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Guidelines on Traffic Management in Work Zones

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Indian Roads Congress
New Delhi

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Section 1. Introduction

1.1 Background

The road construction and maintenance activities are an integral part of road network development particularly for developing and transitional economies. Improving and expanding the roadway network is critical to economic development as well as the quality of life and, these activities create work zones in the network. Due to the increased activity of highway expansion – adding lanes, crash risks are increased for all the road users. There is a need to provide guidance and safe passage for the traffic in the zones where road expansion activities are prevalent. **Fig. 1.1** can be utilized to understand the importance of this issue, which shows the frequency of crashes at various national highways obtained with the support of NHAI data-lake from 1st January 2020 to 1st June 2022 (17 months). These crash frequencies are based on the reported work zone crashes on the data lake (data base). Studies also proved that the crash rate in work zones is 1.68 crashes/km/year as compared to 1.32 in non-work zone national highways (Gupta, 2019). Work zone management would help in addressing this concern.

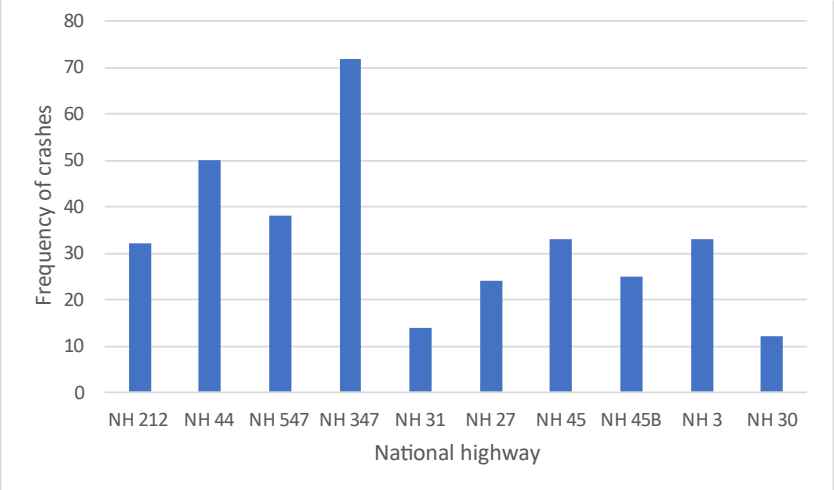


Fig. 1.1 Crashes on national highway work zones

The road work zones are areas of conflict between normal operating traffic, construction workers, road building machinery, and construction traffic. If it is the construction of a new road, normal operating traffic will not be there, but care must be taken to avoid and/or remove conflicts between workers and construction machinery and construction traffic. The problem becomes more serious if it is an urban road with a significant proportion of vulnerable road users.

Work zone accidents are caused by several factors, such as the frequently changing environment during road work that often surprises drivers, insufficient warning signs for both normal and construction traffic, lack of audible warnings for workers, and inadequate provisions of safety devices to protect workers. At most work zones, normal traffic is never more than 15 meters away from construction activities. Major contributing factors to work zone accidents are not paying sufficient attention, going too fast for the prevailing conditions, failure to yield the right-of-way and, following too close. An ideal way to reduce work zone accidents is to create a working area that does not influence the normal traffic flow by segregating and shielding the site.

Massive road building and development is being taken up in India, under various schemes, such as National Highway Development Project (NHDP) and Prime Minister's Rural Road Development Schemes (PMGSY). Activities of improvement of about 45,000 kms of National Highways and around 400,000 kms of rural roads besides numerous urban roads are going on, across the country. To ensure safety of all, there is a need to adopt an efficient and effective plan for management of traffic in work zones. Work Zone Traffic Management Plans (WTMPs) are required to meet the safety needs of regular traffic as well as works traffic, ensuring minimum disruption in access to properties and movement of pedestrians.

This document provides appropriate guidance and examples of best practice to improve safety for all those who could be affected by work zones. These guidelines do not prohibit the use of new methods or devices provided that sufficient technical data is submitted to the Road Authority to demonstrate that the new method or device is equivalent and/or better in quality, effectiveness, durability, and safety compliance as specified in these guidelines.

1.2 Purpose of Work Zone Traffic Management Plans (WTMPs)

The primary purpose of WTMPs is to provide for the reasonably safe and efficient movement of road users through or around the work zones while reasonably protecting the workers and equipment. When the normal function of the roadway is affected by the presence of workers and equipment, the WTMP provides for continuity of the movement for motor vehicles, bicycles, pedestrians, transit operations, and access to properties and utilities.

It is equally important to ensure the safety of workers in work zones, who perform various tasks within the workspace. Work zones present constantly changing conditions that are not expected by road users. It creates an even higher degree of vulnerability for the workers present near the roadway. A concurrent objective of the WTMP is the efficient construction and maintenance of the highway, as well as efficient resolution of traffic incidents, if any, likely to occur in the work zone. The WTMP, therefore, should facilitate the smooth and efficient flow of traffic as well as a safe working environment.

1.3 Who Should Prepare WTMPs?

One set of WTMPs cannot satisfy all conditions of a work zone, and defining all possible applications also may not be practically possible. Therefore, typical applications that depict common deployment of devices are described and illustrated in these guidelines. The site-specific Work zone Traffic Management Plan would have to be prepared and implemented with the concurrence of Road Authority (independent safety engineer/officer). The WTMP selected for each situation would depend on the category of highway, geographical location, road user categories, physical constraints, and the distance / separation from the working space coupled with duration of operation.

WTMPs should be prepared by people knowledgeable and experienced with respect to the fundamental principles of road safety, and the road work activities to be performed. The officer/engineer handling the task of preparing the WTMPs is required to be trained and certified. The design of the layout and selection and placement of traffic control devices for a WTMP would involve careful assessment of their effectiveness and considerable amount of judgment from traffic engineering and safety considerations.

1.4 What Can Make WTMPs Effective?

Improved road user performance can be better achieved through a well-prepared WTMP. The efforts towards publicity giving the nature of the work, the time and duration of its execution, the anticipated effects upon road users, and possible alternate routes and modes of travel are also important. Such programs would result in a significant reduction in traffic conflicts.

The WTMP should be considered at the planning phase and continue through the design, construction, and restoration phases. Implementation of WTMPs shall be the responsibility of the road authority or a public body having jurisdiction over the work zone. The road authority through its Concessionaire / Contractor shall have statutory right for the implementation and enforcement of needed regulations and controls, speed zoning, and the management of traffic. Proper training of workers is necessary for effective implementation. Such statutory rights shall provide sufficient flexibility in the application of WTMP to meet the needs of changing conditions in the work zone.

1.5 Judicious Application of WTMPs

The principles described herein should be judiciously applied to both rural and urban roads. It would depend upon the hierarchy and type of road such as Expressways, dual / single carriageway National Highways, secondary / tertiary roads, urban arterial or access road. A rural National Highway would normally have higher speeds, fewer turning conflicts, and less conflict with pedestrians. An urban road or street is typically characterized by relatively low speeds, wide ranges of road users, varying traffic volumes, narrower roadway lanes, frequent intersections and property accesses, significant pedestrian activity, and more businesses and houses.

In these guidelines, the process of preparation and implementation of the WTMPs are also included to help in deciding the responsibilities and functions of the people involved in managing the work zone operations and safety.

1.6 Legal Aspects of WTMPs

The Motor Vehicles (Amendment) Act 2019 provides legal backing for the erection of traffic signs and traffic operations on roads. Most of the construction and maintenance activities (except for short-term maintenance activities performed departmentally) in India are carried out through contracts signed between the road authority and a contractor or concessionaire. These contract agreements between public authorities and private firms have their legal bases. Normal contracts are generally governed by FIDIC Conditions of Contract, which cover, among other aspects, the safety aspects in construction activities. For all road projects, the Model Concession Agreement and its Schedule L provide for safety requirements for project development and construction.

The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act 1996, the Factories Act 1948, Central Rules 1998, and the Building and Other Construction Workers' Welfare Cess Act 1996 are the legal provisions governing the safety and welfare of construction workers in India. The policy is to minimize road closures and ensure that traffic is delayed as little as possible by construction operations. The highest regard must be given to traffic safety and providing a safe working environment for workers. Before starting construction work that will influence traffic, the contractor (or concessionaire, in cases of private sector participation) must obtain legal permission from the road/traffic authority and local police regarding the means and extent of securing the construction zone. Traffic management strategies used at construction zones should ensure that traffic safety is an integral and high-priority element of the project.

Section 2. Commonly Used Terms

The commonly used terms in these guidelines are described hereunder and shall be applicable wherever they are used in this document (Table 2.1).

Table 2.1 Definitions

Terms	***Definitions***
Activity Zone	*Activity Zone* is the section of the highway where the construction activity is in progress, and which comprises of workspace, traffic space, and buffer space.
Advance Warning Zone	*The Advance Warning Zone* is the section of the road in which the road users are warned about the presence of the work zone ahead and prepare them for the change in driving conditions.
Advance Warning Length (AWL)	The *Advance Warning Length (AWL)* is the road stretch (which is the *Advance Warning Zone*) in which series of warning signs are placed and the length depends upon the approach speed. It is the distance between the first sign indicating the presence of road works ahead to the start of the Approach Transition Zone.
Alternate One-Way Operations	*Alternate One-Way Operations* is a traffic management practice where the Right of Way is allowed to be used alternatively by the traffic moving in one direction and then for the opposing directions, either with the help of flag men or traffic signal.
Approach Longitudinal Buffer (ALB)	*Approach Longitudinal Buffer (ALB)* is the buffer distance to be maintained on the approach side in the longitudinal direction. It is the distance between the first channelizing devices installed on the approach to the start of work area and would vary with the proposed operating speed.
Approach Transition Zone	The *Approach Transition Zone* is that section of work/construction zone, where the road users are redirected from their normal path through a laterally shifted path.
Approach Taper Length (ATL)	The Approach Taper Length (ATL) is the length in which the traffic is redirected from their normal path to a path parallel to workspace and the length is directly proportional to the rate of taper, which also depends upon the operating speed.
Arrow Boards	*Arrow Boards* are static or dynamic signs with a matrix of elements capable of either flashing or sequential displays. The Arrow Boards provide additional warning and directional guidance to assist in merging or diverging, and to control the movement of the road users through or around a work zone.
Authority	*Authority* (Road Authority, Road Administration, and Transport Authority) is the legally responsible body for the provision of road and operation of

	the road traffic. There could be different authorities depending on the category of road and with different responsibilities.
Barricades	*Barricades* are traffic control devices intended to provide containment without significant deflection or deformation under impact and to redirect errant vehicles back to their designated travel path with least damages.
Barriers	*Barriers* are traffic control devices deployed to keep vehicles within their designated lanes/paths and prevent them from colliding with dangerous objects or workers and to prevent vehicles leaving the roadway at hazardous location. These normally include all kinds of guardrails, plastic/ concrete walls or similar devices like metal beam and wire rope crash barriers.
Buffer Space	*Buffer Space* is a lateral and/or longitudinal width/ length that separates the normal traffic flow from the workspace or another unsafe area and includes some recovery space for an errant vehicle.
Built-up Area	*Built-up Area* means the area over which permanent or temporary structures are existing with different land uses along the roadside.
Channelization	*Channelization* is a method of demarcating the flow path of different traffic streams using marking or raised physical islands or even the temporary barriers for guiding the traffic streams for merging or diverging at critical locations to minimize any confusion.
Channelizing Devices	*Channelizing Devices* are those used to physically create the channels of traffic movement paths to help guide the road users through the unusual conditions created by the work zone activities. They include cones, tubular markers, vertical panels, drums, barricades, pavement markings, road studs and different types of barriers.
Cold Applied Road Marking Paint	The Cold *Applied Road Marking Paint* is a solvent based cold paint material used for markings on pavement, which shall be applied on the asphalt/cement concrete road surface with a brush or spray arrangement.
Concessionaire	*Concessionaire* is the person or firm who enters into an agreement with the road (public) authority/agency as the private partner to build, maintain and operate the highway/ road under one of the models of Public-Private Partnership (PPP).
Contractor	*Contractor* is the person or company responsible for the construction or maintenance of the road, and will be engaged in installing, operating and removing all the required arrangements for the traffic management in the work zone including traffic control devices.
Crash Impact Attenuators	*Crash Impact Attenuators* are the impact absorbing devices installed in highly hazardous locations to reduce kinetic energy of the errant or out of control vehicle and to stop or redirect the vehicle away from the main hazard with least damage to life and property.

Crashworthiness	*Crashworthiness* is the ability of a vehicle to protect its occupants during the impact with no or minimum injuries.
Delineators	*Delineators* are the devices with distinct visibility and reflectivity used to supplement the other normal traffic control devices, to delineate and guide the road users through the constrained or critical locations of the highway making the travel path clearly readable.
Designer	*Designer* is a technically qualified expert for designing the geometrics of roads/highways, traffic control measures, and responsible for a safe and economic design of the traffic management plan for the work zone.
Detectable Edging for Pedestrians	*Detectable Edging for Pedestrians* are the clearly distinguishable alternative space or temporary walkway created for pedestrians at the work zone of a road or highway.
Detours	*Detours* are the routes or re-directed vehicular movement paths through other links of the network, when a section of road is taken up completely for work, and the traffic is totally prevented from using this stretch of road. The traffic, in such cases, will use a nearby designated (duly signposted) alternative route (detour) to bypass the work zone.
Direction Indicator Barricades	The *Direction Indicator Barricades* are channelizing devices consisting of one-direction large arrow signs mounted above, a horizontally aligned barrier with diagonal stripes of retro-reflective material on them.
Diversion	*Diversion* is a component of the work zone of the road section, where the traffic movement in one or both directions is organized through a temporary road constructed alongside the work zone, while the main carriageway or bridge/culvert is under construction. The diversion road is reconnected with the main/permanent road after the work zone.
Drums	*Drums* are used for segregating traffic from workspace and also for delineating or channelizing; and are made of lightweight, flexible, and deformable materials of LLDP or plastic so that no damage is caused to the vehicle when stuck. They may be of bright red, yellow or white colors. They should be portable enough to be shifted from place to place within a temporary traffic control project to accommodate changing conditions but would remain in place for a prolonged period. Steel drums shall not be used.
Exit Longitudinal Buffer (ELB)	*Exit Longitudinal Buffer (ELB)* is the minimum buffer distance to be maintained on the leaving side in longitudinal direction from the end of channelizing devices including edge marking to the actual end of work area/space and would vary with proposed operating speed.
Flagman	The *Flagman* is the person who controls the traffic with Stop and Go boards in one-way operation of the traffic in the work zone. He also controls the movement of construction vehicles in and out of the workspace.

Flashing Warning Beacons	*Flashing Warning Beacons* are devices (operated electrically or solar charging) often used to supplement other traffic control devices to draw the attention of the road users, and can be flashing red/yellow lights, operated generally 24 hours in the day.
Floodlights	*Floodlights* are high power lights operated using generators and are used to illuminate the area in the work zone when maintenance and/or construction activities on highways are carried out during night times, when traffic volume is relatively low.
Full Road Closures	*Full Road Closure* is a traffic management practice in which a road is completely closed to traffic temporarily for construction or maintenance. This could be for short-term or long-term activity requiring detours.
General public and Communities	The *General Public and Communities* refer to the neighborhoods and habitations along and around the construction zone, which are getting impacted by the road works.
Give and Take System	Give and Take System is a one-way system (especially for single lane carriageway) operating in alternate directions temporarily by stopping traffic of one direction and giving way to the traffic of the opposing direction. This practice is generally applicable for roads with very low traffic volume and that work is taken up over a very short stretch of road. The length will be such that the traffic approaching from both sides can see each other at the entry points, so that they can judge and decide whether to proceed or wait.
Hand Paddles	*Hand Paddles* are the devices (stop and go boards) used either to stop or allow traffic to proceed by the people controlling one-way system operating in alternate direction (e.g. alternate one-way system).
Hazard Markers	*Hazard Markers* are retro-reflective sign markers invariably placed in front of all exposed roadside hazards adjacent to traffic movement for marking and delineating them.
Hot Thermoplastic Paint	*Hot Thermoplastic Paint* is the plastic road marking material that can be applied to road surface in a hot and molten stage for marking the pavement for the road markings.
Informatory Signs	*Informatory Signs* are the signs used to inform road users of the presence of road works ahead, and to direct/guide them with to the information for safe movement through the construction zone using temporary diversions and detours etc.
Intermittent Closure	*Intermittent Closure* is a traffic management strategy in which traffic in one or both directions is stopped for a relatively short period to allow the critical construction activities, which may be hazardous for traffic, such as launching of bridge girders, and moving construction machinery, etc.

Lanes Closure	*Lanes Closure* is the operation in which one or more traffic lanes and any adjacent shoulder are closed to traffic, in case of a multi-lane highway, for carrying out the road works.
Lane Constrictions	*Lane Constrictions* is the situation which entails reducing the width of one or more travel lanes, for carrying out road works. This permits traffic movement through the lanes with constriction, but at a reduced speed.
Lateral Buffer Space (LBS)	*Lateral Buffer Space (LBS)* is the minimum buffer distance to be maintained in the lateral direction from the moving traffic, i.e. distance measured from outer edge line marking of the carriageway used by the traffic in the work zone and the edge of the work area constituting the actual workspace.
Lighting Devices	*Lighting Devices* are the devices of either permanent or temporary lighting arrangement or the flashing lights used in work zones to make the work zones more conspicuous, and these are essentially required on high-speed multi-lane highways. These may include floodlights, flashing beacons, warning lights, and steady-burning electric lamps and light strings used for delineation.
Long Term Road Works	*Long term roadworks are stationary working zones, with traffic control devices in place, required to be there for more than 24 hours.*
Low Speed	*A low-speed road would have a posted speed limit of 50 kmph or less.*
Low Volume Roads	Low Volume Roads (LVRs) are normally considered as roads with relatively low use, an Average Daily Traffic (ADT) of less than 400 vehicles per day, design speeds typically less than 50 kmph, and corresponding geometry
Marshaling Torch	*Marshaling Torch is* the tough and durable hand flasher used by Marshalls and Flagmen, working on normal or rechargeable batteries with normal/LED bulbs and would provide warning signal for impending hazard or danger of construction work zone, repair sites, trenches, digging of road tunnels etc.
Median Crossover	*Median crossover* is a traffic management practice where traffic of one side of a divided carriageway is to be brought to the other side of the median due to road works or maintenance activities. This can be achieved with a series of warning signs placed on the approach to such work sites and at the median crossover portion to clearly delineate the diversion with barricades for appropriate channelization.
Mobile Road Works	*Mobile road works* are work zones with traffic control devices and safety equipment, which will continuously move forward to the next spot, with progress of work.
New Jersey Barrier	*New Jersey Barrier* is a reinforced concrete barrier of a specific shape, used to separate moving traffic and workspace, generally used in

	worksites of longer construction period. They are designed to minimize vehicle damage in cases of incidental contact while still preventing the crossover case of a head-on collision. Jersey barriers are also used to reroute traffic and protect pedestrians during highway construction,
Normal Regulatory Signs	*Normal Regulatory Signs* are circular shaped signs, either prohibitory or regulatory in nature for managing traffic movements. The shape, color scheme and size are the same as that given in IRC: 67 and used in work zones also.
Ordinary Road Marking Paint	*Ordinary Road Marking Paint* is the paint used for road markings in work zones, and this is very temporary marking and likely to last for a short period.
Portable Traffic Signals	*Portable Traffic Signals* are the traffic signals to regulate and control vehicular movement at work zones of small length and for short construction period.
Portable Variable Message Signs	*Portable Variable Message Signs* are the devices (made of LED based matrix boards) with the flexibility to display a variety of messages in work zones, pertinent to the on-going road works, conveying messages like direction of diversion and warning messages for approaching drivers.
Priority Signs	*Priority signs* are road signs (showing the priority of traffic movement) installed in a work zone to establish the priority of traffic movement, where traffic control is required.
Protective Gears for Workers	*Protective Gears for Workers* are high-visibility safety apparel (called PPE: personal protective equipment), headgear, boots, gloves, eye protectors and protective jackets for the protection of all workers in the work zone.
Reflective Clothing	*Reflective Clothing* is high visibility fluorescent clothing made of retro-reflective material, so that the presence of workers and those in work zone is conspicuous and can be easily seen by drivers in all weather and light conditions.
Regulatory Signs	*Regulatory Signs* are the signs to inform road users of traffic laws or regulations to be adhered to in work zones and to indicate legal validity that would not otherwise be apparent.
Retro Reflective Sheeting	*Retro Reflective Sheeting* has the ability of the surface to return light back to the source (the driver, whose headlight beam has fallen on the sign) and such sheeting is used for signs to be effective in dark hours or when outside light is insufficient.
Road Operator	*Road Operator* is responsible for operating a road network by law, legal act, or contract. A Road Operator could be a department, agency, community, or company and is the primary client or ordering body for the road works.
Road Studs	The *Road Studs* are raised Retro-Reflective Pavement Markers (RRPM) installed on road surface along with pavement markings to delineate the

	traffic paths/lanes in work zones and through diversions. These are also known as cats-eye and can be with fixed reflectors or solar powered blinking type.
Road Users	*Road Users* are all constituent modes of traffic using the work zone, including the Vulnerable Road Users (VRUs).
Road Workers	*Road Workers* includes all workers present in or around the work zone and involved in construction and management of works, including traffic management and any kind of surveying. Due to proximity and exposure to the moving traffic in their workplace, road workers are vulnerable to hazards.
Road Works	*Road Works* include all activities for improving or expanding the road network as well as the maintenance activities that may require warning the traffic about the unusual situation likely to be encountered, which in turn will influence the safety of road users and/or road workers.
Roll up Signs	*Roll-up Signs* are basically portable signs used in construction zones to guide the traffic for meeting emergency situations. Roll-up Signs shall be changeable and shall have provisions for fixing different objects depending on the need.
Safety Auditor	*Safety Auditor* is an expert who undertakes the safety audit of the project in its planning, design, construction (including Work zone Traffic Management Plan) and operation and maintenance.
Shadow Vehicle	*Shadow Vehicles* (security vehicles or service vehicles) are moving trucks fitted with attenuators spaced at a short distance, giving physical protection to workers and equipment and machinery from traffic approaching from the rear. Similarly trailer-mounted attenuators may also be used as shadow vehicles to protect workers and machinery in work zones.
Short Term Road Works	*Short term roadworks* are stationary working zones with traffic control devices in place, required to be there for less than 24 hours. Short term road works are normally done during daylight in good visibility condition. However, they can be carried out during the night also with adequate flood light.
Speed Breakers	*Speed Breakers* are the humps created for slowing down the traffic. They shall be constructed with premix bituminous concrete and shall be as per the design standards specified in this document. Rumble strips are also another kind of speed breaker.
Stop/Go Boards	The *Stop/Go Boards* are the handheld signs of circular shape to control traffic manually on alternate one-way operations.
Supervision	Supervision means all inspection and investigation done by an expert to improve the quality and safety of work zones.

