30	360	100	140	70	16
1800 x 1800	30	540	150	210	105	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 14: Start of Work Zone – Pipe-Laying Works



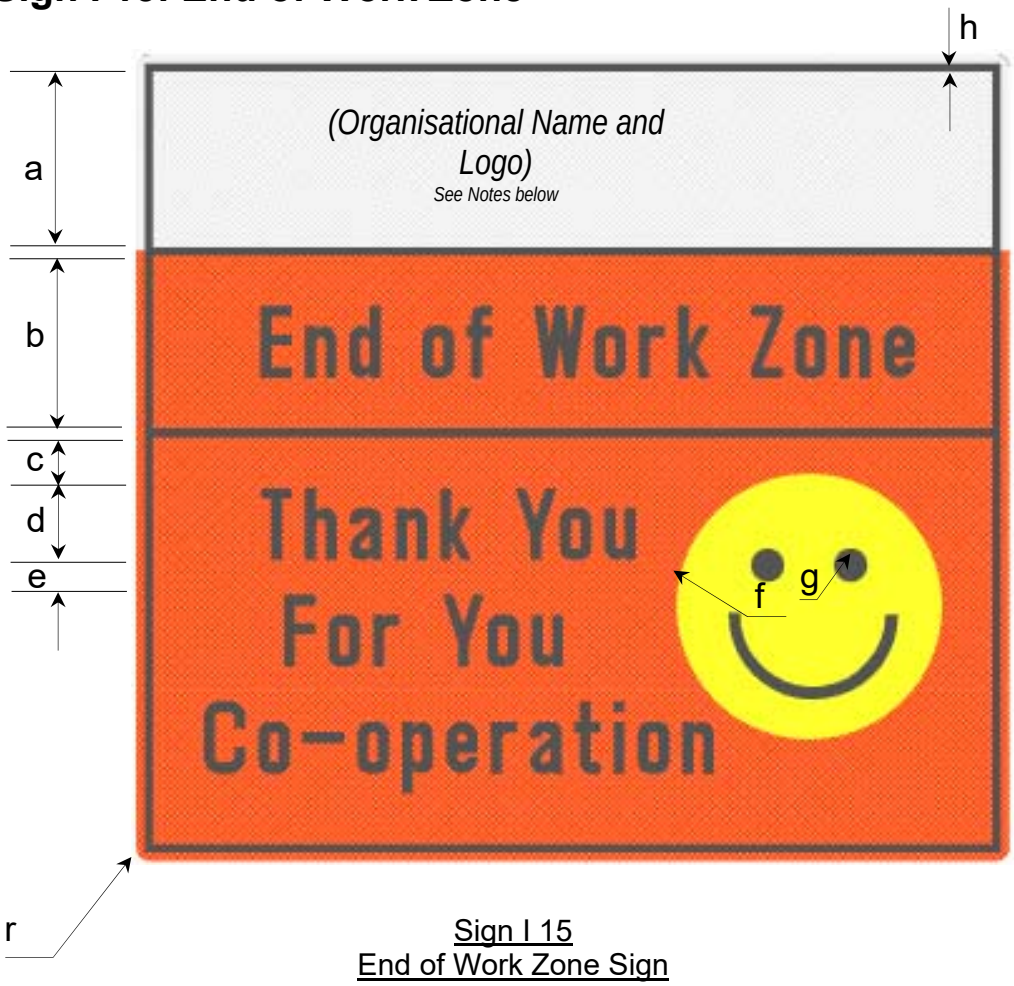
Sign I 14
Start of Work Zone – Pipe-Laying Works Sign

Size	r	a	b	c	d	e
1200 X 1200	30	360	100	140	70	16
1800 x 1800	30	540	150	210	105	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 15: End of Work Zone



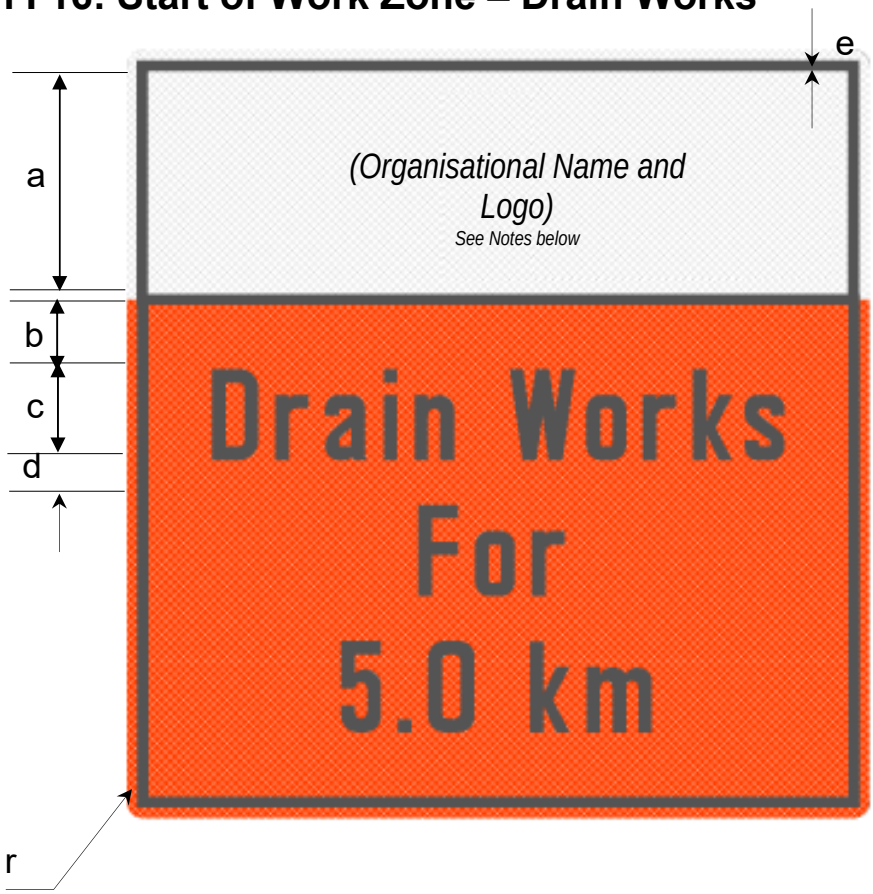
Sign I 15
End of Work Zone Sign

Size	r	a	b	C	D	e	f (R)	g(R)	h
1700 X 1600	30	363	345	100	140	70	260	32	16
2600 X 2400	30	545	515	150	210	105	325	40	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 16: Start of Work Zone – Drain Works



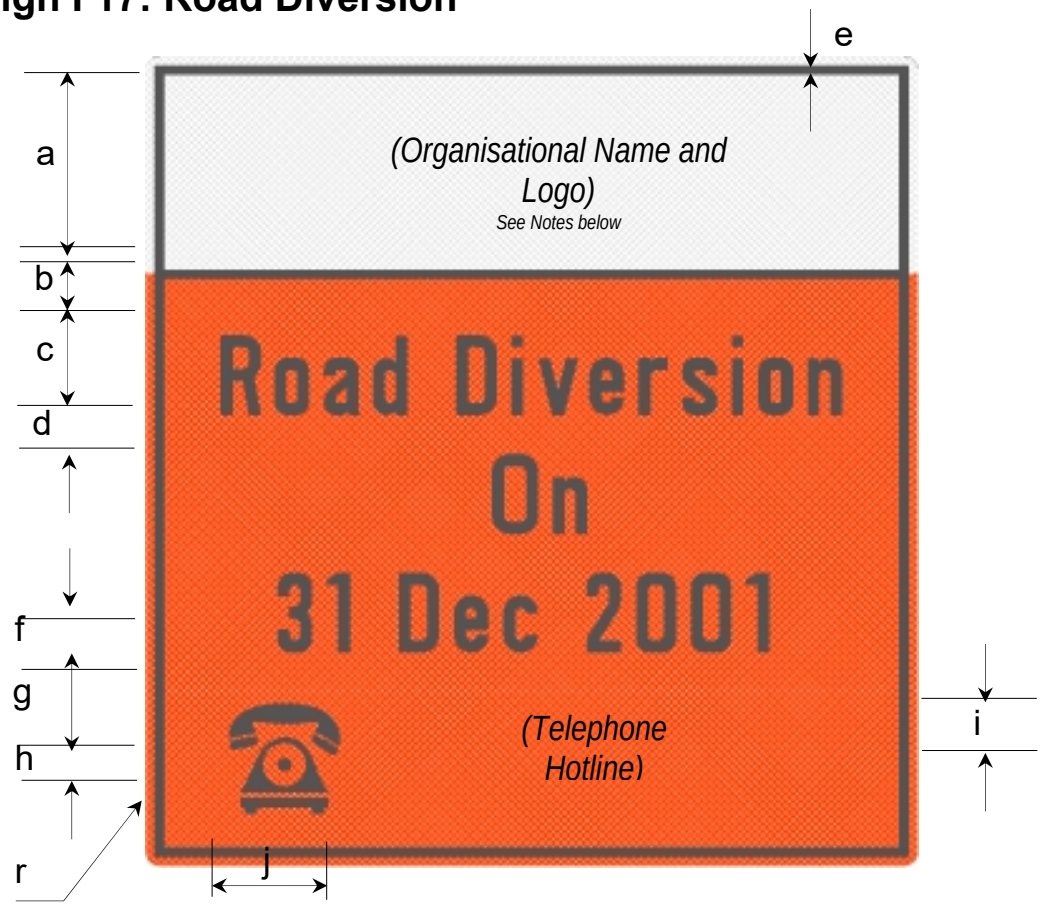
Sign I 16
Start of Work Zone – Drain Works Sign

Size	r	A	B	c	d	e
1200 X 1200	30	360	100	140	70	16
1700 x 1800	30	525	150	210	105	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 17: Road Diversion



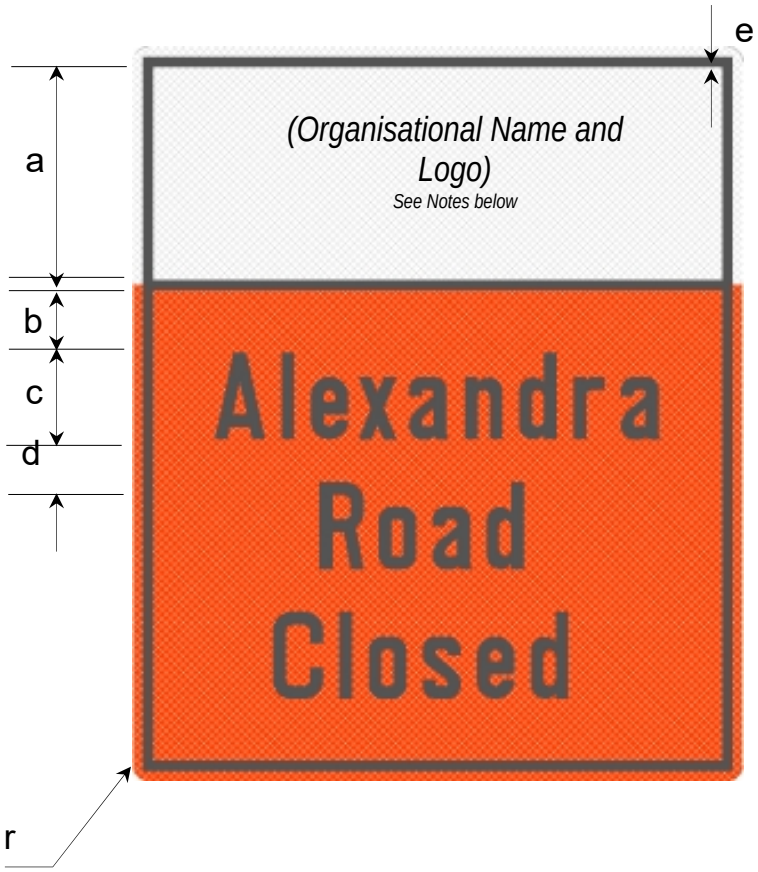
Sign I 17
Road Diversion Forecast Sign

Size	r	a	b	c	d	e	f	g	h	i	j
1400 X 1500	30	410	100	140	70	16	90	195	60	100	195
2100 x 2200	30	555	150	210	105	24	135	305	90	150	305

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. Respective departments and boards shall also be indicated their telephone hotline at the bottom of the sign.

Sign I 18: Road Closed



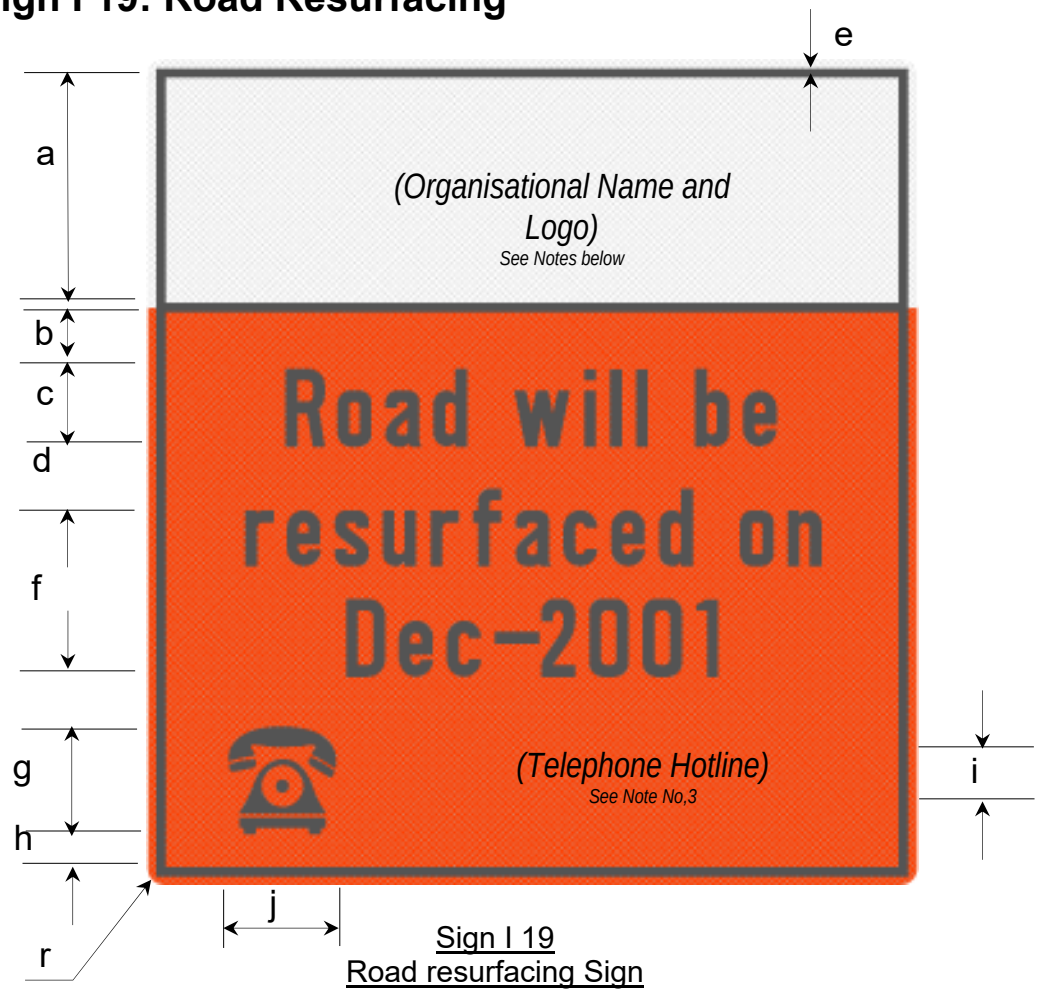
Sign I 18
Road Closed Sign

Size	r	a	b	c	d	e
1000 X 1200	30	360	100	140	70	16
1500 x 1800	30	540	150	210	105	24

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. This sign shall be used to supplement other information signs like Sign I1 that provides telephone hotline number, therefore it is not necessary to repeat the telephone number on this sign.

Sign I 19: Road Resurfacing



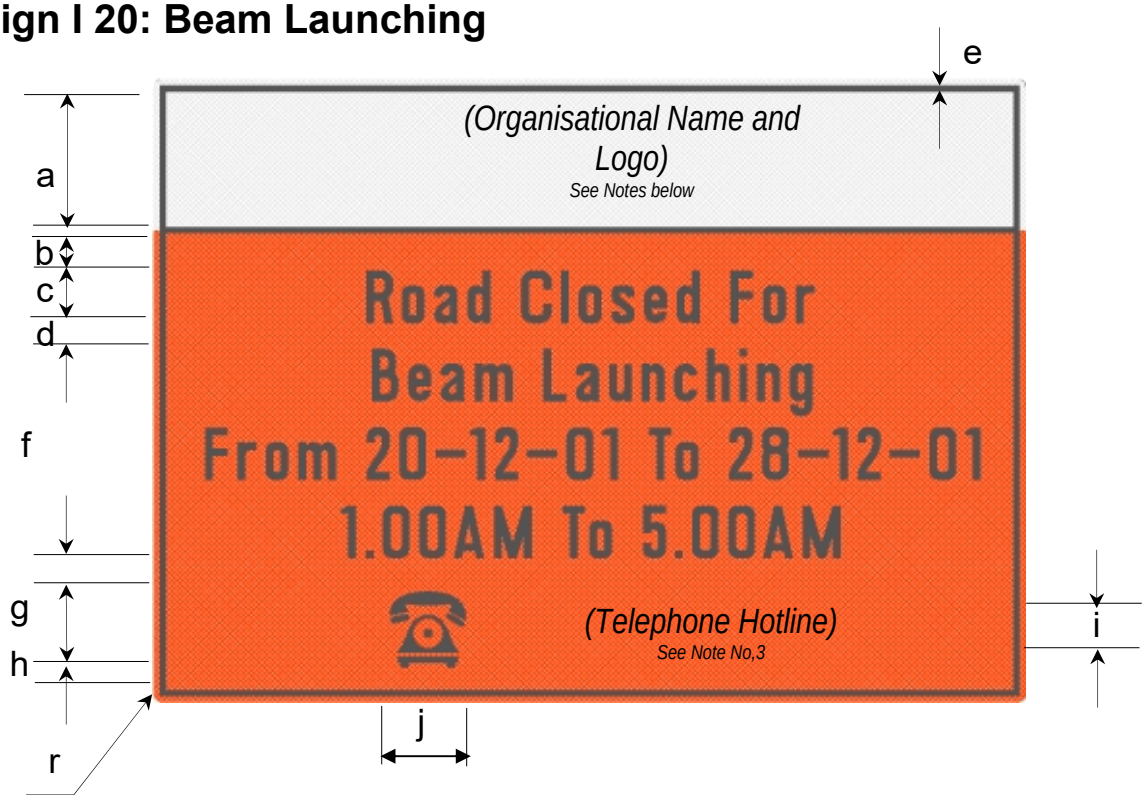
Sign I 19
Road resurfacing Sign

Size	r	a	b	c	d	e	f	g	h	i	j
1400 X 1500	30	410	100	140	70	16	90	195	60	100	195
2100 x 2200	30	555	150	210	105	24	135	305	90	150	305

Note:

1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. Respective departments and boards shall also be indicated their telephone hotline at the bottom of the sign.