Temporary Traffic Control Zone	*Temporary Traffic Control Zone* means the area of a roadway where traffic conditions are changed temporarily using temporary traffic control devices, flaggers, police, or other authorized personnel for facilitating the road works and managing the normal traffic operations in a safe and efficient manner. A Temporary Traffic Control Zone starts from the first advance warning sign or flagger and extends through the last traffic control device where traffic returns to normal conditions.
Temporary Traffic Control Signals	*Temporary Traffic Control Signals* are erected temporarily and used to control road traffic through work zones in a safe manner.
Terminal Transition Zone	*Terminal Transition Zone* is a transition zone in which the traffic will be redirected from the deviated path of construction zone to their normal path, which can be achieved through tapering or through circular curves.
Terminal Taper Length (TTL)	The Terminal Taper Length (TTL) is the section of the work zone in which the traffic is redirected to the normal path and the length of the terminal taper will be dependent upon the rate of taper adopted to accomplish this.
Traffic cones	*Traffic Cones* are rubber or hard plastic cones having a square base to make them stand independently and used to delineate the traffic paths and to channelize the traffic movements as required at the work zone. These can be of different color and made with retro-reflective plastic/rubber materials.
Traffic Control Devices	*Traffic Control Devices* are equipment such as signs, signals, flashers, delineators, markings, barriers used to communicate with the road users and regulate, warn, or guide through the work zone. They are normally placed in/ over and adjacent to a street, highway, pedestrian facility, or cycle track by the persons/organizations responsible for managing the traffic operations efficiently and safely.
Traffic Space	Traffic *Space* is the portion of the work zone in which road users are routed and channelized through the zone of different activities of construction.
Transverse Bar Marking (TBM)	*Transverse Bar Marking* is thermoplastic marking in the form of stripes of width 300 - 600 mm laid across the carriageway in transverse direction at varied spacing, to alert the drivers about the unusual situation or road work ahead and for speed reduction.
Tubular Markers	*Tubular Markers* are channelizing devices used effectively to divide opposing lanes of road users, or to delineate the traffic lanes and to delineate the edge of a pavement where the space limitations do not allow the use of larger devices. These could be reflectorized also for night visibility.
Typical Construction Layouts	*Typical Construction Layouts* are the commonly occurring/adopted construction scenarios (as included in this document) and would serve as guide in preparing the site-specific Work Zone Traffic Management Plans (WTMPs).

Vulnerable Road Users (VRUs)	Vulnerable Road Users (VRUs) in India are generally considered to be the road users in the form of pedestrians, bicyclists and two- wheeler riders and other non-motorised vehicles, who are more exposed and susceptible to road traffic hazards.
Warning Sign	The *Warning Signs* are triangular signs with yellow background and red borders used to warn/ caution the road users about the presence of work zone. This is in variation with the normal warning sign of IRC: 67 (2012) where the background sheet is white.
Water-Filled Barricades	*Water-Filled Barricades* are modular plastic containers of various sizes and shapes, which can be filled with water, and are forgiving type. They are generally made from frangible materials like rubber/plastic and are in the shape of a crash barrier.
Workspace	The *Workspace* is that portion or area of the construction zone closed and excluded from the use of road users and set aside for construction workers, equipment, and materials.
Work zone	Work zone is the s*tretch/* area of a road with construction, maintenance, or utility work activities. Signs, channelizing devices, barriers, pavement markings, and/or work vehicles typically mark a work zone. A work zone extends from the first warning sign or flashing lights on a vehicle to the end of the road work sign or the last traffic control device.
Work Zone Direction Information Sign	Work Zone Direction Information Signs are the signs installed to guide traffic into and through a temporary diversion prepared for the normal traffic on the road, which may be arranged by use of part of the roadway or a temporarily constructed diversion roadway and detour on account of road works.
Work Zone End	The Work Zone End is announced by sign and is the point where the last temporary traffic sign is posted to indicate the end of the work zone, and normal operation of traffic resumes from this point.
Work Zone Informatory Sign	Work Zone Informatory Signs are signs used to inform the road users about any facility provided temporarily as part of traffic management plan in and around work zones. Some work zone specific signs shall be rectangular in shape with yellow background and black letters/ legends.
Work Zone Signs	Work Zone Signs are basically temporary signs installed in work zones to convey general and specific messages by means of words or symbols and are categorized as regulatory, warning, and informatory/guide signs.
Work zone Regulatory Signs	The Worksite Regulatory Signs are the specific regulatory and mandatory signs required for temporary traffic management within the limits of work zones in addition to the regulatory signs provided in IRC-67 (2012). Some work zone specific signs shall be rectangular in shape with red background and white letters/ legends.

Work zone Warning Signs	Worksite Warning Signs are the temporary warning signs used in work zones. These are triangular in shape with yellow background, black legends and red borders and also rectangular in shape with yellow background and black words/ legend.
Work/activity category based on duration	• Very Long-term stationary: This refers to work that remains in one location for more than fifteen days. Such as vehicle under pass (VUP) Construction, Bridge Repair, etc. • Long-term stationary: This refers to work that remains in one location for more than three days to fifteen days • Intermediate-term stationary: Work that lasts for more than one daylight period but up to three days or nighttime work that exceeds one hour. • Short-term stationary: This is daytime work that occupies a location for more than one hour during a single daylight period. • Short Duration: Work that lasts for up to one hour at a specific location. • Dynamic/Mobile work: This involves work that is either continuously or intermittently moving or work at any specific location will be completed within 15 minutes *(MUTCD, 2023)*

Section 3. Principles of Work Zone Traffic Management Plans

3.1 Basic Principles of WTMP

Work Zone Traffic Management Plans (WTMPs) should adhere to safety principles similar to those governing roadway design. They should ensure clarity for all road and footpath users, minimizing hazards and disruptions. Key points include:

- Design WTMPs assuming drivers will adjust speed only if necessary, avoiding sudden geometric changes. Avoid frequent and abrupt changes in geometrics such as lane narrowing, dropped lanes, or main roadway transitions, that require rapid maneuvers.
- Ensure safe working operation, especially on high-speed and high-volume roads.
- Provide clear guidance for bicyclists and pedestrians, including those with disabilities. Bicyclists and pedestrians should be guided in a clear and positive manner while approaching and traversing the work zones.
- Schedule roadway occupancy during off-peak hours or consider night work cautiously.
- Prioritize road user and worker safety throughout project phases.
- Coordinate early with relevant authorities for cross street closures and emergency services.
- Coordinate plans with transit, law enforcement, utilities, schools, railways, and others to minimize disruptions.
- Coordinate early with railways, if the work zone includes highway-rail at-grade level crossings.
- Implement measures to regulate heavy commercial vehicle traffic in work zones.

3.2 Planning of WTMPs

The planning of WTMPs should prioritize safety for both road users and workers, ensuring compliance with safety regulations and continuous maintenance of safety devices. Key considerations include:

- **Safety for road users and workers:** WTMPs should adhere to safety regulations and be developed in consultation with stakeholders (like road owning agencies, contractors, consultants, and independent engineers). They should prioritize maintaining a safe working environment, considering the needs of all road users, especially vulnerable ones in urban areas. Warnings should be provided before changing road conditions, and measures should be placed to guide and control road users while forgiving them about mistakes.
- **Minimize hindrance or delay to road users:** WTMPs should be designed to encourage drivers to reduce speed where necessary, with effective enforcement of speed limits using methods such as speed cameras. Sudden lane changes or roadway transitions should be avoided, and work scheduling should aim to minimize disruptions, potentially including night work and alternative routing. The safety of pedestrians and bicyclists should be integrated into planning considerations.
- **Provide clear and positive guidance to road users:** Clear signage and delineation should be employed to ensure road users understand what is expected of them, reducing the likelihood of errors and accidents.

- **Ensure roadside safety maintenance:** Despite challenges, efforts should be made to maintain roadside recovery areas free from obstructions, ensuring they are not used for storage or debris from the work site.
- **Ensure planners and decision makers have the necessary knowledge:** Only trained individuals with an understanding of safe work zone principles should be involved in planning and designing TMPs to ensure compliance with safety standards.
- **Provide good public relations:** Collaboration with traffic enforcement and emergency services is crucial during the planning phase. Utilizing news media and other communication channels to inform the public about upcoming work zones, alternate routes, and expected delays can help minimize inconvenience to road users.

3.3 Primary Features of WTMP

The primary features of a WTMP require careful attention to ensure maximum safety and efficiency in traffic operations within work zones. Here is an expanded breakdown of these features:

- Proper warning signs, pavement markings, and other devices should be strategically placed to guide road users through the work zone. Consideration should be given to providing information in formats usable by pedestrians with visual disabilities.
- Temporary traffic plans should ensure accessible paths for pedestrians, especially when regular routes are blocked or detoured. Alternative routes suitable for pedestrians with disabilities should be clearly communicated and marked.
- Temporary bus stops, safe intersections with accessible signals, and other routing concerns should be addressed to ensure pedestrian safety, including providing detectable barriers and channelization devices for those with visual impairments.
- Inappropriate traffic control devices should be removed or covered, and adjustments should be made as work progresses to maintain safe and efficient traffic flow. Consideration should be given to accessibility for pedestrians with disabilities.
- Flagging procedures, when used, should provide positive guidance to road users. Procedures of flagging the traffic are separately explained.
- Trained road safety professionals should oversee safety in work zones, ensuring consistency with traffic management plans and effectiveness in providing safe conditions for all road users.
- Work zones should be regularly monitored under varying conditions to ensure the effectiveness and compliance of traffic control devices, with adjustments made as needed.
- Coordination between adjacent or overlapping projects is essential to avoid duplicate signage and ensure compatibility of traffic control measures.
- When warranted, engineering studies should be conducted in collaboration with law enforcement officials to address reported crashes within work zones. Monitoring crash records can identify the need for adjustments to improve safety within traffic control zones.

3.4 Requirements of WTMP

A WTMP should describe traffic control measures to be used for facilitating the safe and efficient movement of road users through a work zone. WTMP should play a vital role in providing reasonably safe and efficient road traffic flow for all road users.

- WTMPs may range in scope from being very detailed to simply referring to typical drawings contained in these guidelines or specific drawings contained in the contract documents. The degree of detail in the TMPs depends entirely on the nature and complexity of the work to be implemented.
- WTMPs should be prepared by professionals, who are knowledgeable about the fundamental principles of safety, traffic control measures and work activities to be performed (for example, trained and/or certified). The design, selection, and placement of traffic control devices for a TMP should be based on engineering judgment.
- The planning for traffic control for the work zone should be completed for all highway construction, utility work, maintenance operations, including minor maintenance and utility projects prior to occupying the work zone. Planning for all road users should be included in the process.

3.5 Data required at the work zones

The work zone information could be useful for research. It could aid researchers in analyzing the work zones and improving incident-related factors. In addition to the data listed in the NHAI safety manual (IIT Delhi) (Annexes 2.1 and 2.2), the following information should also be collected.

Table 3.1 Sample data collection format

S. No.	Item	Details
1	Work zone location(chainage)	-
2	Work zone location (i.e. activity zone)	-

- To accommodate run-off-the-road incidents, disabled vehicles, or emergency situations, unencumbered roadside recovery areas or clear zones should be provided where practical.
- As part of the WTMP, the Contractor/Concessionaire to keep and maintain crane facilities to tow away any disabled vehicle promptly from the work zone area.
- Work equipment, workers' private vehicles, materials, and debris should be stored in such a manner to reduce the probability of being impacted by run-off-the-road vehicles.
- Whenever traffic control devices are no longer necessary, they should be promptly removed. Similarly, during temporary work suspensions, any traffic control devices that become unnecessary should either be removed or covered.

3.6 Development of WTMP

The traffic management processes at different stages of work zones, as shown in **Fig. 3.1, 3.2 and 3.3**, should be followed for implementing WTMPs.

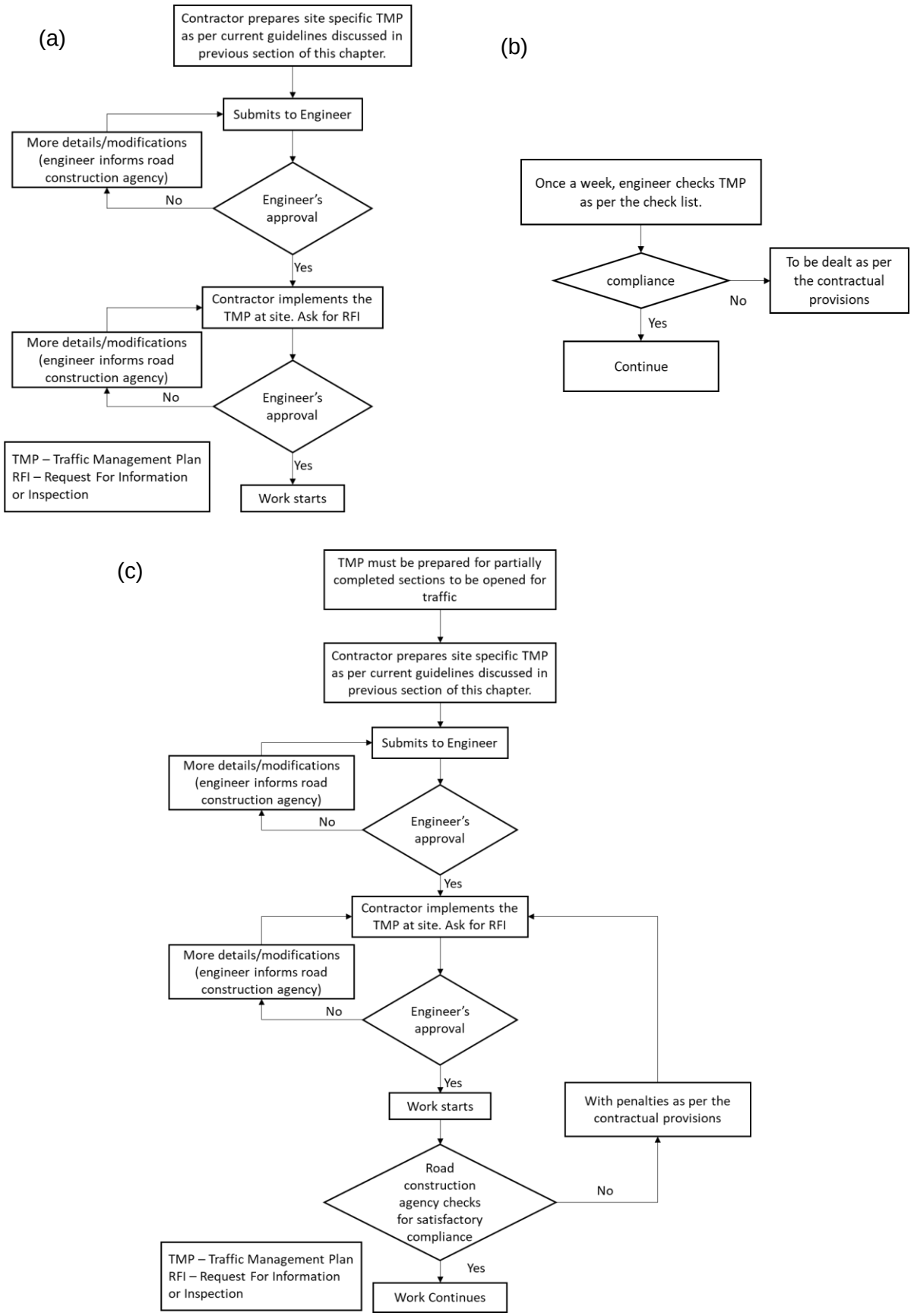


Fig. 3.1 Traffic management process for construction zone: (a) Before starting of the work, (b) During execution, and (c) Partially completed section

3.7 WTMP in Urban Areas

- In urban situations, where road works are to be carried out, more attention should be given to the problems of pedestrians and non-motorized vehicles in places where heavy traffic volumes are involved. As far as possible, the roadwork should be carried out at night, and whenever nighttime road repairs are not possible, then only daytime repairs should be carried out. Repairs during peak hours should also be avoided (NHAI Road safety manual, IIT Delhi).
- Road users should be channelized and routed through and around the area under repair with the minimum of delays. Driver behavior should be effectively influenced so that the speeds are reduced to desired levels on approaches to construction zones. The traffic control and construction activity should be coordinated in such a manner as to provide for safe and efficient flow of traffic together with safe, efficient, and rapid progress of construction activity.
- As pedestrians are likely to be present at urban construction sites, there must always be safety or buffer zone between the outer pedestrian barrier and the traffic.
- Availability of proper sight distance for the movement of vehicles at the recommended speed for the stretch in the work zone should always be kept in mind.

3.8 WTMP in Project Development

There are five phases of WTMP for major projects:

- **Planning Phase** - To identify and include traffic control requirements, work program and method of construction in the contract specification.
- **Design Phase** - To design the Traffic Management Plan in detail, regarding types, location, and layout of traffic control devices for submission to the road authority for approval.
- **Implementation Phase** - To install the temporary traffic control devices safely in accordance with the approved Traffic Management Plan.
- **Operation and Maintenance Phase** - To inspect the Traffic Management Plan and devices regularly both in day and night to ensure that they are effective and safe.
- **Close out Phase** - To remove all the temporary traffic control devices safely and reinstate the permanent traffic control scheme. Removing these signage/work zone related devices/debris is important.

Section 4. Temporary Traffic Control Zones

4.1 Introduction

A work zone is an area of a highway where road user operating conditions are changed because of construction and maintenance activities. The construction and maintenance activities would involve the movement of workers and construction equipment requiring dedicated space for performing the activities and moving materials for the activities. The presence of regular traffic and works traffic makes the work zone a potential zone of conflict resulting in disruption to normal traffic and hazards. A work zone is typically distinguished by the presence of signs, channelizing devices, barriers, pavement markings, and/or work vehicles. It extends from the first warning sign or high-intensity rotating flashing or oscillating or strobe lights installed on roadside, or a vehicle-mounted sign posted to indicate the work zone and continues to delineate the channelized vehicle paths till up to the end road work sign.

4.2 Elements of Temporary Traffic Control Zone

The elements of Temporary Traffic Control Zone are:

- Advance warning zone
- Approach transition zone
- Activity zone
- Terminal transition zone
- Work zone end zone

Suggested lengths for Temporary Traffic Control Zone for different speeds are given in **Table 4.1** and illustrated in **Fig. 4.1**. The normal posted speed of the highway shall be the speed at the start of each traffic control zone. For example, the speed at the start of the advance warning zone shall be the approach speed of highway and length of the advance warning length shall be chosen based on this approach speed. However, the speed to be considered for taper rate or the radius of circular curve at the diversion shall be dictated by the geometric properties of these elements, as traffic is expected to reduce the speed as they are adequately warned through number of signs.

4.2.1 Advance Warning Zone

The “Advance Warning Zone” is the area to warn the road user of the approaching hazard and to prepare them for the change in driving conditions. It should provide information on:

- The presence of the hazard through the “Men at Work” sign, accompanied by the distance to the hazard,
- Any change affecting traffic arrangements (such as a reduction in the number of lanes and/or in the speed limit) within the traffic control zone,
- Extent of the hazard (for example, the length of restriction), and
- The type of hazard etc.