Sign I 20: Beam Launching



Sign I 20
Beam Launching Sign

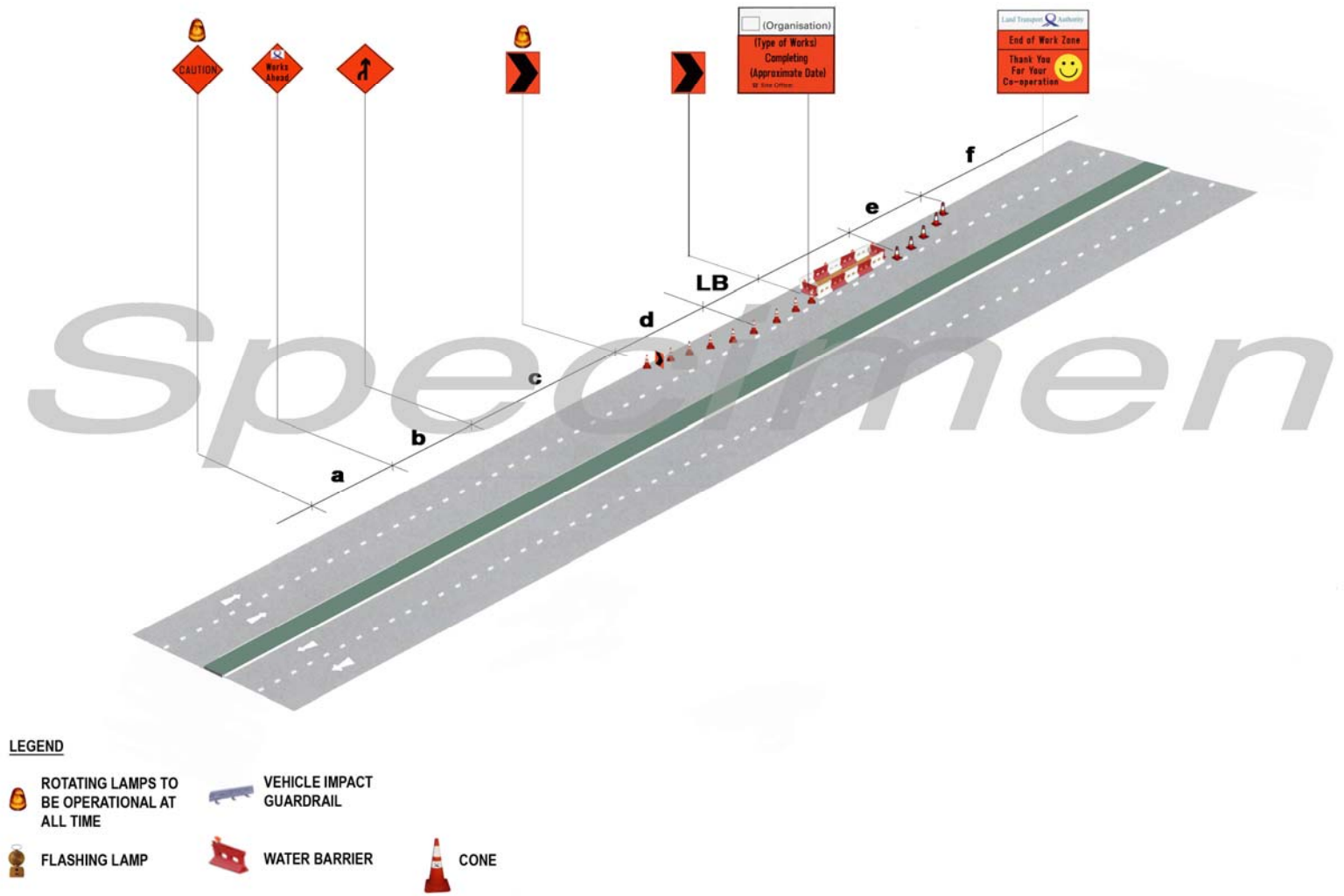
Size	r	a	b	c	d	e	f	g	h	i	j
2300 X 1700	30	402	100	140	70	16	90	195	60	100	195
3500 x 2500	30	545	150	210	105	24	135	305	90	150	305

Note:

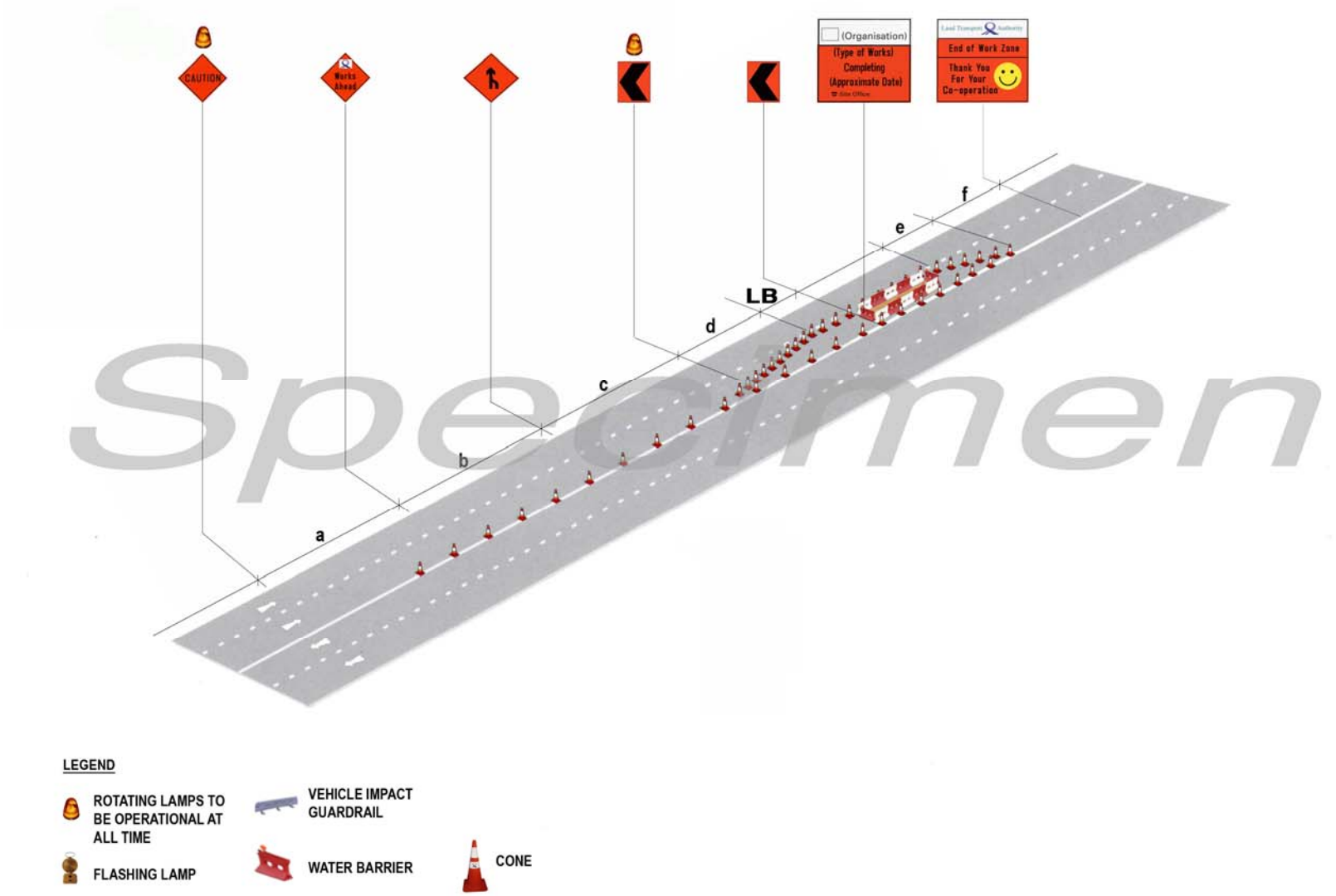
1. The name and logo of the employing organisation working on the road shall be displayed on the white band at the top of the sign.
2. The respective organisation may design their preferred layout within this white band and shall inform the Manager, Road Asset Regulation & Licensing Department of Land Transport Authority on this preferred layout.
3. Respective departments and boards shall also be indicated their telephone hotline at the bottom of the sign.