Table 4.1 Suggested Lengths for Temporary Traffic Control Zones

Speed at the Start of Traffic Control Zones (kmph)	Advance Warning Zone/Length		Transition Zone/length								'Work Zone End' Length in meters - WEL	Buffer Space			Workspace	Distance Between Sites in kilometers	
	First Sign from Start of Taper i.e. Advance Warning Length- AWL	Minimum Distance between two successive signs in meters- d	Approach Taper Length in meters - ATL				Terminal Taper Length in meters - TTL			Radius in case of Circular Curves in meters - SR		Minimum Approach Longitudinal Buffer in meters - ALB	Minimum Exit Longitudinal Buffer in meters - ELB	Minimum Lateral Buffer Space in meters - LBS		Desirable	Exceptional
			Rate of Taper	Example Width of Hazard (S1) including Buffer Space in meters			Rate of Taper	Examples Lateral Shift including Buffer Space(S2) *in meters									
				1	2	4		1	2	4							
Up to 50	180	40	1:13	13	26	52	1:10	10	20	40	30	45	10	0.5	1	Varies**	2	1
51 to 65	270	55	1:20	20	40	80	1:16	16	32	64	90	60	15	3	1		5	2
66 to 80	350	80	1:25	25	50	100	1:20	20	40	80	165	75	30	3	2		10	5
81 to 100	500	100	1:40	40	80	160	1:36	36	72	144	250	105	60	9	2		10	5
101 to120	1100	120	1:40	40	80	160	1:36	36	72	144	400	135	100	9	2		10	5
more than 120	1600	150	1:55	55	110	220	1:45	45	90	180	450	150	125	9	2		10	5

***The length of the work zone depends upon the nature of the work taken up. For example, for routine maintenance work, it can be quite small, whereas for major improvement work, it can be up to 5 km.*

Note: The recommended length of work zone and distance between two sites given in this Table is based on practice followed in UK (Refer: Traffic Signs Manual, Chapter 8, 2009, DoT UK)

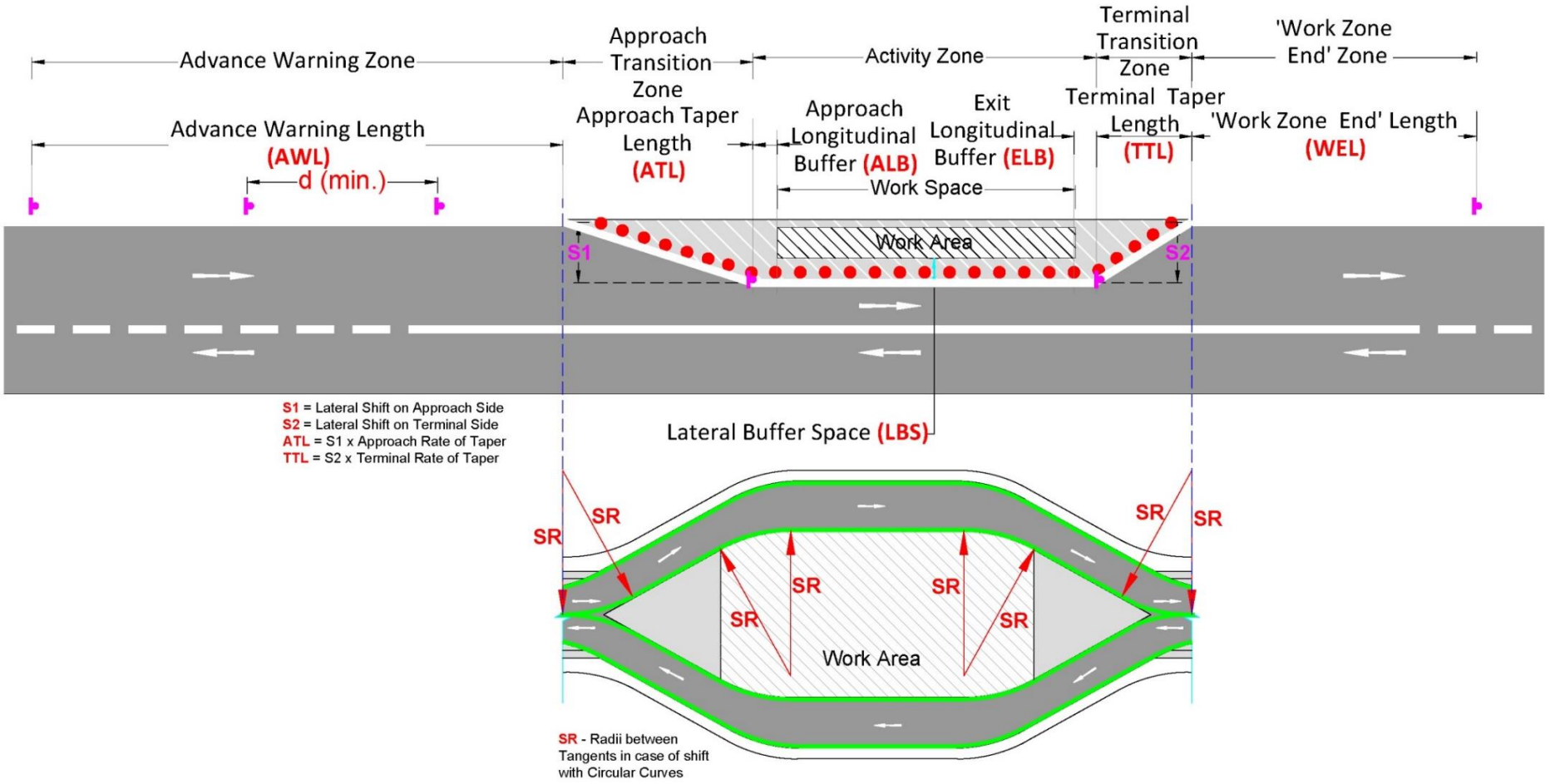


Fig. 4.1 Temporary Traffic Control Zone/Lengths

***Note**: The measured distance of S1 and S2 shown above is same when the road section is straight and may differ in other cases.*

The advance warning zone is where the reduction in speed of vehicles should be notified. The drivers should be advised to reduce their speed to achieve the desired speed of transition zone. The information in this zone is conveyed through a series of traffic signs along the length of the zone. Typical distances for placement of advance warning signs for various approach speeds are also given in **Table 4.1.**

4.2.2 Approach Transition Zone

The transition zone is that section of highway where road users are redirected from their normal path, where the regular traffic is guided to deviate from their normal path of travel through this zone. Lateral shifting of moving vehicles from the normal pathway can be achieved by strategic use of tapers or with circular curves.

The rate of taper and Approach Taper Length (ATL) for a few sample widths are presented in **Table 4.1**, where the speed reduction is expected from the approach speed at the start of taper, and it is illustrated in **Fig. 4.1.** If diversion is achieved through circular curves, the radii of the curves to be inserted between two tangents are also presented in **Table 4.1** and shown pictorially in **Fig. 4.1.** The values suggested for curve radii will be applicable for layouts of median crossovers. Tapers are created by using a series of channelizing devices and/or pavement markings to move traffic out of or into the normal path.

4.2.3 Activity Zone

The activity zone is the section of the highway where the construction activity takes place. It comprises the workspace, the traffic space, and the buffer space.

Workspace: The workspace is that portion of the highway closed to road users and set aside for workers, equipment, and material. Workspaces are usually delineated for road users by channelizing devices or to exclude vehicles and pedestrians in the workspace by temporary barriers. The workspace may be stationary or may move as work progresses, and therefore, the length of the workspace may vary.

Traffic Space: The traffic space is the portion of the highway in which road users are routed through the activity zone. This space should be determined and designed keeping in mind the traffic expected to move through the activity zone.

Buffer Space: The buffer space is a lateral and/or longitudinal length/width that separates the normal traffic flow from the workspace or an unsafe area and might include some recovery space for an errant vehicle. Neither work activity nor storage of equipment, vehicles, or material should occur within buffer space. Buffer spaces may be positioned either longitudinally or laterally with respect to the direction of traffic flow. The activity area may contain one or more lateral or longitudinal buffer spaces. A longitudinal buffer space may be placed in advance of a workspace. The lateral buffer space may be used to separate the traffic space from the workspace, as shown in **Fig. 4.1**, or in such areas as excavations or pavement-edge drop-offs. A lateral buffer space also may be used between two travel lanes, especially those carrying opposing flows. The minimum values for various passing speeds for Approach Longitudinal Buffer, Exit Longitudinal Buffer and Lateral Buffer Space are given in **Table 4.1.** Placing the work zone at closer intervals

will always be inconvenient for road users, and hence the desirable distance between two work zones is given in **Table 4.1**, which may be maintained, as far as possible. However, in unavoidable situations, the distances given for exceptional cases can be adopted subject to the approval of competent authority.

4.2.4 Terminal Transition Zone

In the terminal transition zone, the traffic will be redirected from the deviated path to their normal path through the transition zone, which also can be achieved through tapering or through circular curves.

The rate of taper and Terminal Taper Length (TTL) for a few sample widths are presented in **Table 4.1**, In the terminal transition, a lower value than the approach transition can be adopted as the traffic plying through a temporary diversion should be already at lower operating speed than on normal approach road. The lateral shifts by tapering and by circular curves are presented in **Fig. 4.1.** Channelizing devices and/or pavement markings should be used to bring traffic back to the normal path.

4.2.5 Work Zone End

The work zone end length shall extend from the end of terminal taper length to the last traffic control device such as sign showing the end of road work, if posted. An end road work sign, a speed limit sign, or other signs may be used to inform road users that they can resume normal operations.

Section 5. TRAFFIC CONTROL DEVICES

5.1 Types of Devices

Traffic Control (TC) devices include appurtenances such as signs, signals, flashers, delineators, road markings, barriers and other devices used to regulate, warn, or guide road users, and normally placed on, over, or adjacent to a street, highway, pedestrian facility, or cycle track by the engineer responsible for managing the traffic operations efficiently and safely in the work zones. All traffic control devices used on street and highway construction, maintenance, utility laying or repair, shall conform to the applicable provisions of these guidelines. Traffic control devices notify road users of regulations, provide warnings, and assist motorists with guidance and navigation in order to safely traverse any road open to public traffic Traffic control devices are broadly classified into three categories, and these are discussed in the following subsections.

- Road Signs
- Channelizing Devices
- Lighting Devices & Variable Message Signs

5.2 Road Signs

Work zone signs convey both general and specific messages by means of words or symbols and have the same three categories as in normal highway, viz. (i) regulatory; (ii) warning; and (iii) informatory/guide signs.

The construction zones require more signs than those being used for normal highways to convey site conditions. The regulatory signs to be used in temporary traffic management plans are subdivided into Normal Regulatory (NR) sign and Work zone Regulatory (WR) signs. Those regulatory signs adopted directly from IRC-67 are grouped under normal regulatory signs, and those regulatory signs specifically prepared and included in this guideline for traffic management plan for work zones, are grouped under work zone regulatory signs. The color of normal regulatory signs will be same as that given in IRC-67, whereas the color of work zone regulatory signs shall be of white texts / arrows / borders on red background. The warning signs are also classified as normal warning signs and work zone warning signs. Normal Warning (NW) signs are those taken from IRC-67. In order to retain familiarity among the road users, the shape of the normal warning signs used in work zones shall be triangular, but in yellow background for better conspicuity and to distinguish that the road users are passing through the work zones. The Warning signs (WW) specifically meant for work zones shall be rectangular shape with black text / legend / border in yellow background. The informatory signs shall be either work zone Information Signs (IS) or temporary Direction Signs (DS), and their color schemes shall be black texts / arrows / borders in yellow background. The shape and color of the background plate to be followed for different categories of signs are given in **Table 5.1.**

5.2.1 Retro Reflective Sheeting for Road Signs

For all roads works except on access-controlled highway, the sheeting for ground mounted signs to be used in WTMPs shall be of CLASS B sheeting, i.e. High Intensity Micro -Prismatic grade sheeting as per Class B of IRC-67, whereas for access-controlled highway it shall be of CLASS C sheeting, i.e. Micro Prismatic grade sheeting as given in IRC-67. For maintenance works during

operation stage of National and State Highway having approach speed exceeding 65kmph, the sheeting can be CLASS C sheeting, i.e., Micro Prismatic grade sheeting as per IRC 67.

Table 5.1 Shape & Color Pattern of Signs In WTMP

Category		Color	Shape	Examples
Regulatory/ Mandatory	Normal Regulatory (NR) Signs	As given in IRC-67	Circular	
	Work Zone Regulatory (WR) Signs	Red & White	Rectangular	
Warning Sign	Normal Warning (NW) Signs	As given in IRC-67, but in yellow background	Triangular	
	Work Zone Warning (WW) Signs	Black & Yellow	Rectangular	
Informatory Signs	Work Zone Information Signs (IS)	Black & Yellow	Rectangular	
	Work Zone Direction Signs (DS)	Black & Yellow	Rectangular	

5.2.2 Sign Placement

Signs should be located on the left side of the roadway unless otherwise specified in these guidelines. Where special emphasis is needed, signs may be placed both on the left and right sides of the roadway. The height and lateral clearance of temporary ground-mounted signs are given in **Fig. 5.1 and Table 5.2.** Ground-mounted signs installed at the side shoulder of the road in rural areas shall be mounted at a height of at least 2.1 m measured from the bottom of the sign to the near edge of the pavement.

Table 5.2 Heights and Clearances of Signs

	Minimum (mm)	Desirable (mm)	Maximum (mm)
A	1200	1800	2500
B	1000	2000	2500
C	300	600	1000
D	1500	1800	2100
E	2100	2100	2500
H	-	-	5000
G	1800	2000	2100

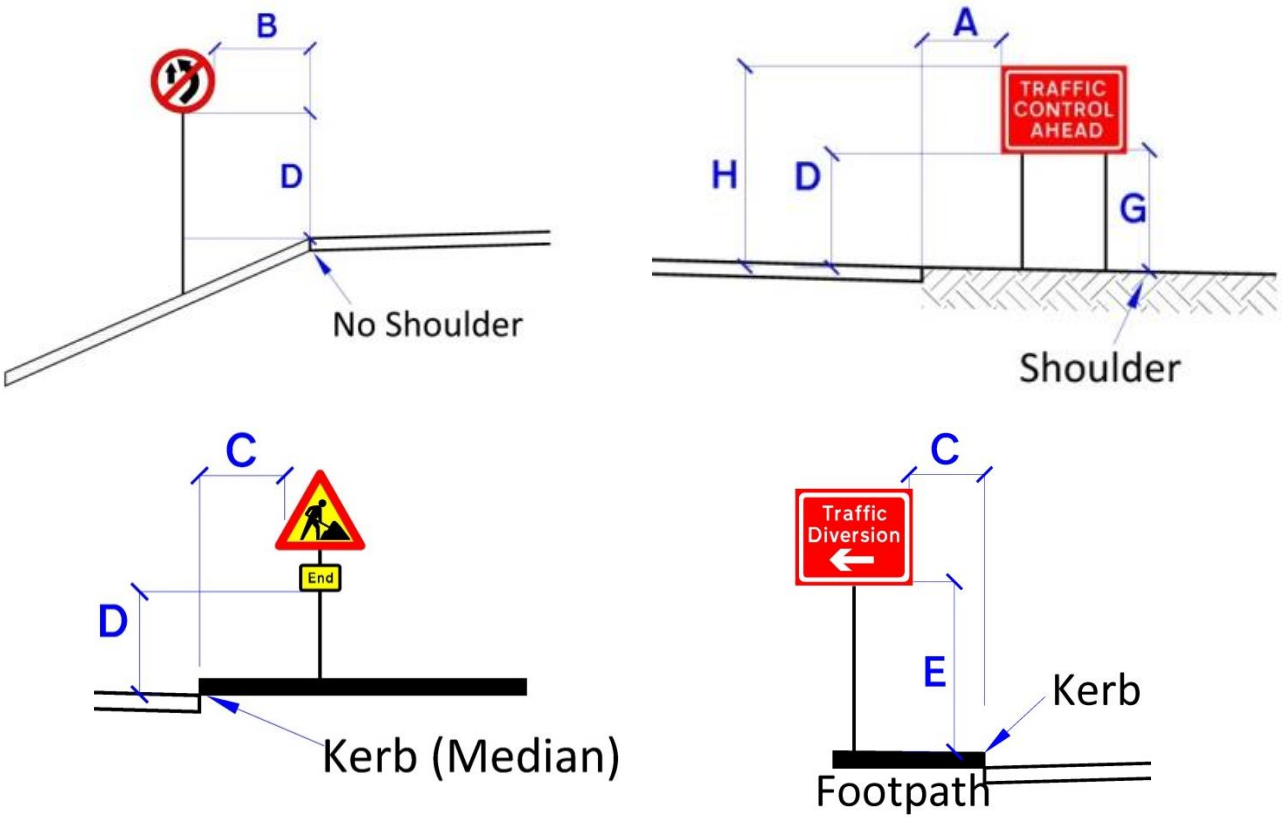


Fig. 5.1 Lateral and Vertical Clearance

In business, commercial, and residential districts where parking and/or bicycle or pedestrian movement is likely to occur, or where there are other obstructions to view, the distance between the bottom edge of the sign and the top of the near edge of the traveled way shall be at least 2.1 m. All signs should maintain this 2.1m clear height irrespective of shoulder, no shoulder, median or footpath. Neither portable nor permanent sign support should be located on footpaths, bicycle facilities, or areas designated for pedestrian or bicycle traffic so that no obstruction is caused in their movements.

Signs mounted on portable supports may be placed within the roadway itself. Signs may also be mounted on or above barricades. Typical mounting of signs on barricades is shown in Fig. 5.2. The signs mounted on barricades, as well as barricade/sign combinations, shall be crashworthy. Signs mounted on barricades, or other portable supports, shall be no less than 0.3 m above the traveled way. Signs mounted on Type III barricades should not cover more than 50 percent of the top two rails or 33 percent of the total area of the three rails.

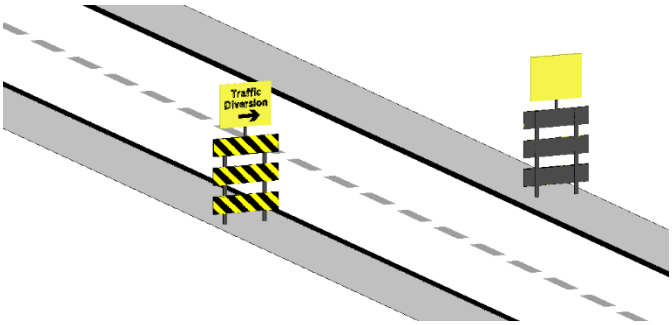


Fig. 5.2 Signs Mounted in Barricades

Large signs having an area exceeding 5 square meters (that are installed on multiple breakaway posts shall be mounted at minimum of 2.1 m above the ground. For mobile operations, a sign may be mounted on a work vehicle, a shadow vehicle, or a trailer stationed in advance of the Temporary Traffic Control (TTC) zone or moving along with it.

5.2.3 Design of Signs

The design of various signs to be used in work zones like work zone regulatory and warning signs and informatory and temporary direction information sign shall be governed by the speed at which the sign is expected to be read by the driver and with the font sizes as given in **Table 5.3** (Woodson and Conover 1966). The letter sizes in upper and lower cases in **Table 5.3** can be obtained using the equations (1)- (3) and from **Fig.I.1** in **Annexure-I**.

Table 5.3 Letter Size

Speed of Operation	"X" height (mm) upper case	"x" height (mm) lower case	Minimum clear visibility to the sign (m)
Up to 50km/h	190	145	75
51 - 65 km/h	240	180	95
66 - 80 km/h	330	250	130
81 - 100 km/h	400	300	160
101 - 120 km/h	580	435	230
121-150 km/h	630	475	250

$$Desired\ letter\ height = \frac{Viewing\ distance\ (ft) \times 0.3''}{10} \quad (1)$$

Which in metric units can be written as following

$$Upper-case\ letter\ height\ in\ mm = 2.5 * Minimum\ clear\ visibility\ to\ the\ sign\ (m) \quad (2)$$

$$Lower\ case\ letter\ height\ in\ mm = 0.75 * Upper\ case\ letter\ height\ (m) \quad (3)$$

Plate III and Annexure III of IRC-67 lay the principles for designing various sign boards involving texts in English, Hindi or other regional languages and arrows like the Work Zone Regulatory Signs, Work zone Warning Signs and Information Signs. The sign boards shall be designed for English and Hindi or other regional languages as appropriate for the location.

5.2.4 Regulatory Signs

The regulatory signs to be used in work zones are subdivided as normal regulatory signs and work zones specific regulatory signs. Regulatory signs are to instruct road users of traffic laws or regulations and to indicate the applicability of legal requirements that would not otherwise be apparent. For ensuring legibility and emphasis at night, the signs shall be retro-reflective of at least Grade Type IV, i.e. high intensity Micro prismatic grade conforming to IRC:67. The material shall be smooth, sealed outer surface or illuminated to depict the same shape and similar color for both day and night. Sign illumination may be either internal or external and the sign boards may be made of rigid or flexible material.

If a Temporary Traffic Control (TTC) zone requires regulatory measures different from those existing, the existing permanent regulatory devices will be removed or covered and superseded by the appropriate temporary regulatory signs. This change shall be made in conformity with applicable ordinances or statutory orders of the local jurisdiction. It is essential, therefore, that they are used only after consulting the local police and traffic authorities.

5.2.4.1 Normal Regulatory Signs

The normal regulatory signs are the circular signs prescribed in IRC-67 and similarly the color and shape pattern shall be the same as given in IRC-67. The regulatory/mandatory signs in the work zones will be the same as per IRC 67 (Plate I). The speed of the road governs the size of the signs, and they vary from 600 mm to 1200 mm as given in **Table 5.4**, The 'STOP' and 'GIVE WAY' signs are the exceptions, where the height of an octagonal 'STOP' sign shall be 750 mm, 900 mm, and 1200 mm respectively for an approach speed of up to 50 kmph, 51 to 65 kmph and greater than 65 kmph. In the case of 'GIVEWAY' sign, the one side shall be 600 mm, 900mm, 1200mm respectively for approach speed up to 50 kmph, 51 to 80 kmph and greater than 80 kmph.