APPENDIX V - Examples of Traffic Control Plans

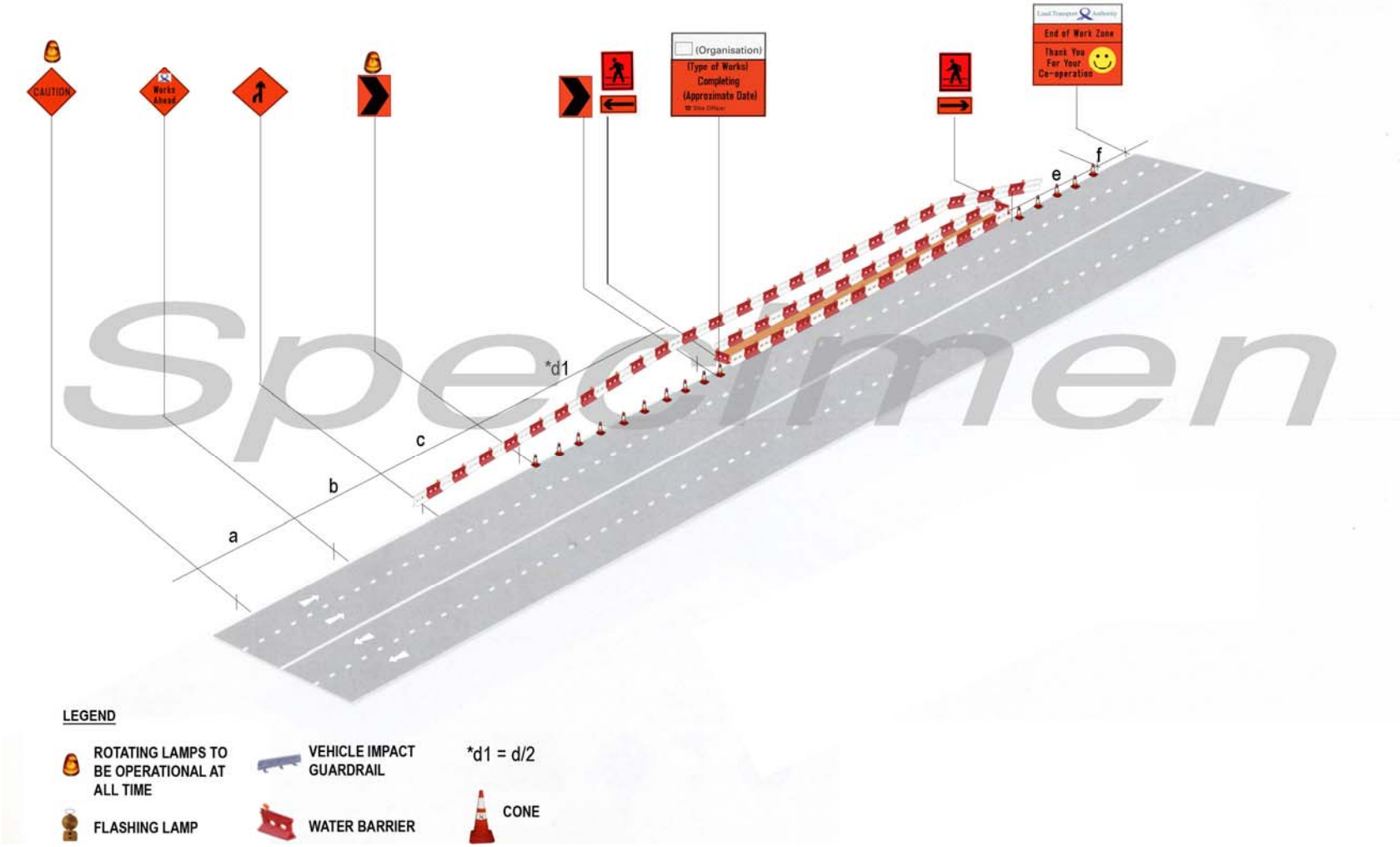
Traffic arrangement for single lane closure of two or more lane carriageway



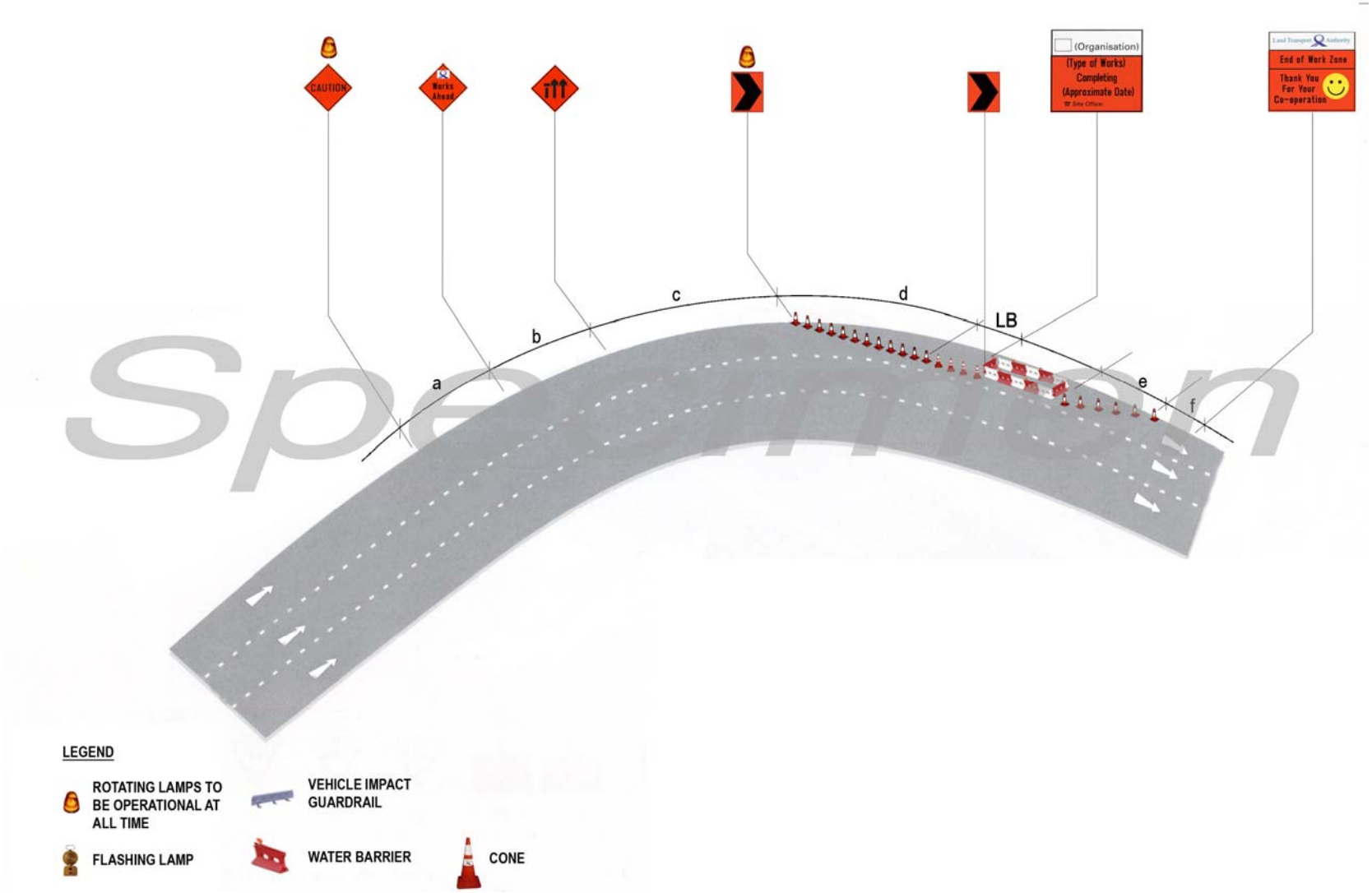
Traffic Arrangement for Closure of Fast Lane



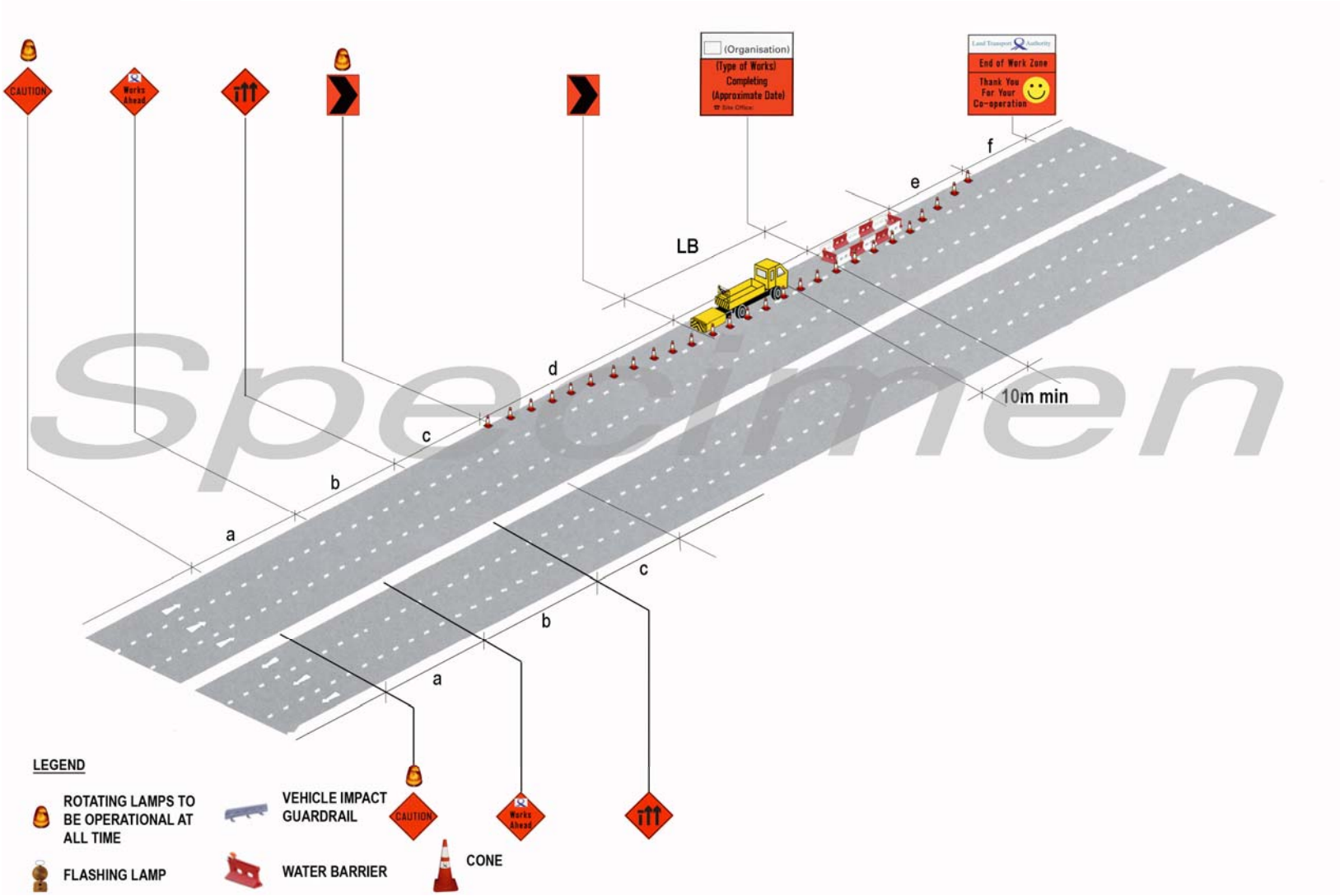
Traffic arrangement for works on side-table with provision of footpath



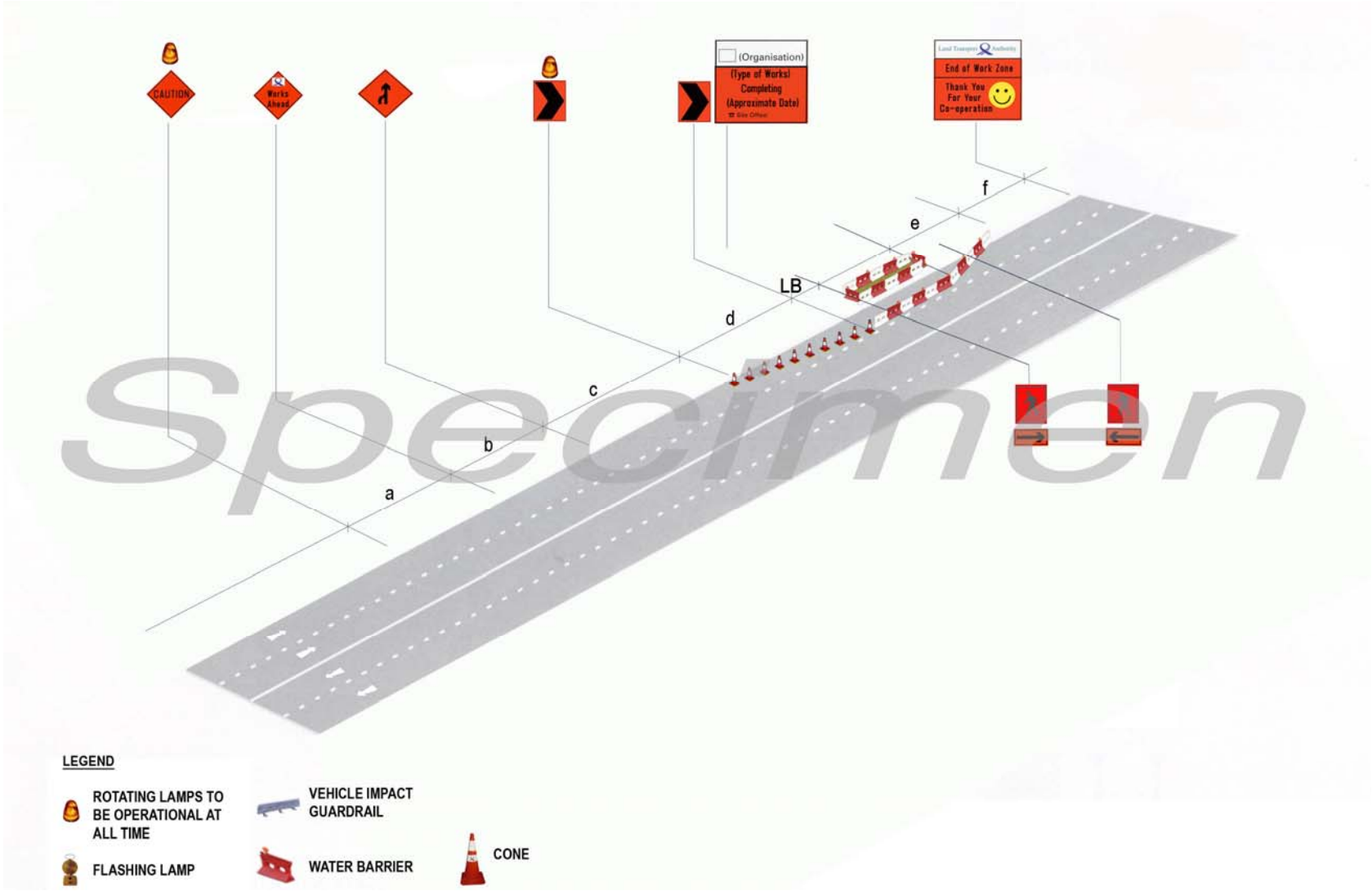
Traffic arrangement for works at road bends



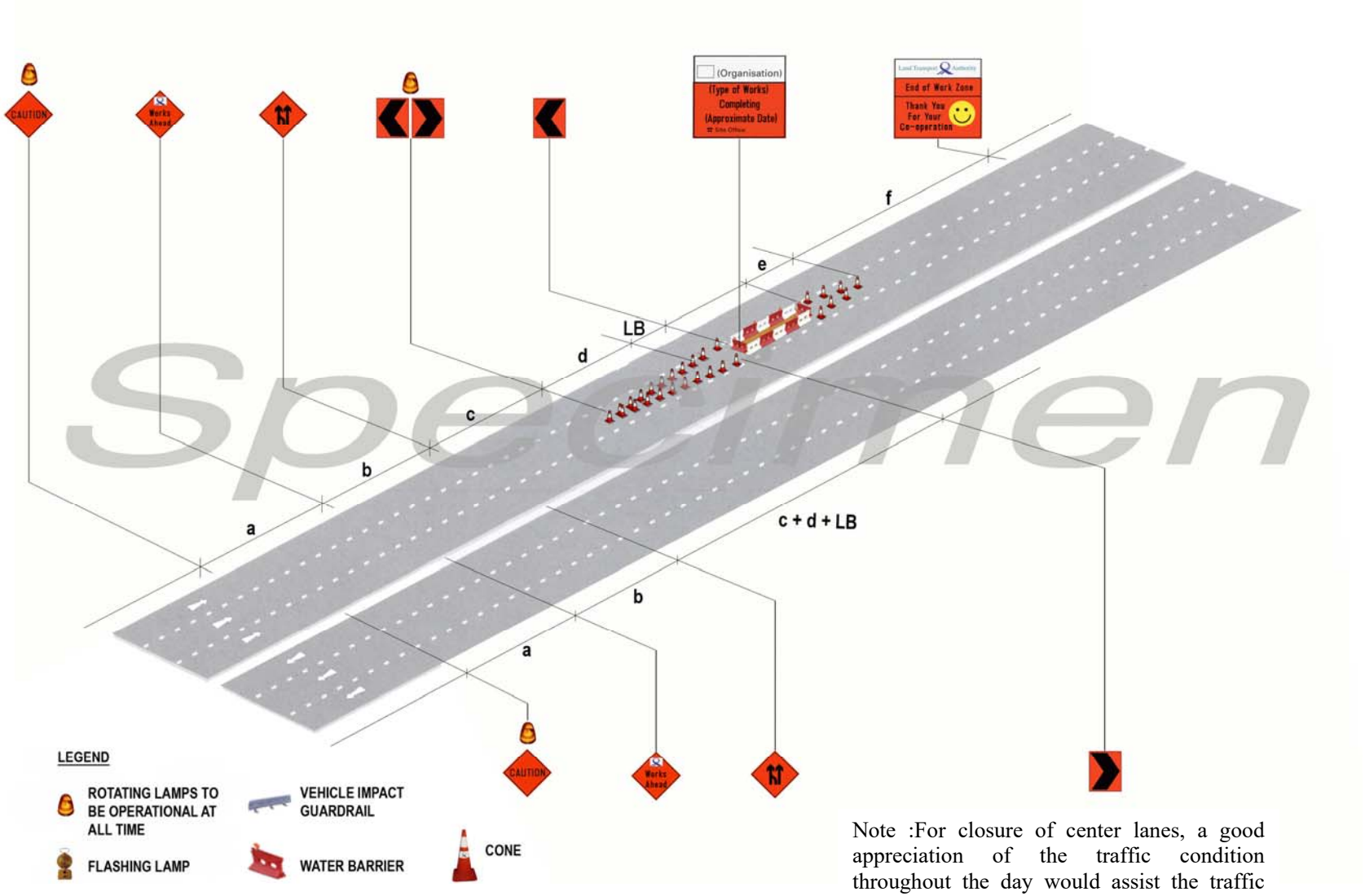
Traffic arrangement for works on roads with speed limit of 70 Kph and above