Table 5.4 Size of Circular Signs

Speed (in Kmph)	Size	Diameter of Circle (mm)
Up to 65	Small	600
66 - 80	Medium	750
81-100	Normal	900
101-120	Large	1200
121-150	Extra Large	1500

5.2.4.2 Hazard Markers

The hazard markers are normal regulatory signs and shall have alternative yellow and black retro-reflective stripes of Class C as per IRC-67, sloping downward at an angle of 45 degrees in the direction of vehicular traffic. With respect to the position of traffic movement and roadside hazard, it can be for either left or right i.e. OHM (Left & Right). If traffic can pass on both sides, it shall be Two Way Hazard Markers (TWHM). The one-way and two-way hazard markers are shown in **Fig 5.3** and the placement of hazard markers is presented in **Fig 5.4.**

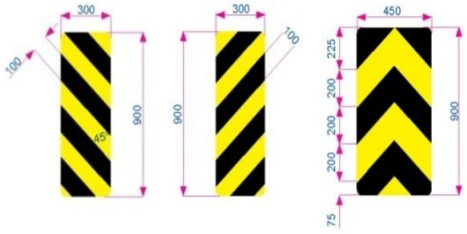


Fig. 5.3 Hazard Markers OHM (Left & Right) & TWHM

Application: All exposed roadside fixed objects, like tree, culvert / bridge parapet, etc., adjacent to traffic movement are to be delineated with hazard markers just in front of them and at location of diversion or gore area where traffic is expected to change the direction due to temporary or permanent diversion.

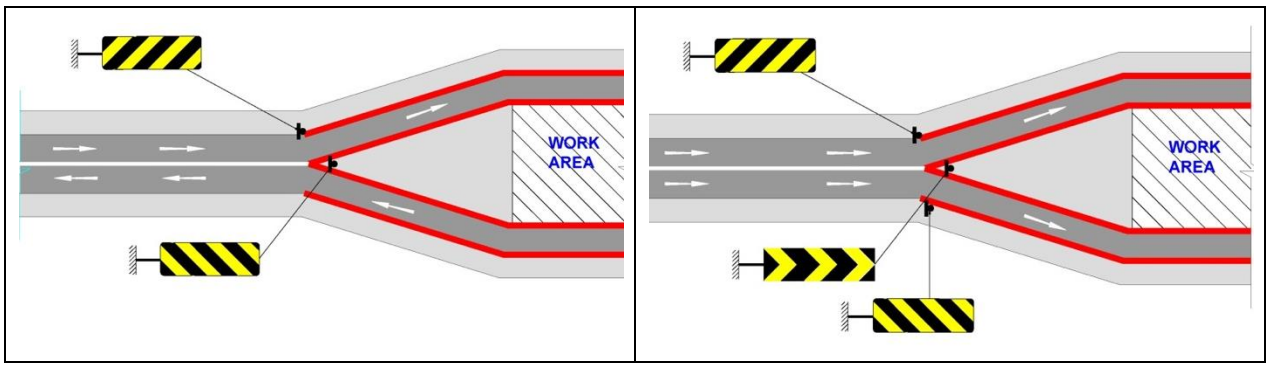


Fig. 5.4 Application of OHM (Left & Right) & TWHM

5.2.4.3 Work Zone Regulatory Signs

As mentioned earlier, the regulatory / mandatory signs required for temporary traffic management in addition to regulatory signs that are to be adopted from IRC-67 are grouped under work zone regulatory signs. These are to be installed for WTMP either to regulate or to control. The design of work zone regulatory sign shall be done for speed and font size as given in **Section 5.1.3.** Wherever required, signboards are to be designed and installed in Hindi or in other regional languages. The application of different work zone regulatory signs is presented in **Fig. 5.5.**

Sign is to indicate that road ahead has been closed as part of temporary traffic management plan

Fig. WZ.WR01

The sign to be installed where a pathway or opening is kept for entry of works traffic only and all other traffic must follow the WTMP provided for them

Fig. WZ.WR02

Fig. 5.5 Application of Work Zone Regulatory Signs

The sign is installed so that approaching traffic shall realize that the road that was kept apparently opened is wrong way for them on account of temporary diversion and traffic shall not enter it.

Fig. WZ.WR03

It is mandatory to inform that traffic control exists ahead through any of the methods of alternate one-way movement.

Fig. WZ.WR04

The sign shall be located at the very point where the traffic shall be deflected to a diverted pathway. The arrow shall be right if the deflection is to the right of approach direction. The sign shall be positioned in such a way that the head beam from an approach vehicle will directly collide with the sign for better visibility.

Fig. WZ.WR05

The sign shall be located at the very point where the traffic must take a sharp deflection in its movement direction. The arrow shall be reversed if the deflection is to the right of approach direction. The sign shall be positioned in such a way that the head beam from an approach vehicle will directly collide with the sign for better visibility.

Fig. WZ.WR06

The sign to be used in alternate one-way movement through portable traffic signal wherein traffic must wait when red light blows.

Fig. WZ.WR07

The sign to be used in alternate one-way movement with STOP & GO control where traffic must wait when STOP board is shown for them.

Fig. WZ.WR08

Sign for traffic diversion at the very location where the sign is installed. It shall be positioned in such a way that signs fall in the funnel of the head beam from an approaching vehicle.

Fig. WZ.WR09

Sign to indicate the one-way movement to direction to which arrow is shown. The arrow direction be reversed if it is to the right of approach direction. It shall be positioned in such a way that signs fall in the funnel of the head beam from an approaching vehicle.

Fig. WZ.WR10

Fig. 5.5 Application of Work Zone Regulatory Signs (Continued)

Sign to indicate that road has been closed for through traffic. However, local, or residential traffic can go up to a point, beyond which it will be totally blocked.

Fig. WZ.WR11

Sign to indicate that road has been closed for all traffic due to temporary traffic management plan.

Fig. WZ.WR12

Sign to permit exit only.

Fig. WZ.WR14

The "STOP" board in STOP and GO control in a one lane-two directional traffic control. The sign shall not be used at night unless the signs are directly illuminated. When a frame is used to support the sign, it shall be circular, not octagonal as sign is mounted on circular substrate.

Fig. WZ.WR15

The "GO" board in STOP and GO traffic control in work zone in a one lane two directional traffic control. The illumination of both in STOP and GO boards shall be uniform across the sign face and neither partial nor intermittent illumination is permitted.

Fig. WZ.WR16

The "SLOW" board to slow down the traffic.

Fig. WZ.WR17

Fig. 5.5 Application of Work Zone Regulatory Signs (Continued)

The overall size of work zone regulatory signs (Chevron, Octagonal, and Circular) for different speeds are given in **Table 5.5.** The overall size of other work zone regulatory signs in **Fig. 5.5** for different speeds can be obtained based on the letter size and number of words used, also can be done following design principles given in Section 5.2.3 of IRC: SP: 55 and Plate III and Annexure III of IRC-67.

Table 5.5 Overall Size of Work zone Regulatory Signs (Length x Height in mm)

Figure No.	Up to 50 kmph		51 to 65kmpH		66 to 80 kmph		81 to 100 kmph		101 to 120 kmph		121 to 150 kmph	
	English	Hindi	English	Hindi	English	Hindi	English	Hindi	English	Hindi	English	Hindi
Fig WZ.WR05	1070 x 430 (Chevron)											
Fig WZ.WR06	1600 x 430 (Chevron)											

Fig WZ.WR15	600 (Octagonal)	900(Octagonal)
Fig WZ.WR16	600(Circular)	900(Circular)
Fig WZ.WR17	600(Circular)	900(Circular)

5.2.5 WARNING SIGNS

The warning signs in work zone are classified into two categories namely normal triangular warning signs and work zone specific warning signs.

5.2.5.1 Normal warning sign

The triangular warning sign when used for work zones shall be on yellow background in order to highlight the hazardous situation in work zone. The size shall be governed by the speed as given in **Table 5.6.** The application of normal warning signs is explained in **Fig 5.6**.

Table 5.6 Size of Normal Warning Sign

Speed	Size	Side (mm)	Border (mm)	Clear Visibility Distances (m)
Up to 50 kmph	Small	600	45	45
51 -65 kmph	Medium	750	60	60
66- 80 kmph	Normal	900	70	70
81-120 kmph	Large	1200	90	90
121-150 kmph	Extra Large	1500	110	110

Fig. WZ.NW01 Sign to indicate change of direction to left in a work zone.

Fig. WZ.NW01

Fig. WZ.NW02 Sign to indicate change of direction to right in a work zone.

Fig. WZ. NW02

Fig. WZ.NW03 Sign in case of a reverse bend where first is right turn in a work zone.

Fig. WZ.NW03

Fig. WZ.NW04 Sign in case of a reverse bend, where the first bend is a left turn in a work zone.

Fig. WZ.NW04

Fig. 5.6 Application of Normal Warning Sign

Fig. WZ.NW05 Sign to indicate a traffic control in an alternate one-way movement ahead through a portal signal.

Fig. WZ.NW06 Sign to traffic from left is merging as part of temporary traffic management plan.

Fig. WZ.NW05

Fig. WZ.NW07

Fig. WZ.NW07 Sign to traffic from right is merging as part of temporary traffic management plan.

Fig. WZ.NW06

Fig. WZ.NW08

Fig. WZ.NW08 Sign to indicate road suddenly narrows due to road construction.

Fig WZ.NW09

Fig. WZ.NW09 Sign to indicate to pavement width widens ahead in a temporary traffic control zone.

Fig. WZ.NW10

Fig. WZ.NW10 Sign to indicate narrow bridge ahead where the width of carriageway is less than the normal width of carriageway in work area.

Fig WZ.NW11

Fig. WZ.NW11 Sign to indicate to steep ascent more than 10% in a traffic control zone.

Fig. WZ.NW12

Fig. WZ.NW12 Sign to indicate to steep descent more than 10% in a traffic control zone.

Fig. WZ.NW13

Fig. WZ.NW13 Sign to indicate that left traffic lane tapers due to construction work.

Fig. WZ.NW14

Fig. WZ.NW14 Sign to indicate that right traffic lane tapers due to construction work.

Fig. WZ.NW15

Fig. WZ.NW15 Sign to indicate road becomes dual carriageway in a work zone.

Fig. WZ.NW16

Fig. WZ.NW16 Sign to indicate road becomes undivided carriageway in a work zone.

Fig. 5.6 Application of Normal Warning Sign (Continued)

Fig. WZ.NW17 Sign to warn that pedestrians are crossing in work zone.

Fig. WZ.NW18 Sign to warn that school in work zone area.

Fig. WZ.NW17

Fig. WZ.NW18

Fig. WZ.NW19 Sign to warn that two way movement is ahead as part of WTMP.

Fig. WZ.NW19

Fig. WZ.NW20 Sign to warn that one (right) lane closure out of two lanes.

Fig. WZ.NW20

Fig. WZ.NW21 Sign to warn that one (right most) lane closure out of three lanes.

Fig. WZ.NW21

Fig. WZ.NW22 Sign to warn that one (right most) lane closure out of four lanes.

Fig. WZ.NW22

Fig. WZ.NW23 Sign to warn that traffic has to be shifted to other carriageway due to WTMP.

Fig. WZ.NW23

Fig. WZ.NW24 sign should be displayed when men or machines are working on the road or adjacent to it. The sign with supplementary plate "END" shall be provided at the leaving side of the work zone where traffic reverts back to normal flow.

Fig. WZ.NW24

Fig. WZ.NW25 Sign to warn that sudden dip in road profile to road work area.

Fig. WZ.NW25

Fig. WZ.NW26 Sign to warn speed reduction hump ahead due to work zones.

Fig. WZ.NW26

Fig. WZ.NW27 Sign to warn speed reduction with rumble strip due to work zones.

Fig. WZ.NW27

Fig. WZ.NW28 Sign to warn about rough road in a temporary traffic control zone.

Fig. WZ.NW28

Fig. 5.6 Application of Normal Warning Sign (Continued)

Fig. WZ.NW29 Sign to warn about rough road in temporary traffic control zone.

Fig. WZ.NW29

Fig. WZ.NW30 Sign to warn about loose gravel may be thrown due to traffic movement in road works.

Fig. WZ.NW30

Fig. WZ.NW31 Sign to warn road is slippery due to road works.

Fig. WZ.NW31

Fig. WZ.NW32 to indicate Single Chevron in a temporary diversion

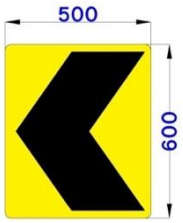


Fig. WZ.NW32

Fig. WZ.NW33 to indicate that stop and go traffic control established using Flagman in an alternate one movement as part of WTMP

Fig. WZ.NW33

Fig. 5.6 Application of Normal Warning Sign (Continued)

5.2.5.2 Work zone Warning Signs

In addition to normal warning signs prescribed in IRC-67 (2022), the warning signs for traffic management are grouped under work zone warning signs. They shall be in black arrows/border/text in yellow background. The applications of work zone warning signs are given in **Fig. 5.7.**

Fig. WZ.WW01 to indicate the roadworks progress ahead and the sign is installed in the advance warning area.

Fig. WZ.WW01

Fig. WZ.WW02 to indicate the temporary traffic diversion and can be installed in the advance warning area.

Fig. WZ.WW02

Fig. 5.7 Application of Work Zone Warning Signs

Fig. WZ.WW03 to indicate slow traffic ahead due to road works and can be installed in advance warning area

Fig. WZ.WW03

Fig. WZ.WW04 to inform of one lane road due to traffic control and can be installed at advance warning area

Fig. WZ.WW04

Fig. WZ.WW05 to inform the closure of road at 500m ahead.

Fig. WZ.WW05

Fig. WZ.WW06 to inform the Detour of traffic at 300m ahead

Fig. WZ.WW06

Fig. WZ.WW07 to warn of blasting zone at 500m ahead

Fig. WZ.WW07

Fig. WZ.WW08 to inform of roadwork for the next 5km or so.

Fig. WZ.WW08

Fig. 5.7 Application of Work Zone Warning Sign (Continued)

Fig. WZ.WW09 as supplementary plate and shall be always with a warning sign to inform that a particular situation depicted in the warning sign exists 500m ahead.

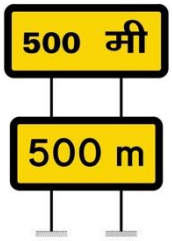


Fig. WZ.WW09

Fig. WZ.WW10 as supplementary plate and shall be always with a warning sign to inform that a particular situation depicted in the warning sign exists 1 km. ahead.

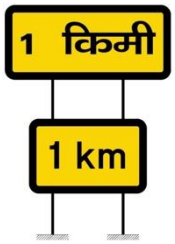


Fig. WZ.WW10

Fig. WZ.WW11 to inform that 10 km ahead through road has been closed and local traffic only is permitted to move forward.

Fig. WZ.WW11

Fig. WZ.WW12 to inform that at 10 km ahead the bridge has been, and local traffic only is permitted to move forward

Fig. WZ.WW12

Fig. WZ.WW13 to inform roadwork ends at the end of traffic control zones

Fig. WZ.WW13

Fig WZ.WW14 as supplementary plate of inform the hazardous situation shown previously ceases to exist. The supplementary plate shall be installed along with warning sign on the same post

Fig. WZ.WW14

Fig WZ.WW15 to inform the through traffic that construction vehicles are likely to exit from the work zone in order join the mainstream and be cautious

Fig WZ.WW15

Fig. 5.7 Application of Work Zone Warning Signs (Continued)

The overall size of work zone warning signs in **Fig. 5.7** for different speeds can be obtained based on the letter size and number of words used, also can be done following design principles given in Section 5.2.3 of IRC: SP: 55 and Plate III and Annexure III of IRC-67.

5.2.6 Informatory Signs

The informatory signs for traffic management plans at work zone are also subdivided into Work zone informatory signs and Work zone direction signs for diversion / detour.

5.2.6.1 Work zone Informatory sign

The information signs will serve the road users about a facility prepared either permanently or temporarily as part of traffic management plan at work zones. It may serve for vehicular traffic, pedestrians, and bicyclists. The sign shall be rectangular in shape with white symbols / letters in yellow background. The work zone informatory signs are also to be designed as per Section 5.2.3. The application of informatory sign is presented **Fig. 5.8.**

Fig. WZ.IS01 to indicate the footpath for pedestrians to walk.

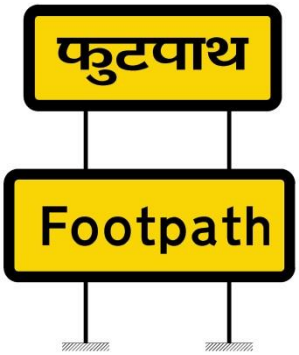


Fig. WZ.IS01

Fig. WZ.IS02 to warn that the footpath has been closed due to roadwork.

Fig. WZ.IS02

Fig WZ.IS03 to inform that footpath has been closed and they may use the sides the arrow leading to

Fig WZ.IS03

Fig WZ.IS04 to inform that footpath has been closed and the pedestrian to cross as indicated by the arrow. The arrow can be reversed also.

Fig WZ.IS04

Fig. 5.8 Work Zone Informatory Sign

Fig WZ.IS05 to inform pedestrians to proceed with the arrow leading to

Fig WZ.IS05

Fig WZ.IS06 to inform of cycle track and for a facility for bicyclists to avail.

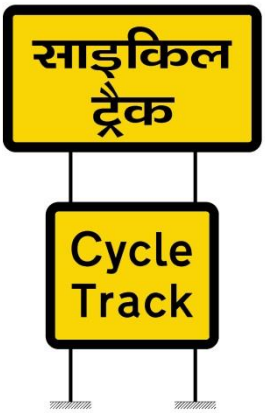


Fig WZ.IS06

Fig WZ.IS07 is to inform that priority has been given to forward movement and traffic in the opposite direction is expected to yield. A definition plate can be installed written 'Priority over oncoming vehicles'

Fig WZ.IS07

Fig. 5.8 Work Zone Informatory Sign (Continued)

The size of informatory sign for Fig. WZ.IS07 in Fig. 5.7 is 600 x 800 mm for all the speeds varying up to 150 kmph. Whereas the size of other work zone informatory signs shown in **Fig. 5.8** for different speeds can be obtained based on the letter size and number of words and also can be determined following design principles given in Section 5.2.3 of IRC: SP: 55, and Plate III and Annexure III of IRC-67.

5.2.6.2 Work Zone Direction Information Sign

The direction information sign for temporary diversion and detour are also required to be designed and the design principles in Section 5.2.3 of IRC: SP: 55, and Annexure III and Plate III of IRC-67 shall be followed. The shape of direction information sign for temporary traffic management plan shall be rectangular and color shall be black border/arrows/text in yellow background. The application for direction information signs for diversion and detours are given in **Fig 5.9.**

Fig. WZ.DS01 to inform approaching traffic to take a detour due to temporary traffic diversion plan

Fig. WZ.DS01

Fig. WZ.DS02 to inform of end of detour.

Fig. WZ.DS02

Fig. WZ.DS03 to inform bicyclists to take a detour due to road works

Fig WZ.DS03

Fig. WZ.DS04 to inform pedestrians to take a detour due to road works

Fig WZ.DS04

Fig. WZ.DS05 to inform to take a detour at the location where the sign is placed.

Fig. WZ.DS05

Fig. WZ.DS06 is a direction information that traffic bound to destination shown here may take the direction shown, as part of traffic detour.

Fig. WZ.DS06

Fig. 5.9 Direction Information for Diversion

The overall size of direction information signs for diversion shown in **Fig. 5.9** for different speeds can be obtained based on the letter size and number of words used, also can be determined following design principles given in Section 5.2.3 of IRC: SP: 55 and Plate III and Annexure III of IRC-67.

5.3 Channelizing Devices

The function of channelizing devices is to warn and channelize the movement of road users through changed path of movement due to the conditions created by work activities in or near the

roadway. Channelizing devices include cones, tubular markers, vertical panels, drums, barricades, pavement markings and road studs.

Channelizing devices provide and facilitate smooth and gradual vehicular traffic flow from one lane to another, onto a bypass or detour, or into a narrower traveled way. They are also used to separate vehicular traffic from the workspace, pavement drop-offs, pedestrian or shared-use paths, or opposing directions of vehicular traffic. Devices used to channelize pedestrians shall be detectable to road users and visible to people who have low vision.

Where barricades are used to channelize pedestrians, there shall be continuous detectable bottom and top rails with no gaps between individual barricades. The bottom of the bottom rail shall be no higher than 150 mm above the ground surface, and the top of the top rail shall be no lower than 900 mm above the ground surface. If drums, cones, or tubular markers are normally used to channelize pedestrians, they shall be located such that there are no gaps between the bases of the devices, to create a continuous bottom.

Channelizing devices should be constructed and ballasted to perform in a predictable manner when inadvertently struck by a vehicle. Channelizing devices should be crashworthy. Fragments or other debris from the device or the ballast should not pose any significant hazard to road users or workers.

The retro-reflective material used on channelizing devices shall have a smooth, sealed outer surface that will display a similar color in day or night. Particular attention should be paid to maintaining the channelizing devices to keep them clean, visible, and properly positioned at all times. Devices that are damaged or have lost a significant amount of their retro-reflectivity and effectiveness shall be replaced**.**

5.3.1 Traffic Cones

Traffic cones may have heights of 750 mm or 1000 mm, and diameters of 300 to 500 mm or may be in a square shape. It should have a broader and heavier base for stability so that they do not fall easily. They shall be of brilliant red/orange/yellow colour with white retro reflective bands and the material used must be UV stabilized for better durability and shall be made of a material that can be struck without causing damage to the impacting vehicle. **Fig. 5.10** shows the traffic cones of 750mm and 1000mm.