Traffic arrangement for works on side-table with provision of footpath on the road

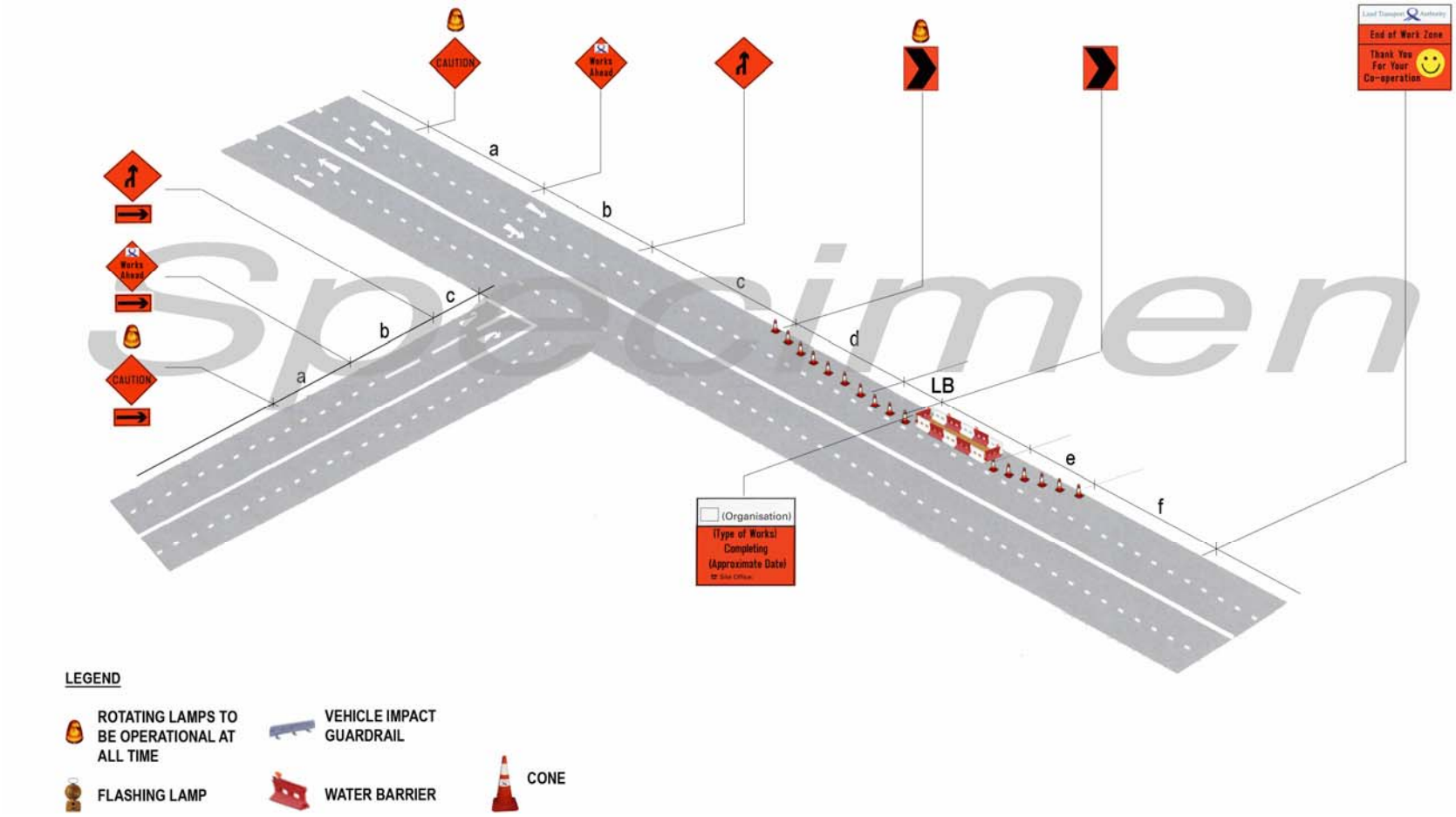


Traffic Arrangement for Closure of Centre Lane

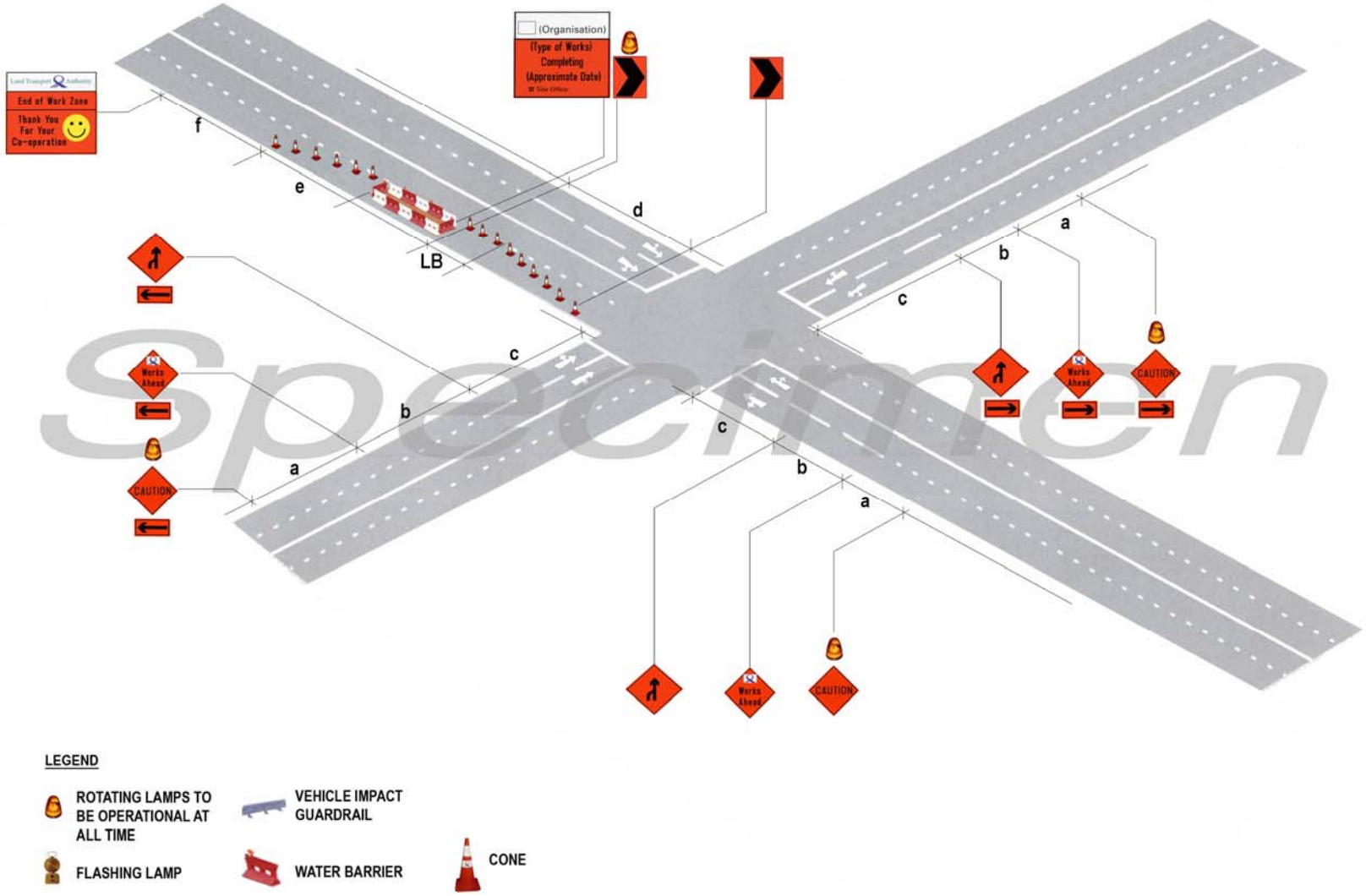


Note :For closure of center lanes, a good appreciation of the traffic condition throughout the day would assist the traffic engineer in deciding which lane to divert the traffic to.