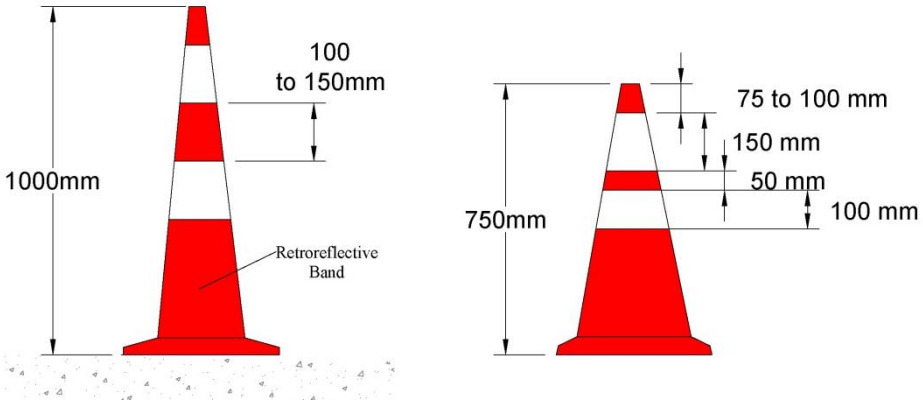


Fig. 5.10 Traffic Cones

For night use, they should be invariably retro reflectorized and if required, they shall be equipped with lighting devices. Cones shall have retro-reflective white bands of 150 mm and 100 mm size with sheeting of Class B Type III OR IV grade that meets the required parameter as per ASTM D

4956. The cones shall also have sufficient provisions for installing lighting devices on the top and for attaching chain/railings. Traffic Cones shall be tested for their physical performance such as Stability & Drop Resistance, coefficient of retroreflection of wet retroreflective samples (shall meet Type III OR IV grades).

Traffic cones may be used to channelize road users, divide opposing vehicular traffic lanes, divide lanes when two or more lanes are kept open in the same direction, and delineate short duration maintenance and utility work.

Steps should be taken to minimize the possibility of cones being blown over or displaced by wind or moving vehicular traffic.

Cones should not be used for pedestrian channelization or as pedestrian barriers in work zones on or along footpaths unless they are continuous between individual devices.

Cones may be doubled up to increase their weight. Some cones are constructed with bases that can be filled with ballast. Others have specially weighted bases, or weights such as sandbag rings that can be dropped over the cones and onto the base to provide added stability. Ballast should be kept to the minimum amount needed. The application of traffic cones for roadways with various speeds is presented in **Table 5.7.**

Table 5.7 Application of Traffic Cones (Spacing)

Speed (kmph)	Size	Cones in Transition Area	Cones in Straight Portion
Up to 65	500mm	1.5 m	3 m
66 – 100	750mm	1.5 m	3 m
> 100	1000mm	1.5 m	3 m
A minimum 300mm clear distance shall be provided from the traffic edge lane marking to the traffic cones.			

Application: The traffic cones are ideally proposed for temporary works and maintenance activities. Since the traffic cones are easily portable and can be installed and removed quickly, it can be used at places where they are required to be installed and dismantled quite often. Traffic cones along with tape shall form a regular and smooth geometry of traffic path, to streamline the traffic in a well-defined path.

5.3.2 Tubular Markers

Tubular markers as shown in **Fig. 5.11** may be used effectively to divide opposing lanes of road users, or to divide vehicular traffic lanes when two or more lanes of moving vehicular traffic are kept open in the same direction, and to delineate the edge of a pavement drop-off zones. These tubular structures shall be flexible plastic bollards.

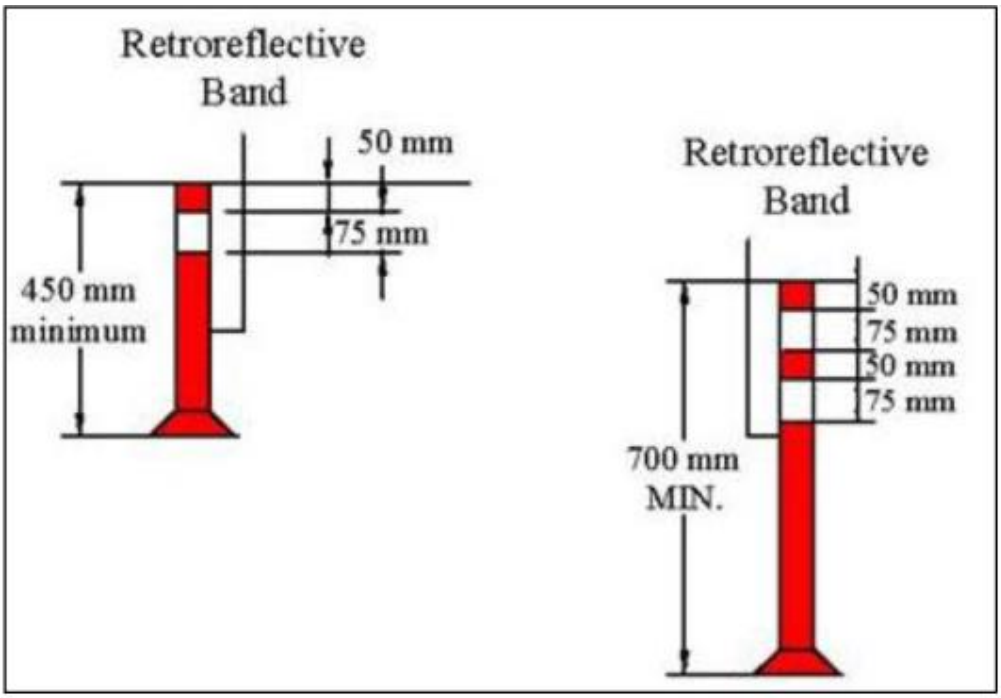


Fig. 5.11 Tubular Markers

When a non-cylindrical tubular marker is used, it shall be attached to the pavement in a manner that the width facing road users meets the minimum requirements. A tubular marker shall be attached to the pavement to display the minimum 50 mm width of reflective bands to the approaching road users.

They should have the following important features:

(i) A minimum 300 mm clear distance shall be provided from the traffic lane marking to the tubular markers.

(ii) Tubular Marker shall be tested for its physical performance such as Bending test, Fatigue test, measurement of coefficient of retroreflection of white band shall meet to Class B as per IRC-67.

The application of tubular markers is presented in Table 5.8.

Table 5.8 Application (Spacing) of Tubular Markers Along the Running Direction***

Speed (kmph)	Size of the Tubular Marker / Bollard (in mm)	Between Two Opposite Streams of Traffic	Between Two Streams on Same Direction	At the End for Pavement Edge Drop
Up to 65	450 mm	9 m	6 m	9 m
66 - 100	700 mm	9 m	6 m	9 m
> 100	N.A.		Not Applicable	
****Tubular Markers will be used in situations where there are acute space constraints to install larger devices in roads of low traffic volume.*				

Speed (kmph)	Size of the Tubular Marker / Bollard (in mm)	Between Two Opposite Streams of Traffic	Between Two Streams on Same Direction	At the End for Pavement Edge Drop
A minimum 300 mm clear distance shall be provided from the traffic lane marking to the tubular markers.				

Application: Tubular markers are suitable in urban or in rural sections where pedestrian and bicyclist movements are there due to abutting roadside activities. If the traffic approaching in one direction is required to be diverted into two different pathways, it can be used in longitudinal direction along with traffic lane line marking. It is generally used where traffic moves at relatively slow speed and traffic volume is relatively high.

5.3.3 Drums

Drums are generally made from lightweight and deformable materials. They should be a minimum of 800 mm in height and have at least 300 mm width, regardless of orientation, as shown in **Fig. 5.12**. The markings on drums shall be horizontal, circumferential, alternating red and white retro-reflective stripes 100 to 150 mm wide conforming to Class C as per IRC-67. Refer IRC 67. Each drum shall have a minimum of two red and two white stripes with the top stripe being red. Any non-retro-reflectorized space between the horizontal red and white stripes shall not exceed 75 mm wide. Drums shall have closed tops that will not allow the collection of construction debris or other debris.

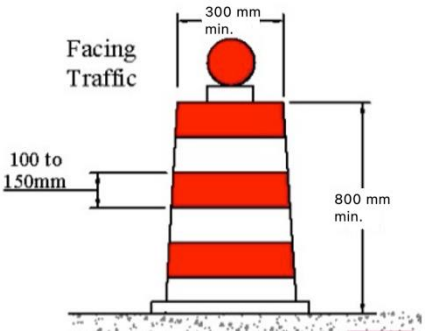


Fig. 5.12 Drum

Drums are highly visible and give the appearance of being formidable obstacles, and therefore, command the respect of road users. They are portable enough to be shifted from place to place within a work zone to accommodate changing conditions but are generally used in situations where they will remain in place for a prolonged period.

Although drums are commonly used to channelize or delineate traffic flow, they may also be used alone or in groups to mark specific locations, including as crash attenuators.

Drums should not be used for pedestrian channelization or as pedestrian barriers in work zones or along sidewalks unless they are continuous between individual devices. Drums should not be weighted with sand, ballast, water, or any material to the extent that would make them hazardous to road users or workers when struck. Ballast shall not be placed on the top of a drum. Drums used in regions susceptible to freezing should have drain holes in the bottom so that water will not accumulate and freeze causing a hazard, if struck by traffic.

The application of drum delineators is permitted in worksites where there is adequate space to install drums with adequate minimum clearance distance. In Indian context, in areas of high vandalism, the drum channelization can be explored and spacing indicated in **Table 5.7** will be applicable for drum channelization also.

The following points must be borne in mind while placing drums:

a) Drums shall have closed tops that will not allow the collection of construction debris or other debris.

b) Metal drums shall not be used.

Application: Drums are ideal for worksites of long construction period and where length of worksite is relatively long, and they are placed parallel to traffic movement path. Since drums occupy more space than other channelizing devices, they can be used at locations where they can be placed with adequate lateral clearance set forth in this guideline. Drums shall be tied up with proper reflective tape. The drums along with tapes shall form regular and smooth geometry to streamline the traffic in a well-defined path.

5.3.4 Barricades

The barricades are used to warn and alert drivers of hazards created by construction or maintenance activities on or around carriageway/footpath. Barricades are intended to provide containment without significant deflection or deformation under impact and to redirect errant vehicles along the barrier. They are designed to be easily relocated and have four specific functions, such as to:

1. Prevent traffic from entering work areas including excavations or material storage sites;
2. Provide protection and perceived safety to both traffic as well as construction workers;
3. Separate two-way traffic; and
4. Protect construction, such as form work for culverts and other exposed objects, to avoid hazards to road users.

Barricades can be portable or permanent. Portable barricades should be stable under adverse weather conditions and appear substantial but not so much as to cause excessive damage to the vehicles if they are struck. **Fig. 5.13** shows standard barricades; Type I and II are portable, whereas Type III and Type IV (**Fig. 5.14**) are permanent. The recommended dimensions of various components are given in **Table 5.9** and the details of Type IV barricades are shown in **Fig. 5.14.**

The horizontal members of Type I and II barricades may be of wooden planks and metal. These should be 200 mm - 300 mm wide and should be pasted retro reflective sheeting type IV alternate yellow and black stripes of 150 mm width. The stripes should slope away at an angle of 45º in the direction traffic is to pass. Where the barricades extend entirely across the carriageway, the stripes should slope downward towards the direction the traffic must turn in detour. Where both left and right turns are provided for, the chevron stripes should slope downward in both directions from the center of the barricade. The entire area of chevrons should be reflectorized so as to be visible from a safe distance.

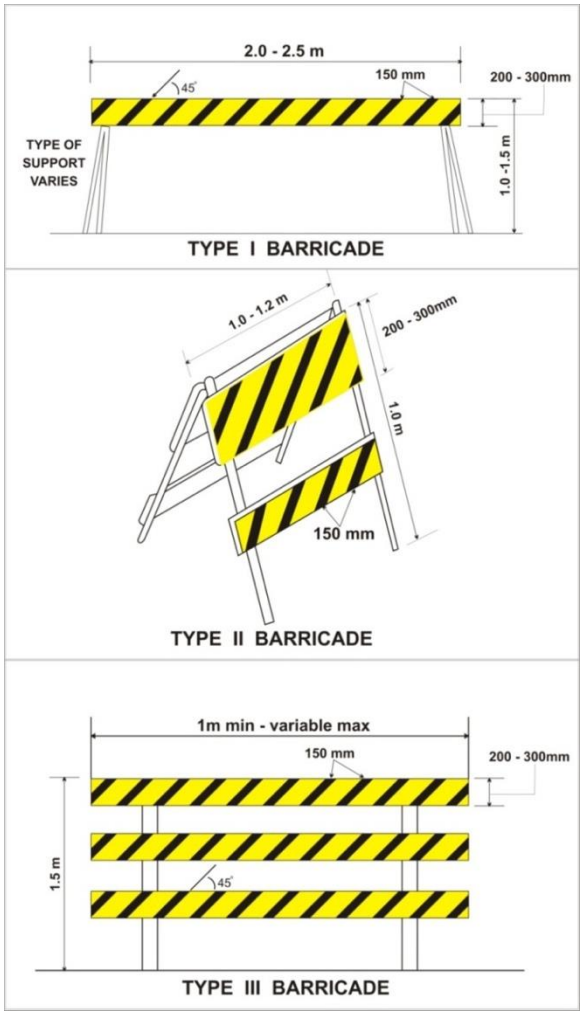


Fig. 5.13 Standard Barricades

Table 5.9 Characteristics and Dimensions of Barricades

Type / Component	I	II	III	IV
Width of Rail	200 mm - 300 mm	200 mm - 300 mm	200 mm - 300 mm	2000 mm (Width of barricade)
Length of Rail	2.0 m - 2.5 m	1.0 m - 1.2 m	1 m min - variable max.	2550 mm (Length of barricade)
Width of Strip	150 mm	150 mm	150 mm	150 mm
Height of Barricade	1.0 - 1.5 m	1.0 m	1.5 m	2.15 m
Type of Frame	Heavy 'A' Frame	Light 'A' Frame	Fixed, Demountable	Fixed, Demountable
Flexibility	Essentially movable	Portable	Essentially Permanent	Essentially Permanent
Retro-reflective sheeting	CLASS B Type III OR IV sheeting as per IRC-67	CLASS B Type III OR IV sheeting as per IRC-67	CLASS B Type III OR IV sheeting as per IRC-67	CLASS B Type III OR IV sheeting as per IRC-67

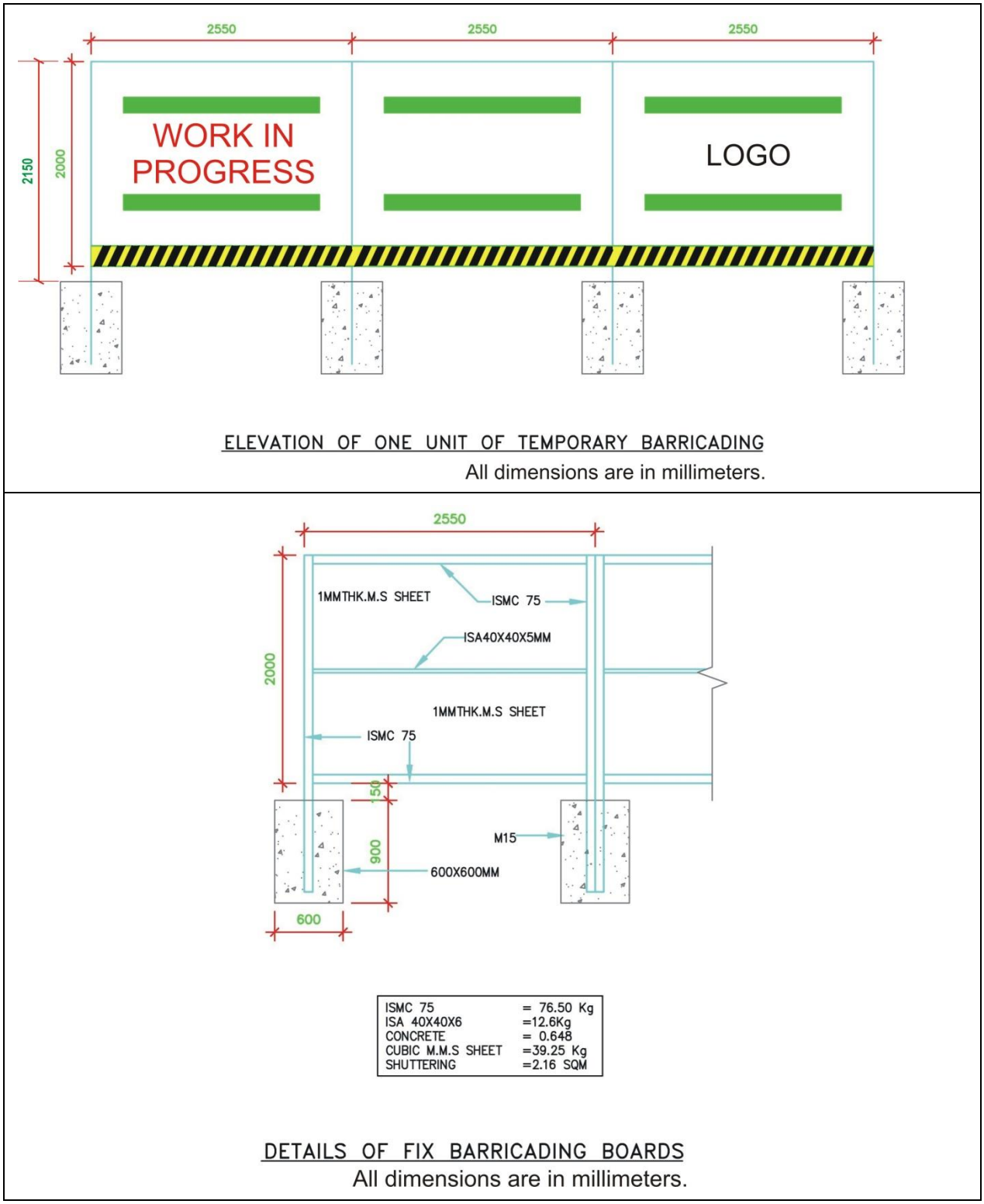


Fig. 5.14 Type IV Barricade

Application: Type I or Type II barricades shall be used when traffic is redirected. These barricades can be used interchangeably and are more useful in repair work that is generally initiated on an emergency basis. The support should be of an “A” frame configuration or hinged or otherwise

flattened at the top to permit convenient folding and stacking for transportation. Since these barricades are susceptible to overturning in wind, their stability can be improved through ballast.

Type III barricades are the permanent type and can be made of wood or metal. These are erected at the point of closure when a road section is closed to traffic in construction projects. They may extend completely across a roadway and its shoulders or from kerb to kerb. Where provision must be made for the access of construction and supervision vehicles, type III barricades must be provided with a gate or movable section that can be opened and/or closed as required. Signs such as “ROAD CLOSED” and "DETOUR ARROWS" should be erected on the fixed barricade.

Type IV barricades are to be used in road construction works of long duration, in urban areas. They serve the purpose of screening and separation of traffic from work area but should not be expected to provide much protection. Therefore, they should be installed at such locations which should prevent all kinds of entry and exit by the road users/ construction workers to workspace and also those works which are not intended to be seen by public, lest it can distract the driving attention. These should not be used on roads/highways having high traffic volume and speed since they do not provide much protection when impacted.

5.3.5 Direction Indicator Barricades

The direction indicator barricade **Fig. 5.15** shall consist of a one-direction large arrow sign mounted above a diagonal striped, horizontally aligned, retro-reflective rail.

The one-direction large arrow sign shall be white on a red background. The stripes on the bottom rail shall be alternating yellow and black retro-reflective type XI stripes sloping downward at an angle of 45 degrees in the direction road users are to pass. The stripes shall be 100 mm wide. The one-direction large arrow sign shall be of size 600 x 300 mm. The bottom rail shall have a length of 600 mm and a height of 200 mm.

The direction indicator barricade, including any associated ballast or lights, should be crashworthy.

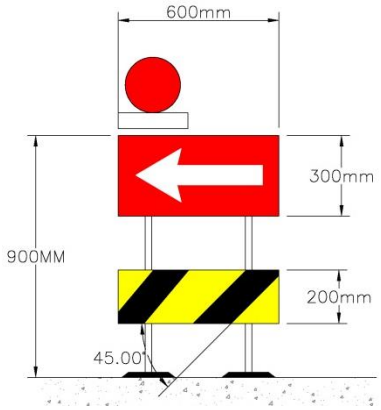


Fig. 5.15 Direction Indicator Barricade

Application: The direction indicator barricade may be used in tapers, transitions, and other areas where specific directional guidance to drivers is necessary. If used, direction indicator barricades should be used in series to direct the driver through the transition and into the intended travel lane.

5.3.6 New Jersey Barrier

The New Jersey Barriers are 1 m to 2.0 m long pre-cast reinforced concrete/polymer modular pieces with shaped ends that can be interlocked and connected. Where the road works are to be undertaken, which would continue for some time or where the space is limited and there is a need for the protection of the work force, particularly where the speed of passing traffic may be high, New Jersey Barrier as shown in **Fig. 5.16** may be used.