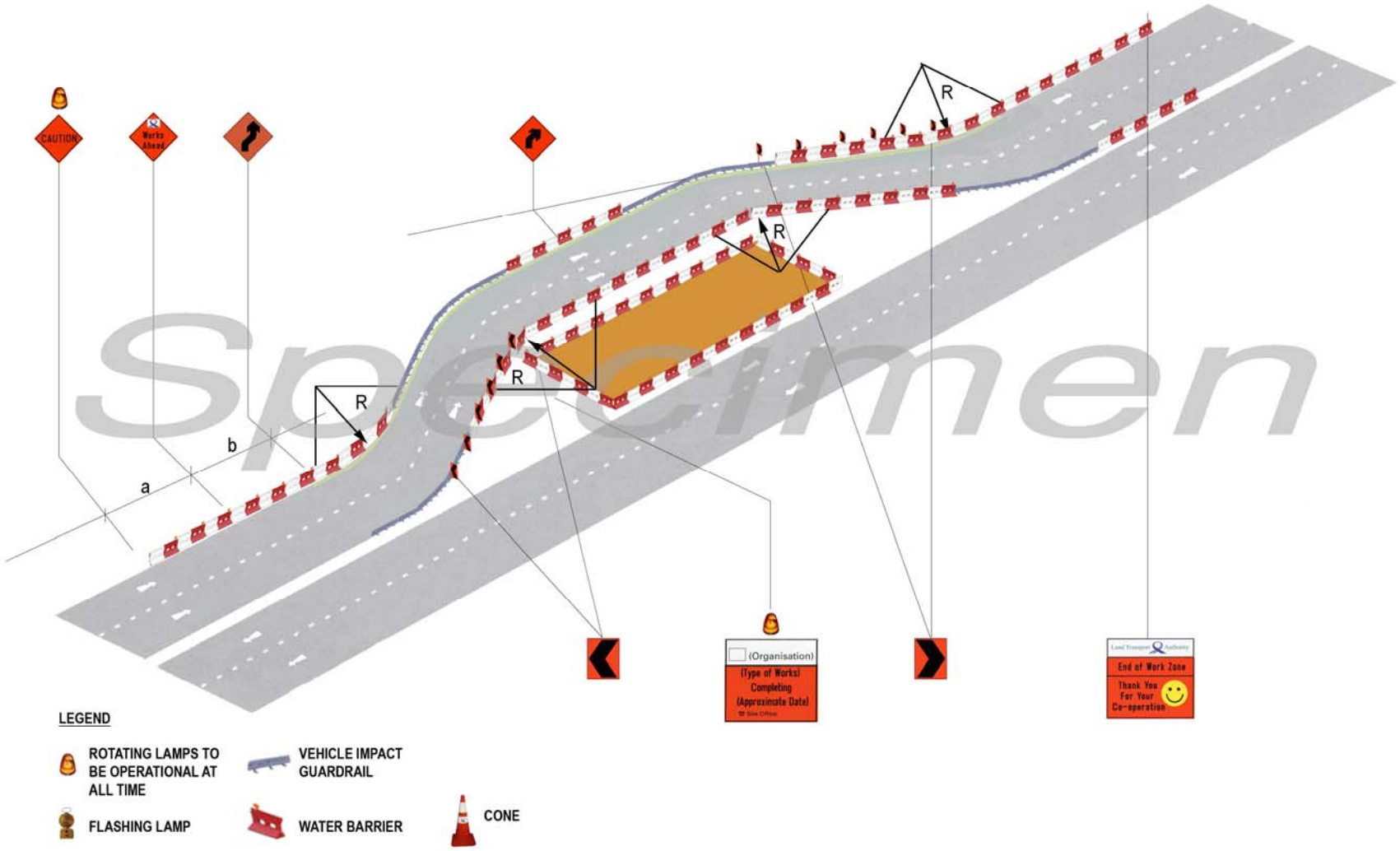
Traffic arrangement for closure of slow lane after a T-junction



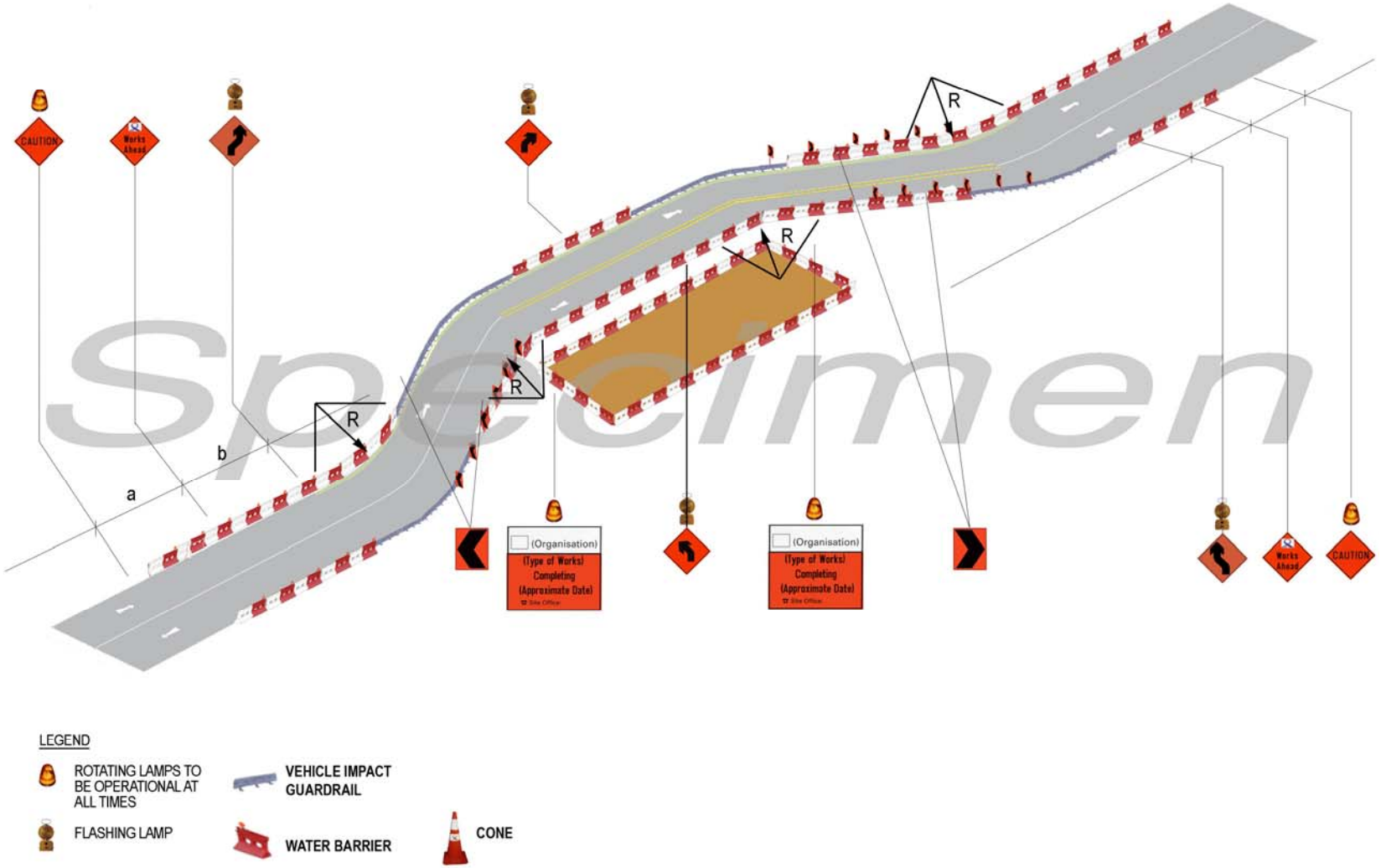
Traffic arrangement for closure of slow lane after a cross-junction