Application: The New Jersey barrier is to be used to barricade or segregate workspace from traffic, where traffic moves parallel to barricading. It is intended to minimize damage in case of any

accident. The new jersey barrier should be provided at the locations especially where there is edge drop of more than 300mm between the carriageway and adjacent strip of land as part of work area. While installing barricade, the minimum clearance as shown in **Fig. 5.17** shall be always kept. Barrier shall be retro reflectorized by using Median Markers and Object Markers.

Fig. 5.16 New Jersey Barrier

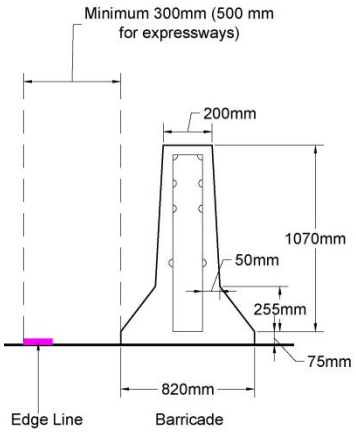


Fig. 5.17 Placement of Barricade

5.3.7 Water-Filled Barrier

Water-filled barricades are modular water-filled plastic (polymer) containers of various sizes and shapes, and an example is given in **Fig. 5.18.** Hollow polyethylene barriers in trapezoidal shape of about 80 cm to 100 cm length have been developed for short-term applications where portability is important. These plastic barriers are normally filled with water after placement on-site to provide a moderate level of stability and crash protection. These barriers can also be filled with soil/sand, or concrete to produce a heavier barrier with greater crash protection, at the cost of reduced portability. Their use should be carefully monitored until more experience is gained with them. They will enable the deployment of narrower traffic lanes and buffer zones where space is limited, and vehicle speeds are high. The following points must be borne in mind while placing:

- They shall be at a minimum of 0.7 m tall for major roads and expressway, and 0.5 m tall for other roads.
- Each unit shall come with interlocking devices for use on tangent/straight and horizontal curves with mounting arrangement to fix devices for lighting.
- It is very stable and offers better resistance to vehicle impact as compared to traffic cones and barricades.
- It shall be used as a traffic delineator for long-term works, to separate traffic from pedestrians when the footpath is temporarily diverted next to a carriageway.
- It shall be placed at least 0.5m from the edge of the carriageway for expressway and 0.3m for other roads as shown in **Fig. 5.17.**
- Reflective sheeting to Class C as per IRC-67 to be placed on these plastic barricades shall.

Application: Water/sand filled New Jersey barrier is recommended for segregating and barricading the workspace and vehicular movement, where traffic is expected to change direction of movement on account of temporary diversion plan. Forgiving type water filled barriers are

required in transition areas, where vehicles are likely to hit them if they fail to negotiate the deflected pathway provided as part of temporary diversion plan. The water filled barrier shall be conspicuous enough to be seen by drivers under the headlight beam.

Fig. 5.18 Water-filled barrier

5.3.8 Detectable Edging for Pedestrians

Various detectable edgings and their application for pedestrians include:

- Prefabricated lightweight sections of plastic, metal, or other suitable materials that are interconnected and fixed in place to form a continuous edge.
- These are placed at ground level to provide a continuous connection between channelizing devices located at intervals along the edge of the sidewalk or walkway.
- Sections of lumber interconnected and fixed in place to form a continuous edge.
- In-situ asphalt or concrete kerb.
- Prefabricated concrete kerb sections that are interconnected and fixed in place to form a continuous edge.
- Continuous temporary traffic barrier or longitudinal channelizing barricades placed along the edge of the sidewalk or walkway that provides a pedestrian edging at ground level.
- Chain link or other fencing equipped with a continuous bottom rail.

Detectable pedestrian edgings should be red or yellow and should match the color of the adjacent channelizing devices or traffic control devices, if any are present. **Fig. 6.2 and Fig. 6.3** may be referred.

5.3.9 Delineators

Delineators are generally combined with or are used to supplement other traffic control devices. They shall be mounted on crashworthy supports so that the reflecting unit is approximately 1.0 m above the nearside carriageway edge. The standard color for delineators used along both sides of two-way streets and highways and the right side of one-way roadways shall be black and white, where white color is of type XI reflective sheeting. The tubular markers shown in **Fig. 5.11** and other similar devices including the cones (**Fig. 5.10**), drums (**Fig. 5.12**) can be used as delineators.

Spacing along roadway curves should be such that several delineators are always visible to the driver. Delineators may be used in work zones to indicate the alignment of the roadway and to outline the required vehicle path through the work zone.

Application: Delineators are appropriate at locations where there is no edge drop at all and should serve as alignment markers so that drivers can judge the carriageway edges while passing through the work zone. The retro-reflective delineators can be suitably placed at regular interval, e.g. 2m spacing if used in transition portion and 5m spacing if used in straight reaches. Delineators, when tied up with proper reflective tape, form a regular and smooth geometry to guide the traffic in the changed path at the intended speed.

5.3.10 Reflective devices

Reflective devices such as cat's eye/ road studs and solar studs, kerb stone reflectors, median wall reflectors, median marker, Delineators, Tubular Markers, and object markers shall be placed on the pavement along with the markings, kerb and dividers median, the crash barrier or any hazardous structure to warn and guide motorists during nighttime.

The following points must be borne in mind while placing:

a) The underlying principle is that when headlight falls on such devices, they reflect light and become self-illuminating and visible.

b) These are recommended for bridges, toll plazas, sharp curves, pedestrian crossings, lane transitions, speed humps, junctions, construction sites, railroad crossings, median openings, accident-prone locations, median, any concrete structure, crash barriers and lane changing locations.

5.3.11 Temporary Pavement Markings and Road Studs

Pavement markings shall be maintained along paved streets and highways in all long- and intermediate-term stationary work zones. All pavement markings shall be in accordance with IRC-35. Pavement markings shall match the markings in place at both ends of the work zone. Pavement markings shall be placed along the entire length of any surfaced detour or temporary roadway prior to the detour or roadway being opened to road users.

Warning signs, channelizing devices and delineation shall be used to indicate required road user paths in work zones where it is not possible to provide a clear path by pavement markings. All pavement markings and devices used to delineate road user paths shall be carefully reviewed during daytime and during nighttime.

For long-term stationary operations, pavement markings in the temporary traveled way that are no longer applicable shall be removed or obliterated as soon as practical. Pavement marking obliteration shall leave a minimum of pavement scars and shall remove old marking material. Painting over existing pavement markings with black paint or spraying with asphalt shall not be accepted as a substitute for removal or obliteration.

Road users should be provided with pavement markings within a work zone comparable to the pavement markings normally maintained along such roadways, particularly at either end of the work zone.

The intended vehicle path should be defined by markings in day, night, and twilight periods under both wet and dry pavement conditions.

The color of pavement markings shall be white or yellow conforming to IRC 35. The conspicuity shall be ensured throughout the construction phase and if required reapplication for a few times, as ordinary road marking paint get defaced within a short time. The word messages like 'DO NOT PASS', 'PASS WITH CARE' and 'NO PASSING ZONE' can be written upon the pavement surface, and for this principles and dimensions laid out in IRC 35 may be followed. The WTMP shall include location and type of pavement markings to meet the site requirements and conform to IRC 35. A typical pavement marking detail is shown in **Fig. 5.19.**

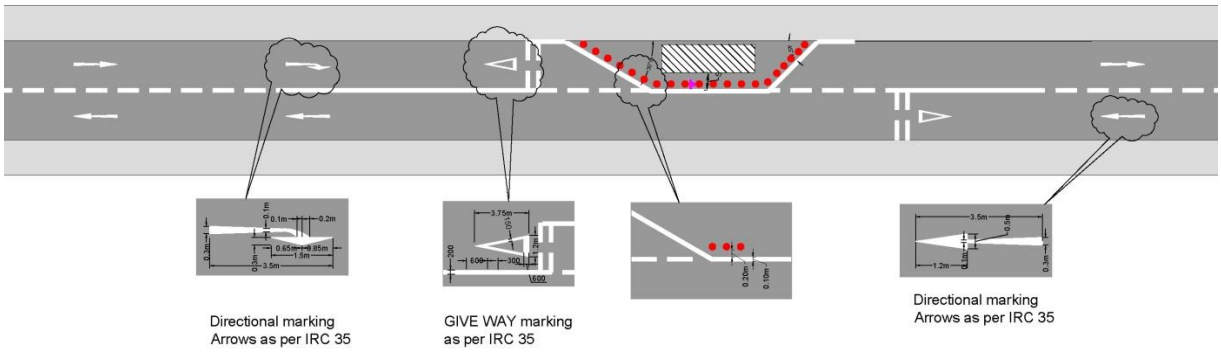


Fig. 5.19 Pavement Markings

5.3.11.1 Road Studs

Road studs shall be used at acute temporary diversions to reinforce the temporary continuous marking and where the contra flow situation is required to be adopted as part of work zone traffic management plan. The specifications of road studs will be as per IRC-35- 2024

a. **Solar Road Studs:**

- Solar Powered Road Markers made of Aluminium/Polymer Body with compressive strength of more than 13,635 kg tested as specified in MoRTH specification for Road & Bridge works (Section 804.6) are more effective and shall be provided at locations such as approach to road crash prone locations and highly hazardous locations such as bridge, toll plaza, sharp curves, pedestrian crossing, lane transition, speed humps, junctions, etc.
- The solar road studs work automatically, as the name implies, and do not rely on vehicle headlights. Under ideal conditions, the tremendous brightness of the Light Emitting Diode (LEDs) allows them to be seen from a distance of more than 800 m. The solar studs are also more apparent in rainy and foggy weather when road markers may be useless. The LED must be capable of providing visibility from both directions. NO NAILS can be used to secure the Solar Road Stud to the road. Solar stud dimensions must not be less than 100x100x10mm (as per Section 804.6 of the MORT&H Specification for Road & Bridge Works).
- At locations where solar studs are intended to be used, the spacing shall be same as that indicated for conventional road studs in Section of IRC 35.

The typical arrangement of road studs is indicated in **Fig. 5.20**.

Fig. 5.20 Road Studs

Warranty & durability of studs

Durability Solar Road stud and all other types of road studs must have satisfactory durability of minimum 2 years.

Warranty The contractor must provide the Engineer with a two-year warranty for satisfactory field performance, including the specified retro reflection of the reflector. Furthermore, the contractor who does the work of fixing Reflective Road stud/Solar studs shall provide a two-year warranty for satisfactory infield performance of the finished Road studs.

5.3.11.2 Placement of Road Studs

The pavement markings shall be reinforced with road studs and the color of the road studs shall be amber. Where it is essentially required to divide the two streams of traffic, and bi-directional road studs shall be provided at 1.5m to 9m spacing. Roads studs shall be used at acute temporary diversions to reinforce the temporary continuous marking and where contra-flow situation is required to be adopted as part of work zone traffic management plan shown in **Fig 5.21**. Road studs shall be used across the road application to highlight work zone area and works as a speed arrester.

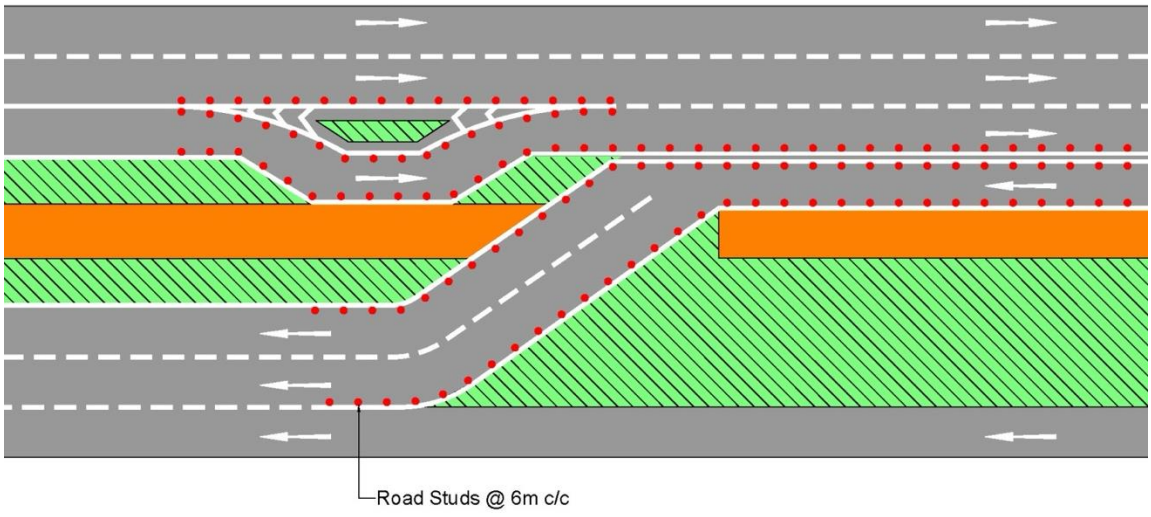


Fig. 5.21 Placement of Road Studs

Median Markers: Median Marker should be used for illumination of median as well as parapet wall structures etc. Use of Median Marker provides safety against collision with medians/parapets during the nighttime or severe weather. The recommended minimum application distance is 2 m

in the case of urban areas, 5 m for interurban highways and expressways or as suggested by Engineer in charge. Median markers could be of any shape.

5.4 Lighting Devices & Variable Message Signs

5.4.1 Lighting Devices

Lighting devices should be provided in work zones based on engineering judgment. When used to supplement channelization, the maximum spacing for warning lights should be identical to the channelizing device spacing requirements.

Four types of lighting devices are commonly used in work zones. They are floodlights, flashing warning beacons, warning lights, and steady-burn electric lamps.

Lighting devices may be used to supplement retro-reflectorized signs, barriers, and channelizing devices. During normal daytime maintenance operations, the functions of flashing warning beacons may be provided by high intensity rotating, flashing, oscillating, or strobe lights on a maintenance vehicle. Some illustrations are given in **Fig. 5.22.**

5.4.2 Floodlights

Utility, maintenance, or construction activities on highways are frequently conducted during nighttime periods when vehicular traffic volumes are lower. Large construction projects are sometimes operated on a double-shift basis requiring night work.

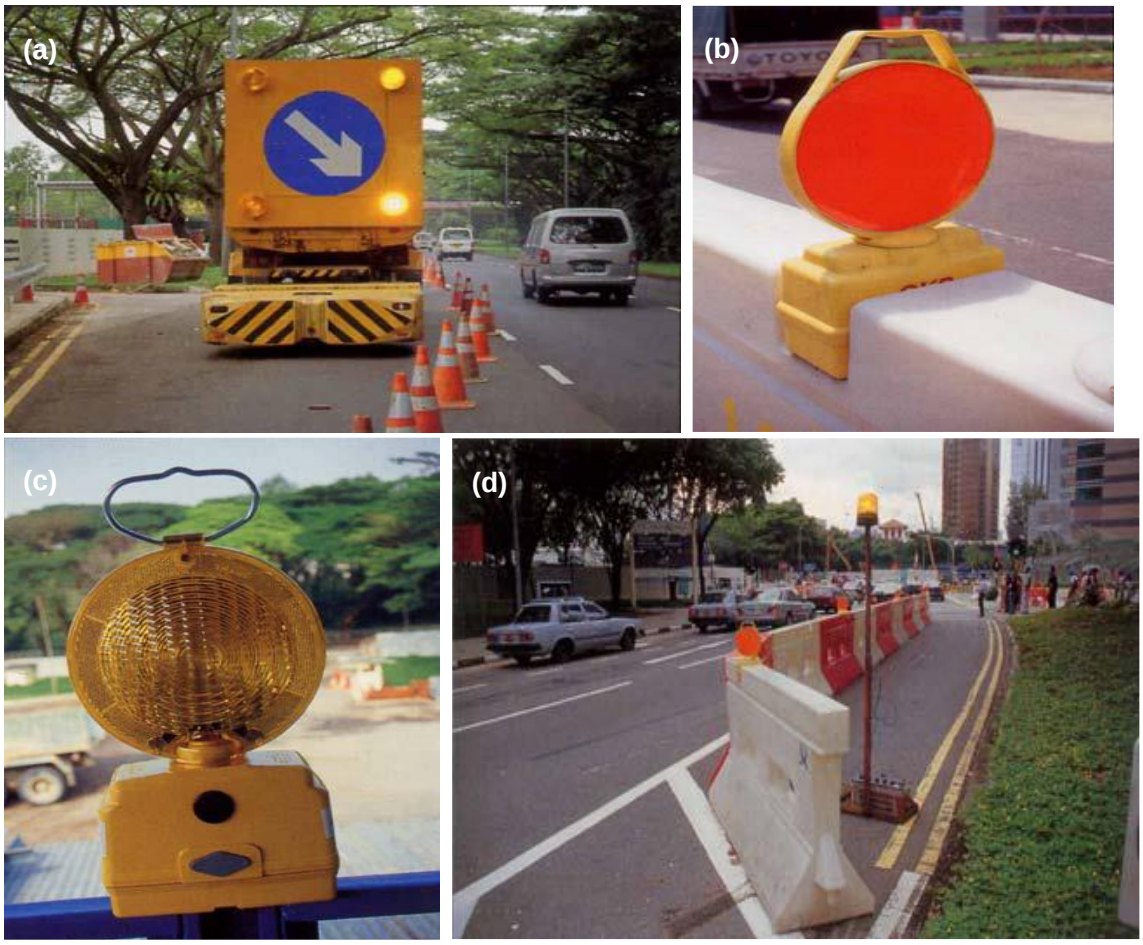


Fig. 5.22 Types of Lighting Devices (a) Truck Mounted attenuator; (b) Warning Lights; (c) Flashing Warning Beacons; (d) Rotating Amber Light

When nighttime work is being performed, floodlights should be used to illuminate the work area, equipment crossings, and other areas.

The adequacy of the floodlight placement and elimination of potential glare should be determined by driving through and observing the floodlighted area from each direction on all approaching roadways after the initial floodlight setup, at night, and periodically.

Desired illumination levels vary depending upon the nature of the task involved. An average horizontal luminance of 50 lux can be adequate for general activities. Tasks requiring high levels of precision and extreme care may require an average horizontal luminance of 216 lux.

5.4.3 Flashing Warning Beacons

Flashing warning beacons are often used to supplement a traffic control device. The flashing warning beacon shall be a flashing yellow light with a minimum nominal diameter of 200 mm with rotating amber lights equipped to be operated over the entire 24-hour duration. The temporary terminus of an expressway is an example of a location where flashing warning beacons alert drivers to the changing roadway conditions and the need to reduce speed in transitioning from the expressway to another roadway type.

5.4.4 Warning Lights

Type A, Type B, Type C, and Type D 360-degree warning lights are portable, powered, yellow, lens-directed, enclosed lights. When warning lights are used, they shall be mounted on signs or channelizing devices in a manner that, if hit by an errant vehicle, they will not penetrate through the windshield. The maximum spacing for warning lights should be identical to the channelizing device spacing requirements.

Flashing warning lights shall not be used for delineation, as a series of flashers fails to identify the desired vehicle path.

Type A low-intensity flashing warning lights, Type C steady-burn warning lights, and Type D 360 degree steady-burn warning lights shall be maintained so as to be capable of being visible on a clear night from a distance of 900 m Type B high-intensity flashing warning lights shall be maintained so as to be capable of being visible on a sunny day when viewed without the sun directly on or behind the device from a distance of 300 m. Warning lights shall have a minimum mounting height of 750 mm to the bottom of the lens.

Type A low-intensity flashing warning lights are used to warn road users during nighttime that they are approaching or proceeding in a potentially (isolated) hazardous area. Type A warning lights may be mounted on channelizing devices.

Type B high-intensity flashing warning lights are used to warn road users during both daylight and nighttime hours that they are approaching a potentially hazardous area.

Type C steady-burn warning lights and Type D 360-degree steady-burn warning lights may be used during nighttime to delineate the edge of the traveled way and channelize traffic.

When used to delineate a curve, Type C and Type D 360-degree warning lights should only be used on devices provided on the outside of the curve, and not on the inside of the curve as these may be hit by the passing traffic.

5.4.5 Temporary Traffic Control Signals

Temporary traffic control signals used to control road user movements through work zones and in other work zone situations shall meet the applicable provisions.

Temporary traffic control signals are typically used in work zones such as temporary haul road crossings; temporary one-way operations along a one-lane, two-way highway; temporary one-way operations on bridges, reversible lanes, and intersections.

One-lane, two-way vehicular traffic flow requires an all-red interval of sufficient duration for road users to clear the portion of the work zone controlled by the traffic control signals. Safeguards shall be incorporated to avoid the possibility of conflicting signal indications at each end of the work zone.

Temporary traffic control signals may be portable or mounted on temporarily fixed supports. Temporary traffic control signals should only be used in situations where temporary traffic control signals are preferable to other means of traffic control, such as changing the work staging or work zone size to eliminate one-way vehicular traffic movements, using flaggers to control one-way or crossing movements, using STOP or YIELD signs, and using warning devices alone.

5.4.6 Portable Variable Message Signs

Portable VMS will be used to warn the motorists about ongoing or upcoming activities that will impact traffic flow. The message may include information on lane closure, lane shift, one-way movement etc. Portable message signs shall be devices with the flexibility to display a variety of messages. In each message there are units of information. A unit is one separate piece of data that the driver can recall and use to make a decision. A unit normally is one or two words but can be up to four words long. The message length is the number of words or characters in the message. The average motorist traveling at a high rate of speed can handle 8 word messages of 4 to 8 characters per word, (excluding prepositions). IRC: SP: 85 shall be referred for detailed features and application of portable VMS.

Portable variable message signs have a wide variety of applications in work zones including roadway, lane, or ramp closures, crash or emergency incident management, width restriction information, speed control or reductions, advisories on work scheduling, road user management and diversion, warning of adverse conditions, and other operational control. The primary purpose of portable VMS in work zones is to advise the road user of unexpected situations. Some typical applications include the following:

The primary purpose of portable variable message signs in work zones is to advise the road user of unexpected situations. Some typical applications include the following:

a) Where the speed of vehicular traffic is expected to drop substantially
b) Where significant queuing and delays are expected
c) Where adverse environmental conditions are present
d) Where there are changes in alignment or surface conditions
e) Where advance notice of ramps, lane, or roadway closures is needed
f) Where changes in the road user pattern occur.

The components of a portable variable message sign should include: a message sign panel, control systems, a power source, and mounting and transporting equipment. The front face of the sign should be covered with a protective material. The color of the elements should be yellow on a black background. Portable variable message signs should be visible from 800 m under both day and night conditions. For a trailer or large truck mounted sign, the letter height should be a minimum of 450 mm. For variable message signs mounted on service patrol trucks, the letter height should be a minimum of 250 mm.

The message panel should have adjustable display rates (minimum of 3 seconds per phrase), so that the entire message can be read at least twice at the posted speed, the off-peak 85th-percentile speed prior to work starting, or the anticipated operating speed.

Messages should be designed considering the following factors:

a) Each phrase should convey a single thought.
b) If the message can be displayed in one phrase, the top line should present the problem, the center line should present the location or distance ahead, and the bottom line should present the recommended driver action.
c) The message should be as brief as possible.
d) When a message is longer than two phrases, additional Portable Variable Message signs should be used.
e) When abbreviations are used, they should be very conventional and easily understood.

The message sign panel may vary in size. Smaller letter sizes may be used on a Portable Variable Message sign mounted on a trailer or large truck provided that the message is legible from at least 200 m, or mounted on a service patrol truck provided that the message is legible from at least 100 m. Two portable variable message signs may be used for the purpose of allowing the entire message to be read twice at the posted speed.

The control system shall include a display screen upon which messages can be reviewed before being displayed on the message sign. The control system shall be capable of maintaining memory when power is unavailable. Portable variable message signs shall be equipped with a power source and a battery back-up to provide continuous operation when failure of the primary power source occurs.

The mounting of portable variable message signs on a trailer, a large truck, or a service patrol truck shall be such that the bottom of the message sign panel shall be a minimum of 2.1 m above the roadway in urban areas and 1.5 m above the roadway in rural areas when it is in the operating mode.

The text of the messages shall not scroll or travel horizontally or vertically across the face of the sign. Portable variable message signs should be used as a supplement and not as a substitute for conventional signs and pavement markings. When portable variable message signs are used for route diversion, they should be placed far enough in advance of the diversion to allow road users ample opportunity to perform necessary lane changes, to adjust their speed, or to exit the affected highway.

The portable variable message signs should be sited and aligned to provide maximum legibility. Multiple portable variable message signs should be placed on the same side of the roadway. Portable Variable Message signs should be placed on the shoulder of the roadway or, if practical,

further from the traveled lane. They should be delineated with retro-reflective traffic control devices. When Portable Variable Message signs are not being used, they should be removed; if not removed, they should be shielded; or if the previous two options are not feasible, they should be delineated with retro-reflective traffic control devices.

5.4.7 Arrow Boards

An arrow panel shall be a sign with a matrix of elements capable of either flashing or sequential displays. This sign shall provide additional warning and directional information to assist in merging and controlling road users through or around a work zone.

An arrow panel in the arrow or chevron mode should be used to advise approaching traffic of a lane closure along major multi-lane roadways in situations involving heavy traffic volumes, high speeds, and/or limited sight distances, or at other locations and under other conditions where road users are less likely to expect such lane closures. If used, an arrow panel should be used in combination with appropriate signs, channelizing devices, or other traffic control devices.

An arrow panel should be placed on the shoulder of the roadway or, if practical, further from the traveled lane. It should be delineated with retro-reflective traffic control devices. When an arrow panel is not being used, it should be removed; if not removed, it should be shielded; or if the previous two options are not feasible, it should be delineated with retro-reflective temporary traffic control devices.

Arrow panels shall meet the minimum size, legibility distance, number of elements, and other specifications shown in **Table 5.10** and **Fig. 5.23.** Type ‘A’ arrow panels are appropriate for use on low-speed urban streets. Type ‘B’ arrow panels are appropriate for intermediate-speed facilities and for maintenance or mobile operations on high-speed roadways. Type C arrow panels are intended to be used on high-speed, high-volume motor vehicle traffic control projects. Type D arrow panels are intended for use on authorized vehicles.

Table 5.10 Advance Warning Arrow Display Specifications

Panel Type	**Minimum Size Length x Width**	**Minimum Legibility Distance**	**Minimum Number of Elements**
A	1200 x 600 mm	0.8 km	12
B	1500 x 750 mm	1.2 km	13
C	2400 x 1200 mm	1.6 km	15
D	Arrow L=1220mm & W=610mm	0.8 km	12

Type A, B, and C arrow panels shall have solid rectangular appearances. A Type D arrow panel shall conform to the shape of the arrow. All arrow panels shall be finished in non-reflective black. The arrow panel shall be mounted on a vehicle, a trailer, or other suitable support. The minimum mounting height of an arrow panel should be 2.1 m from the roadway to the bottom of the panel, except on vehicle-mounted panels, which should be as high as practical. A vehicle-mounted arrow panel should be provided with remote controls. Arrow panel elements shall be capable of at least a 50 percent dimming from full brilliance. The dimmed mode shall be used for nighttime operation of arrow panels. Full brilliance should be used for daytime operation of arrow panels. The arrow

panel shall have suitable elements capable of the various operating modes. The color presented by the elements shall be yellow.

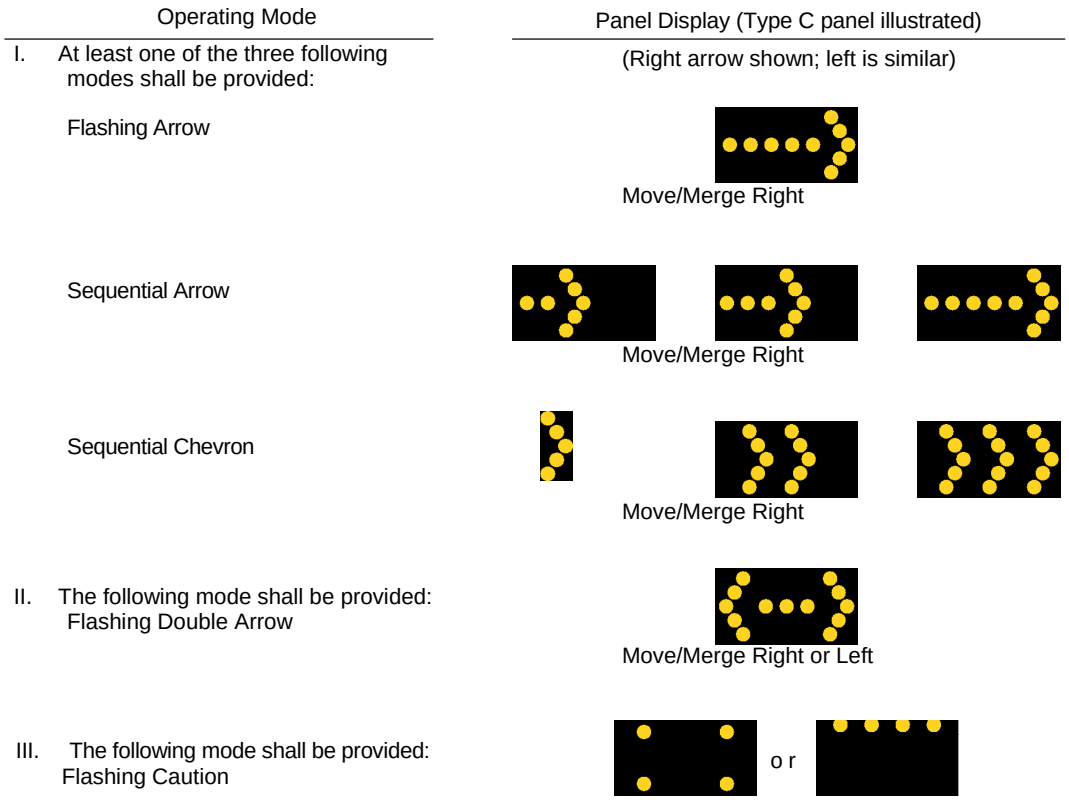


Fig. 5.23 Typical Illustration of Arrow Message

Guidance:

If an arrow panel consisting of a bulb matrix is used, the elements should be recess-mounted or equipped with an upper hood of not less than 180 degrees. The minimum element on time shall be 50 percent for the flashing mode, with equal intervals of 25 percent for each sequential phase. The flashing rate shall be not less than 25 and not more than 40 flashes per minute.

An arrow panel shall have the following three mode selections:

a) A Flashing Arrow, Sequential Arrow, or Sequential Chevron mode;

b) A flashing Double Arrow mode; and

c) A flashing Caution mode.

An arrow panel in the arrow or chevron mode shall be used only for stationery or moving lane closures on multi-lane roadways.

For shoulder work, blocking the shoulder, for roadside work near the shoulder, or for temporarily closing one lane on a two-lane, two-way roadway, and an arrow panel shall be used only in the caution mode. For a stationary lane closure, the arrow panel should be located on the shoulder at the beginning of the merging taper. Where the shoulder is narrow, the arrow panel should be located in the closed lane. When arrow panels are used to close multiple lanes, a separate arrow panel shall be used for each closed lane.

When arrow panels are used to close multiple lanes, if the first arrow panel is placed on the shoulder, the second arrow panel should be placed in the first closed lane at the beginning of the second merging taper. When the first arrow panel is placed in the first closed lane, the second arrow panel should be placed in the second closed lane at the downstream end of the second merging taper.

For mobile operations where a lane is closed, the arrow panel should be located to provide adequate separation from the work operation to allow for appropriate reaction by approaching drivers. A vehicle displaying an arrow panel shall be equipped with high intensity rotating, flashing, oscillating, or strobe lights. Arrow panel(s) shall not be used to laterally shift traffic. A portable Variable Message Sign (VMS) may be used to simulate an arrow panel display.

Section 6. MEASURES FOR VULNERABLE ROAD USERS (VRUs)

6.1 Measures for VRUs

Where pedestrians, including differently abled persons and people with visual impairment, have to negotiate a work site or to cross the road within a work site, they shall be provided with and directed to suitably constructed and protected temporary footpaths and crossing points, or formal pedestrian crossings, and also refuges, where such provisions are made. Such facilities shall meet the requirements described in these guidelines. The pedestrian path shall be of the same width and facilities that existed prior to the works. Since the work zone speed limit is 30km/h, bicyclists can share the carriageway with other vehicles. It is important to ensure speed compliance with all vehicles. Since there is an increasing concern about the safety of motorcyclists, provisions should be made at the work zones to warn them about potential hazards and improve their safety.

6.2 Guidance

In proposing measures for devices for pedestrians, people of disabilities and for bicyclists/ other non-motorized vehicles, in an area of road works, the following guidance shall prevail:

- It should be ensured that there is no danger to pedestrians from falling objects or sharp edges, and these road users will not fall over or bump into anything causing personal injury.
- Scaffolding be marked with white bands at eye level and allow at least 2.1 m head room. It should be ensured that the barriers can be detected easily by a visually impaired person using a cane stick.
- Kerb ramps or raised footpath should be provided to help blind, poorly sighted, elderly, and disabled people and for those with prams or wheelchairs.
- Pedestrian safety shall be ensured by provision of devices such as raised rumble strip markings and speed humps near pedestrian crossings, where traffic speed is likely to be high. If excavations are deeper than 0.3 m, stronger barricades will be required like water filled barricades to protect pedestrians and bicyclists.
- The safety buffer is provided in the carriageway if the works are closer to the kerb than the width of the lateral safety buffer clearance.
- If the works are on or near formally marked pedestrian crossings, care must be taken to avoid confusion to pedestrians.
- Clear guidance must be given as to where they are expected to cross while the work is ongoing.
- Proper signages must be utilized to lead motorcyclists in and out of work zones. The signs shall be electronic variable message signs altering motorcyclist hazards.
- It is recommended to place motorcycle-specific warning signs in coincidence with other warning, regulatory or informational signs applicable for work zones.
- The warning signs to be used to alert motorcyclists of hazards could be related to grooved pavement, unpaved surfaces, uneven and cragged pavement sections, loose gravels, pavement discontinuities and changes in lane geometrics.
- In case of longitudinal joints arising out of resurfacing or overlays, the height differences between joints shall be limited to 2.5 cm to make motorcycle travel safer.

- When there is a temporary change in horizontal alignments, geometric elements must be proportioned in concurrence with the operating speed at the work zone.
- It should be ensured that there is no danger to motorcyclists due to water or other liquid overspray arising out of work zone activities.

6.3 Barriers for Pedestrians

Pedestrian barriers should be used to mark any temporary footpath. Water-filled barricades must always be used to protect pedestrians from traffic, excavations, plants or materials as shown in examples in **Fig. 6.1**.

Place warning lights at the end of the barriers at night. Portable pedestrian barriers, which may include mesh, if used, should be reasonably rigid and have:

- A handrail fixed between 1.0 m and 1.2 m above ground level, which should be reasonably smooth and rigid for pedestrians to hold to obtain guidance and some measure of support.
- A visibility panel at least 150 mm deep which may be integral with the handrail or if separate must be fixed, so that its upper edge is a minimum of 0.9 m above ground level. Visibility panels of yellow, white, or orange color are best for detection by partially sighted people, while the red and white rail gives a good contrast and provides interchangeability with traffic barriers; and
- A tapping rail (for blind people with a white stick) of min depth 150 mm with a lower edge at ground level or up to a maximum height of 200 mm above the ground.

Fig. 6.1 Protective Pedestrian Walking Space

When covers are required to be removed from underground chambers or manholes, a flag man shall always be there, and a barrier with a handrail fixed no lower than 0.8m above ground level will be satisfactory. In this case, the barrier must be large enough to enclose the opening. Pedestrian barriers can be used to block and to redirect pedestrian movement, and plastic mesh barrier can segregate the pedestrians and construction activity area as given in **Fig. 6.2.** The illustration of how to put them into practice is shown in **Fig. 6.3**.

Plastic pedestrian barrier shall be stable and not easily blown over or displaced by moving traffic or pedestrians. It is sometimes a proprietary-made product of plastic post/frame with mounting devices with reflective discs 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. The portability of these

devices is of advantage in emergencies or work that involve their regular displacement. It shall be erected without gaps along pedestrian paths throughout the work zone for the control of pedestrian movement to prevent injury or interference with the construction work activity. They may be erected at spacing not exceeding 20m along existing or new roads to inhibit access if road is closed to traffic use. Plastic pedestrian barrier shall not be used next to deep excavations or steep falls where heavy pedestrian movement is expected. They shall be placed such that a minimum distance of 0.5m space separates the plastic barricade and the excavated pit. Water-filled barricades shall be used if heavy pedestrian movement is expected.

Pedestrian Barrier **Mesh barrier**

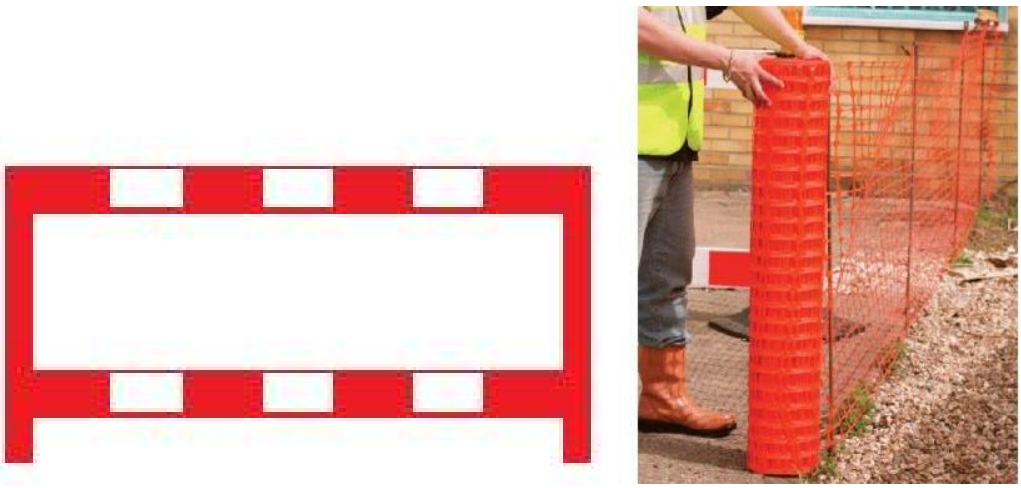


Fig. 6.2 Barrieres

Fig. 6.3 Examples of Installations

6.4 Works on Footpath: Alternative Way for Pedestrians

An alternative safe route for pedestrians must be provided if it is necessary to close an existing footpath or part of a footpath as shown in **Fig 6.4**. Additional equipment may be required to do this. Pedestrian access to property must always be ensured. Temporary pedestrian paths should never be less than 1 m wide and, wherever possible, they should be 1.5 m or more in width. It must be ensured that pedestrians are not diverted onto an unguarded carriageway. If the temporary footpath is in the carriageway, the approach should be properly guarded and provided with signs. The lateral safety buffer clearance(s) must be on the traffic side of the pedestrian barriers. The signage and barricades should be in place before the footpath is blocked.

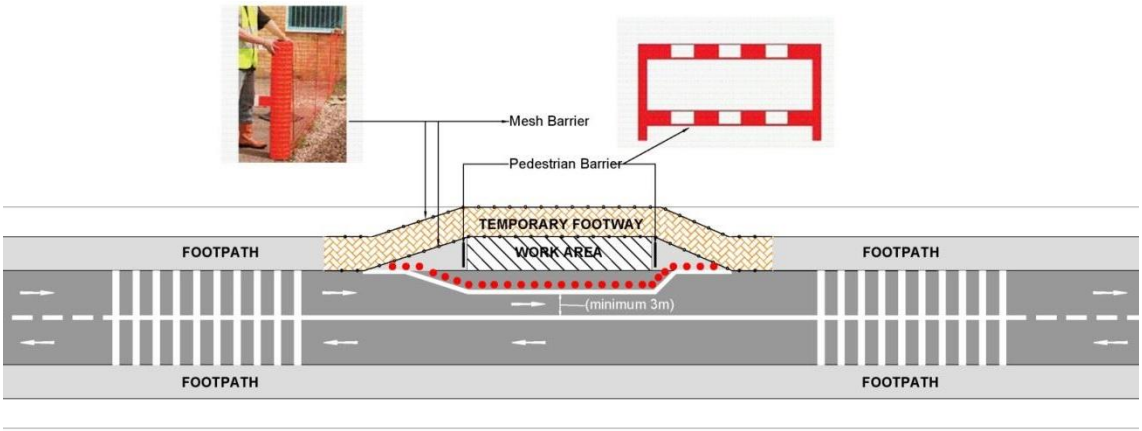


Fig. 6.4 Works on Footpath: Alternative Way for Pedestrians

In exceptional cases, the use of the other footpath may be acceptable on some roads, but if this option is selected, the alternative route must be safe to use, and the needs of children and of people with disabilities must be taken into account.

6.5 Speed Reduction Measures

The most effective speed reduction method in work zones is enforcement using radar speed guns to detect violations of posted speed limits. On urban roads and highways passing through urban areas, physical measures such as speed breakers or raised rumble strip or bar markings may be adopted. However, their placement should be carefully assessed to determine the need and the most appropriate location. Additionally, speed breakers must be installed with adequate warning signs on the approaches and proper lighting to ensure they are clearly visible to approaching vehicles.

Speed breakers can have various chord lengths, allowing different passing speeds over the hump, as illustrated in **Fig. 6.5**. The chord length for constructing a speed hump can range from 3 meters to 9.5 meters. In all cases the height shall be 100 mm only, and care shall be exercised to ensure that the height does not exceed 100 mm.

The raised bar markings using thermo-plastic paint or mastic sheets can be used with installation across the carriageway for alerting the drivers to reduce the speed in work zones in urban areas. The first application can be 300 mm wide strips, and the second can be 150 mm. These strips shall be provided at 500 to 1000 mm spacing's in a series/ set comprising 15 to 20 strips at the distance of 130 m to 180 m from the start of work zone, for both directions of traffic, as shown in **Fig 6.6**.

These bar markings shall be removed upon completion of work at sites.