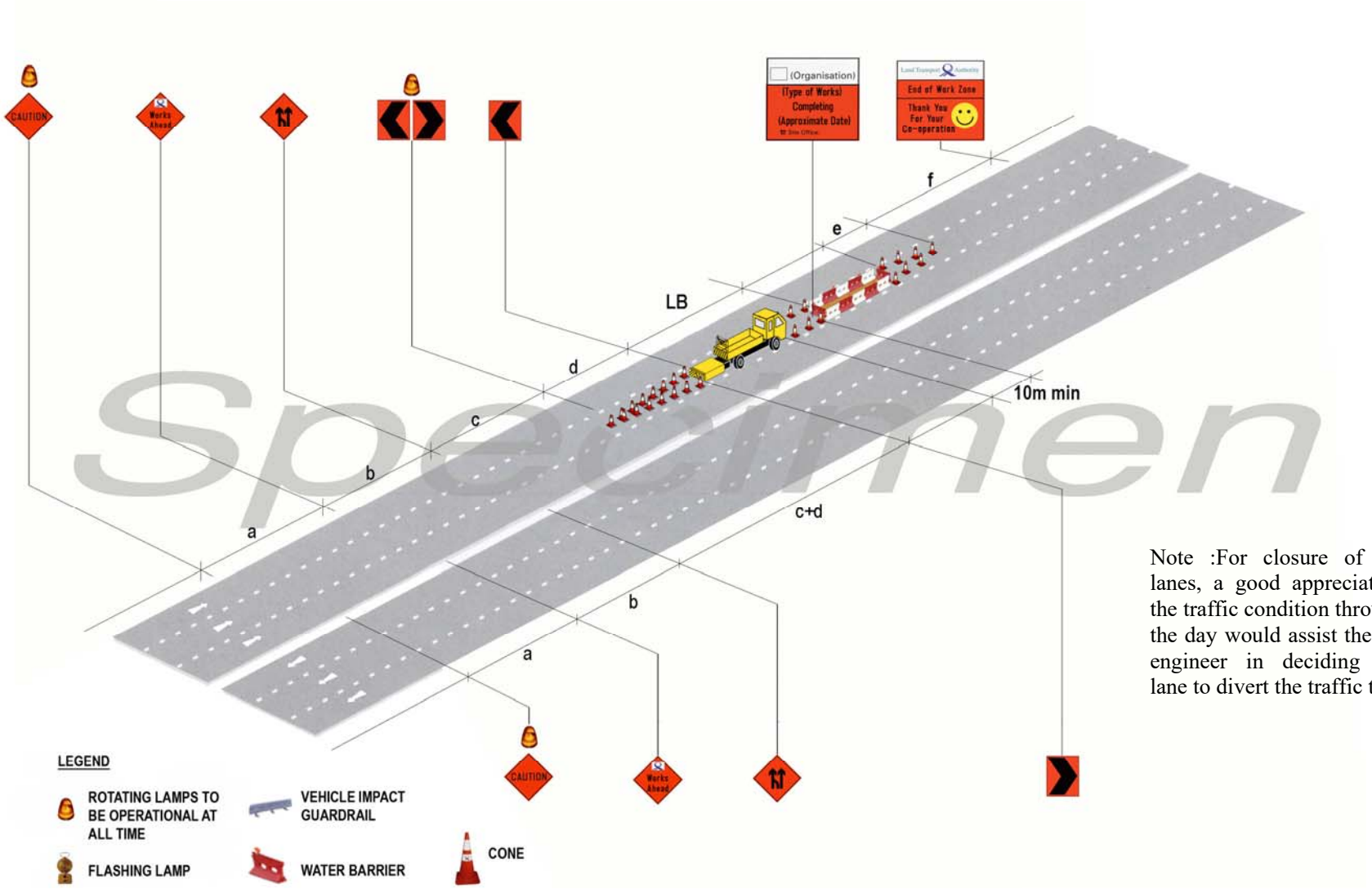
Traffic arrangement for road diversion on a two-lane two-way carriageway



Traffic arrangement for road diversion on a single-lane two-way carriageway

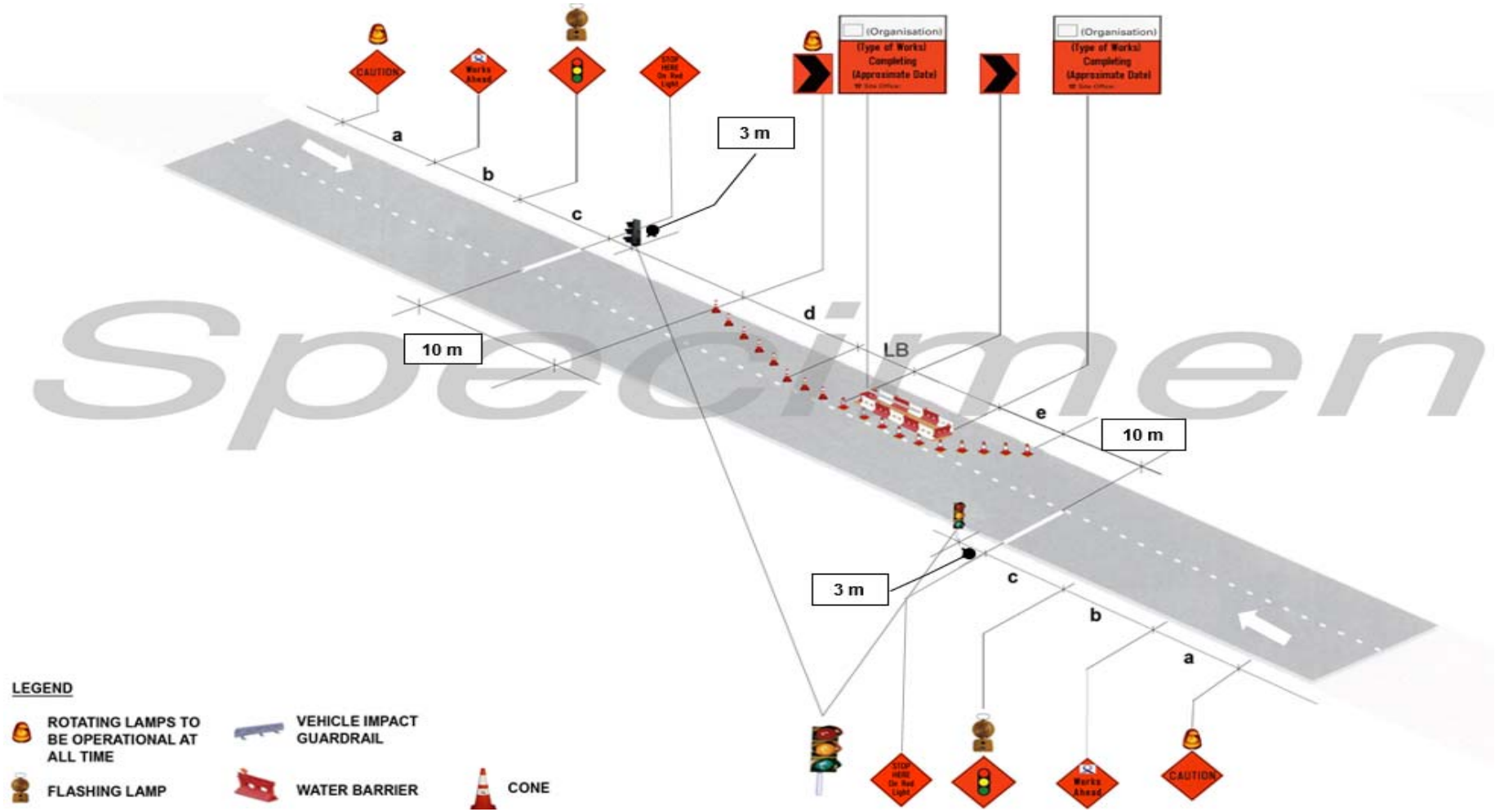


Traffic arrangement for works on roads with speed limit of 70 Kph and above

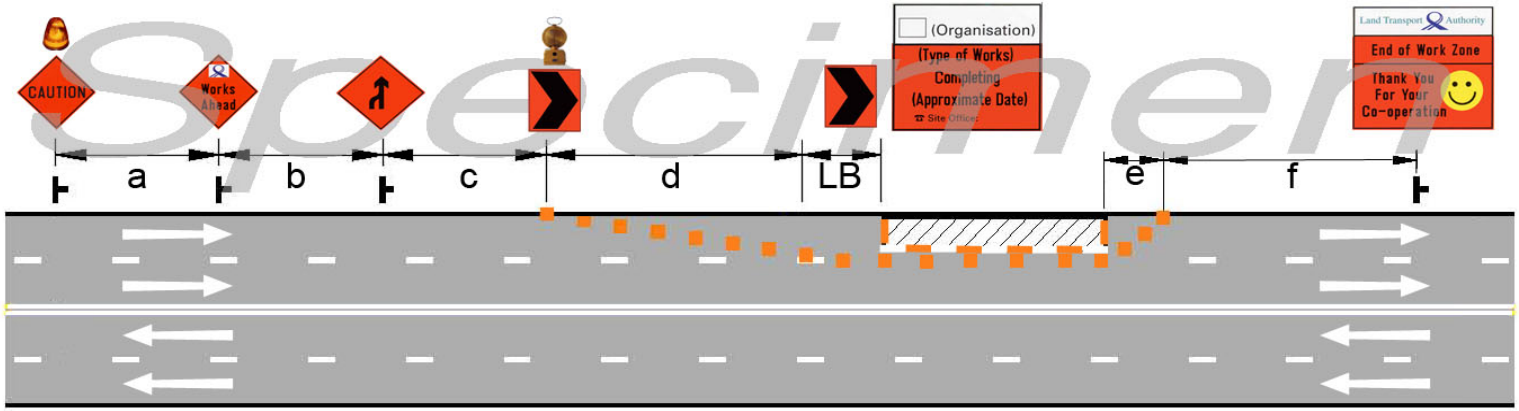


Note :For closure of center lanes, a good appreciation of the traffic condition throughout the day would assist the traffic engineer in deciding which lane to divert the traffic to.

Traffic arrangement for single lane closure of a one-lane two-way carriageway (Shared right of way)



Generic Component Parts of the common Traffic Control Zone



*LB : Longitudinal Buffer

Table 18: Distances of Temporary Signs/Devices

Distance	Expressway 90/80 km/h	Major Road 70 km/h	Major Road 60 km/h	Major Road 50 km/h	Primary Access 50 km/h	Local Access 40 km/h
a	120 m	100 m	80 m	60 m	60 m	30 m
b	120 m	100 m	80 m	60 m	60 m	30 m
c	240 m	200 m	160 m	120 m	120 m	60 m
d	200/150 m	120 m	80 m	40 m	40 m	20 m
*LB	60m	30m	20m	10m	10m	10m
e	100/75 m	60 m	40 m	20 m	20 m	10 m
f	30 m	30 m	30 m	30 m	30 m	30 m(Optional)