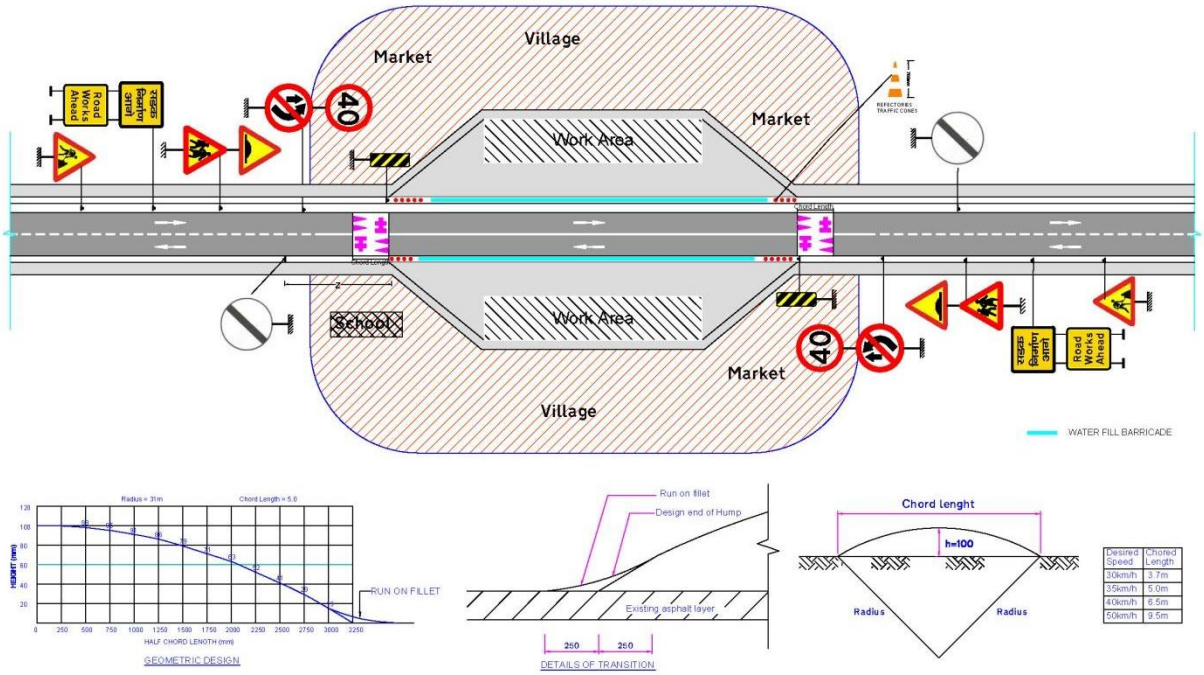


Fig. 6.5 Speed Breakers for Highways Passing through Urban Area

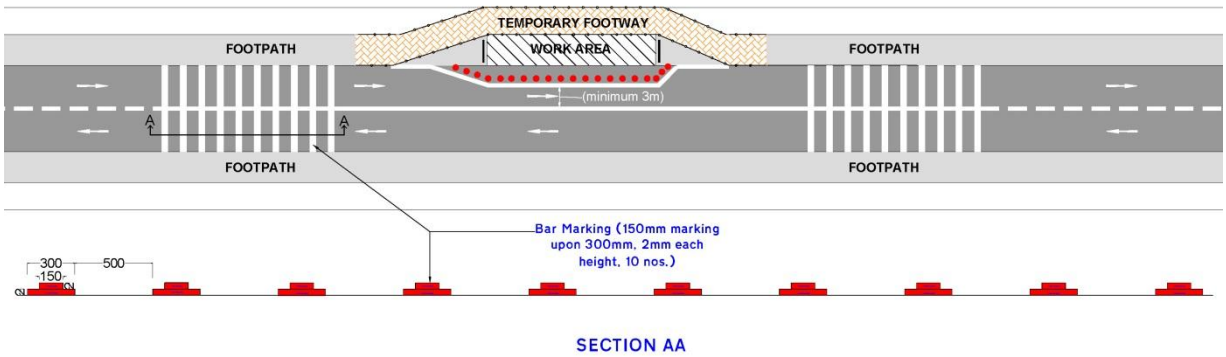


Fig. 6.6 Bar Markings

Section 7. Traffic Management Practices at Worksites

7.1 Introduction

To manage the traffic flow through the work zone, a number of practices are available. Common practices are described below, and selecting the appropriate strategy is crucial to planning of WTMP for a safe work zone.

7.2 Alternate One-Way Operations

The Alternate One-way operations can be put in place on a two-lane bi-directional road; however, this approach is suitable for very low volume roads. While one lane of travel is taken up with construction activities, the remaining lane is alternately used to accommodate traffic travelling in opposite direction. This strategy is generally limited to low volume roads, and requires at least two flaggers, or temporary traffic lights to safely handle the 'Stop' and 'Go' arrangement of traffic.

Different traffic control methods employed for alternate one-way operation are:

- "Give and take" system
- Priority sign
- "STOP/GO" boards or flags
- Portable traffic signals

When traffic in both directions must use a single lane for a limited distance, movements from each end shall be coordinated**.** Provisions should be made for alternate one-way movement through the constricted section using various traffic control methods. The choice of these methods is governed by the conditions outlined in Table 7.1.

Table 7.1 Choice of Traffic Control Methods

Traffic Control Methods	Maximum speed limit (kmph)	Length of work zone + Transition zone (m)	Maximum two-way traffic flow
"Give and take" system	50	50m (max)	• 400 veh/h • 20 commercial veh/h
Priority sign	60	80m (max)	850 veh/h
STOP/GO" boards or flags	60	100m	1400 veh/h
		200m	1250 veh/h
		300m	1050 veh/h
		400m	950 veh/h
		500m	850 veh/h
Portable Traffic Signal	60	300m (max)	No limit

7.2.1 Traffic Control by Give and Take System

Fig. 7.1 illustrates the Give-and-Take system of shuttle working. This is intended for a low volume of traffic and very low volumes of trucks and no buses. The following conditions must apply:

- Total two -way traffic flow of less than 400 veh/h;
- Less than 20 trucks/h;
- Speed limit is 50 km/h or less

- Length of the works from the start of the lead-in taper to the end of the exit taper is not more than 50 meters
- Drivers approaching from either direction can see both ends of the site

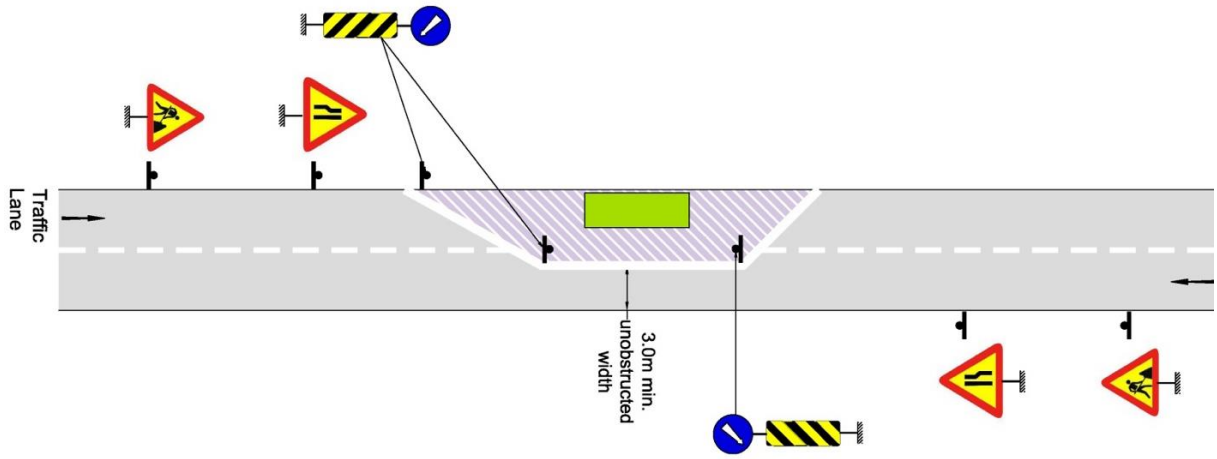


Fig. 7.1 Traffic Control by Give and Take system

7.2.2 Traffic Control by Priority Signs

As the difficulties of the site increase, enhanced systems are more effective. **Fig. 7.2** illustrates the next stage; under traffic control by priority signs the following conditions apply:

- Total two-way traffic flow of less than 850 veh/h
- Length of the works from the start of the lead-in taper to the end of the exit taper should not be more than 80 meters
- Drivers approaching from either direction can see through the site from a point 60 m from their transition zone to a point 60 m beyond their termination zone (coned area), for roads with a 50 km/h speed limit, on higher speed roads, the appropriate clear visibility distances are
- 70m on 60 km/h roads;
- Not applicable above this speed limit.

In Indian conditions, its use is not recommended on higher speed roads.

- Priority must be given to either:
  - The unobstructed vehicle lane; or
  - Vehicles going up a steep gradient

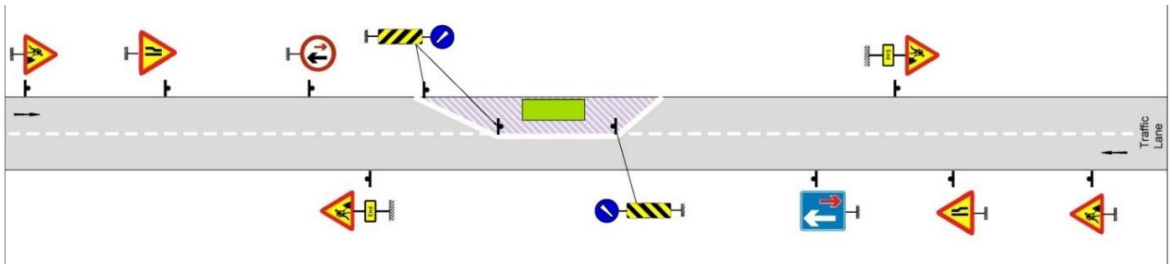


Fig. 7.2 Traffic Control by Priority Signs

7.2.3 Traffic Control by Stop/Go Boards

Fig. 7.3 indicates the layout for the use of Stop/Go boards by flagmen. Traffic can be controlled manually by using Stop/Go boards when the two-way traffic and the length of the site do not exceed the values given in **Table 7.2**

Table 7.2 Maximum Traffic Flows for Length of Site

Site Length (m)	Maximum two-way flow	
	Veh/h	Veh/3 min
100	1400	70
200	1250	63
300	1050	53
400	950	47
500	850	42

(Source: Safety at Street Works and Road Works, U.K., 2001)

7.2.4 Traffic Control by Portable Traffic Signals

a) Portable Traffic Signals for traffic control **(Fig. 7.4)** can be used at most sites that have a length of 300m or less. However, it should be ensured that the exit from the restricted length of road is not blocked. Otherwise, tailbacks will occur which will stop traffic travelling in the opposite direction from moving when the lights change to green.

b) Under no circumstances should portable traffic signals be used at works that straddle railway level crossings, nor to control road traffic within 50 m of a level crossing equipped with twin red light traffic signals.

c) If it is considered that portable traffic signals used elsewhere may cause road traffic to block back to a level crossing, railway management must be consulted before work starts. The solution will probably be to move the traffic control to a point on the side of the crossing opposite the works so that traffic can be stopped before reaching the crossing. The portable traffic signals must be controlled manually. The crossing's own road traffic signals and advance warning and informatory signs should remain clearly visible to approaching vehicle drivers.

d) The road authority and traffic police must be informed when Portable Traffic Signals are going to be used. Authorization will be required if these signals are to be used at road junctions.

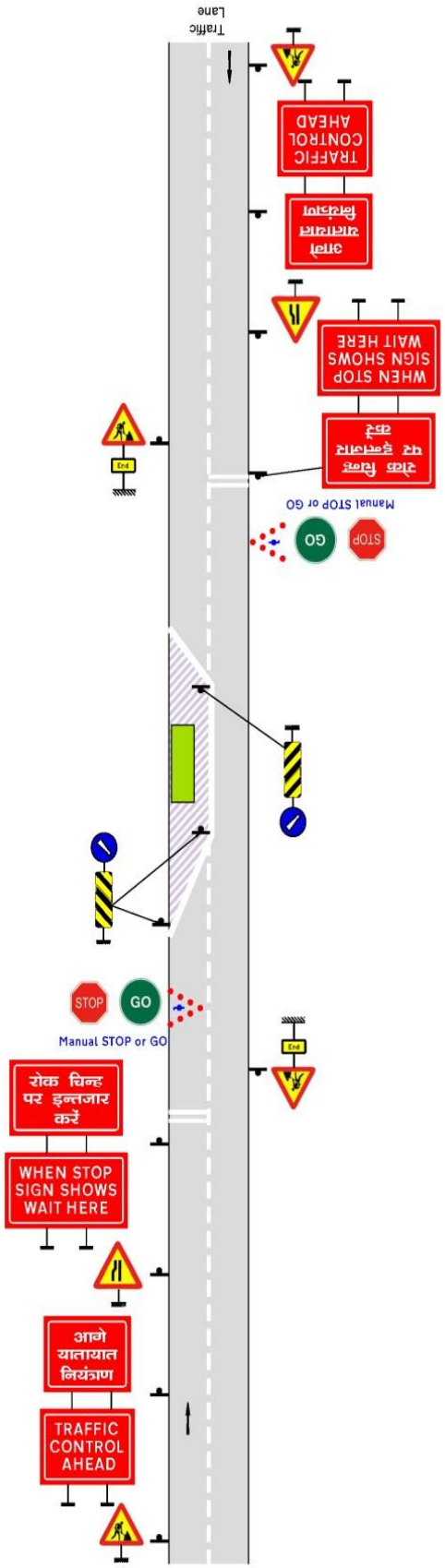


Fig. 7.4 Traffic Control by Stop/Go Boards

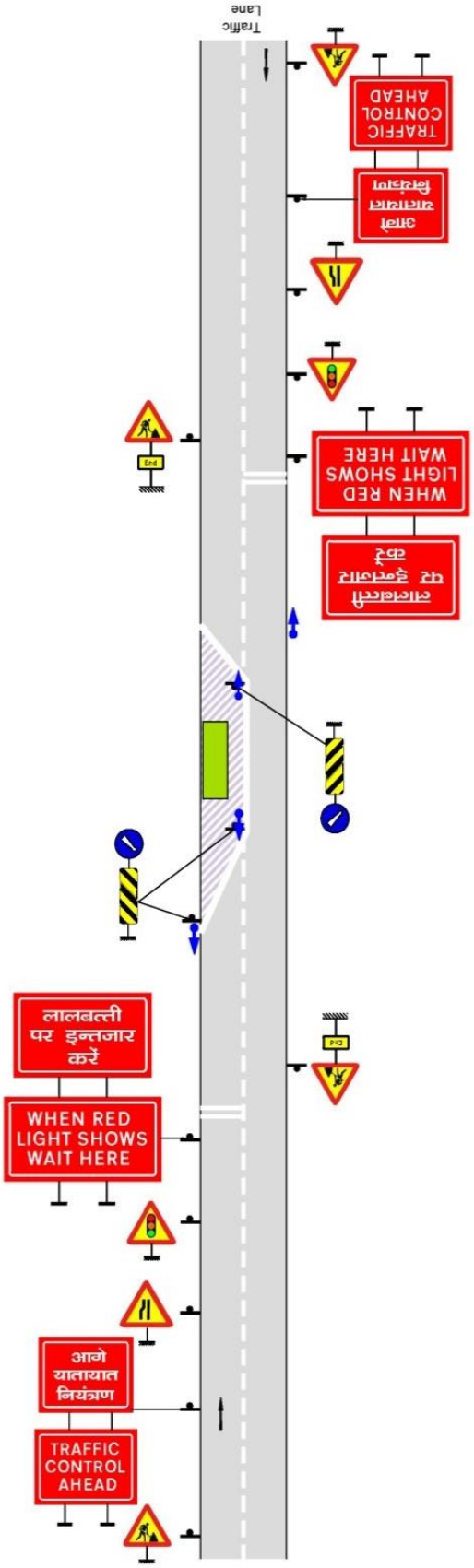


Fig. 7.3 Traffic Control by Portable Traffic Signals

e) The traffic signal timings must be correctly set up to correspond to the length of the works and the speed of the traffic past the site. The detectors must be tested, which are sometimes provided on the signals, to make sure that they are working properly before they are used.

f) As back up, Stop/Go boards should be available in case the Portable Traffic Signals break down.

7.3 Detours

In this strategy, traffic is rerouted on to an alternate road and the traffic totally avoids the work zone. **Fig. 7.5** gives a detour situation. When traffic is directed from a road stretch under construction/ improvement, to an alternative traffic route, construction operations can proceed rapidly. This can improve construction efficiency (i.e., reduce cost) and quality and ensure safety for the workers from passing vehicles. The detour can be applied for all categories of vehicles or applied to certain categories. Detouring traffic imposes additional capacity and load demands on the alternative route and may result in congestion. Safety considerations on the detour route should be considered as well, particularly if the detour route goes through areas with a large volume of vulnerable road users (residential areas, school zones, etc.). Detours should be carefully evaluated to ensure that they are capable of safely accommodating the volume and types (configuration, size, and weight) of detoured vehicles.

7.4 Diversions

The traffic in one or both directions is routed onto a temporary road constructed around the work zone and reconnected with the permanent infrastructure of the designated route. This provides positive separation between traffic and the work zone. Diversions can carry one way or two-way traffic. This is especially useful in construction of bridges and culverts. The **Fig. 7.6** shows a temporary road for culvert construction.

7.5 Full Road Closures

Although dramatic, this strategy, if properly executed, leads to safe work zones, and reductions in work time such that the full closure is better in terms of delay. This can be effective and successful on road strategies with low, medium or high-volume traffic. If a full road closure is chosen, whether it be short term or long term, the need for detours, as discussed above, must be weighed against the safety and operational benefits of the full road closure.

7.6 Intermittent Closures

With this strategy, traffic in one or both direction is stopped for relatively short period to allow for construction. This work zone strategy, alone, is generally not adequate for an entire construction project. It is more suitable for specific operations such as setting bridge beams and moving construction machinery. Intermittent closure should be used for short duration (less than thirty minutes), outside peak periods and only during good weather conditions to minimize traffic disruptions and maximize safety.

7.7 Lane Closures

In this strategy, one or more traffic lanes and any adjacent shoulders are closed to traffic on one lane of a multi-lane highway. When lane closures are used for long term projects, use of barriers

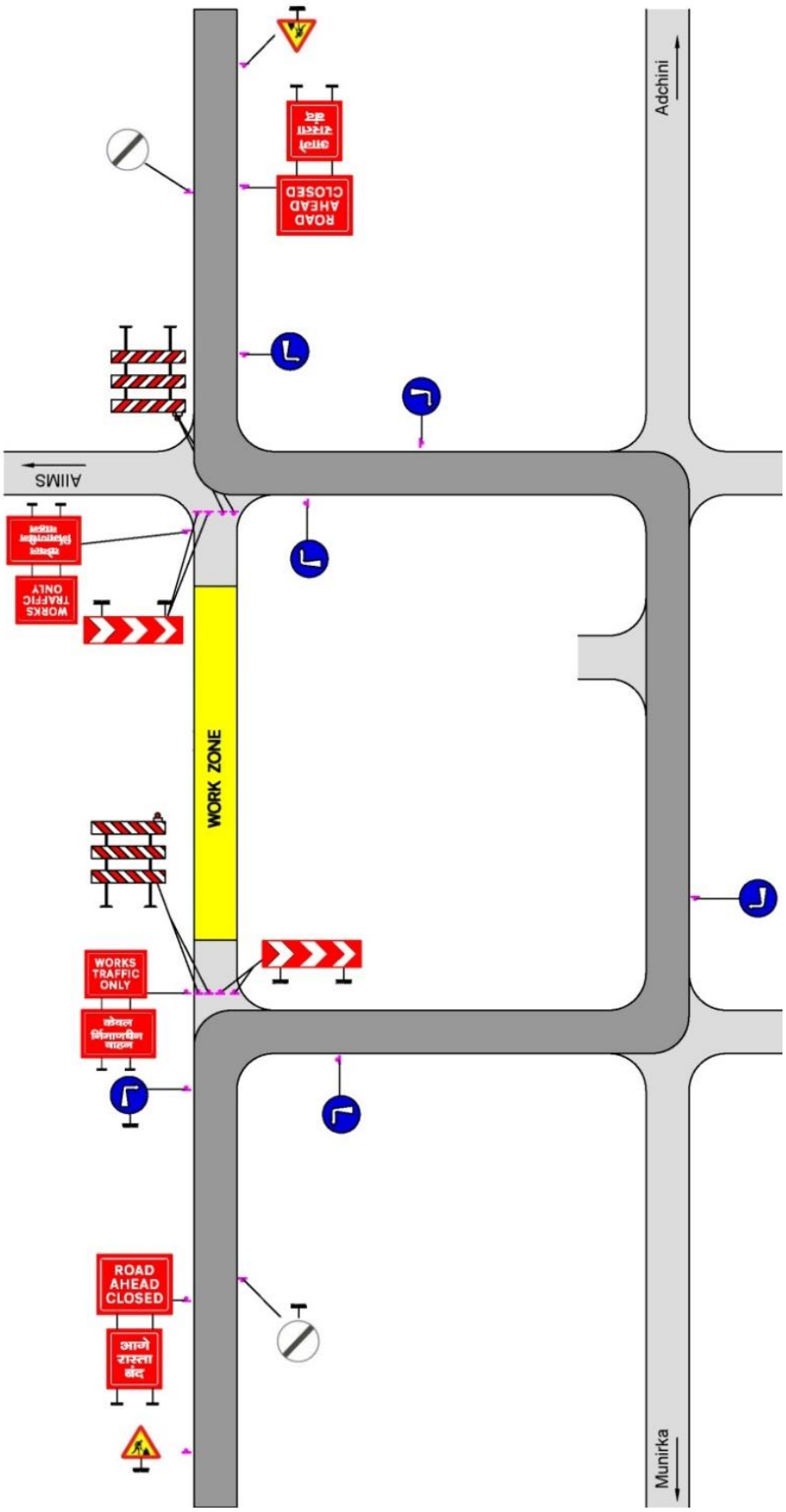


Fig. 7.5 A Detour Situation

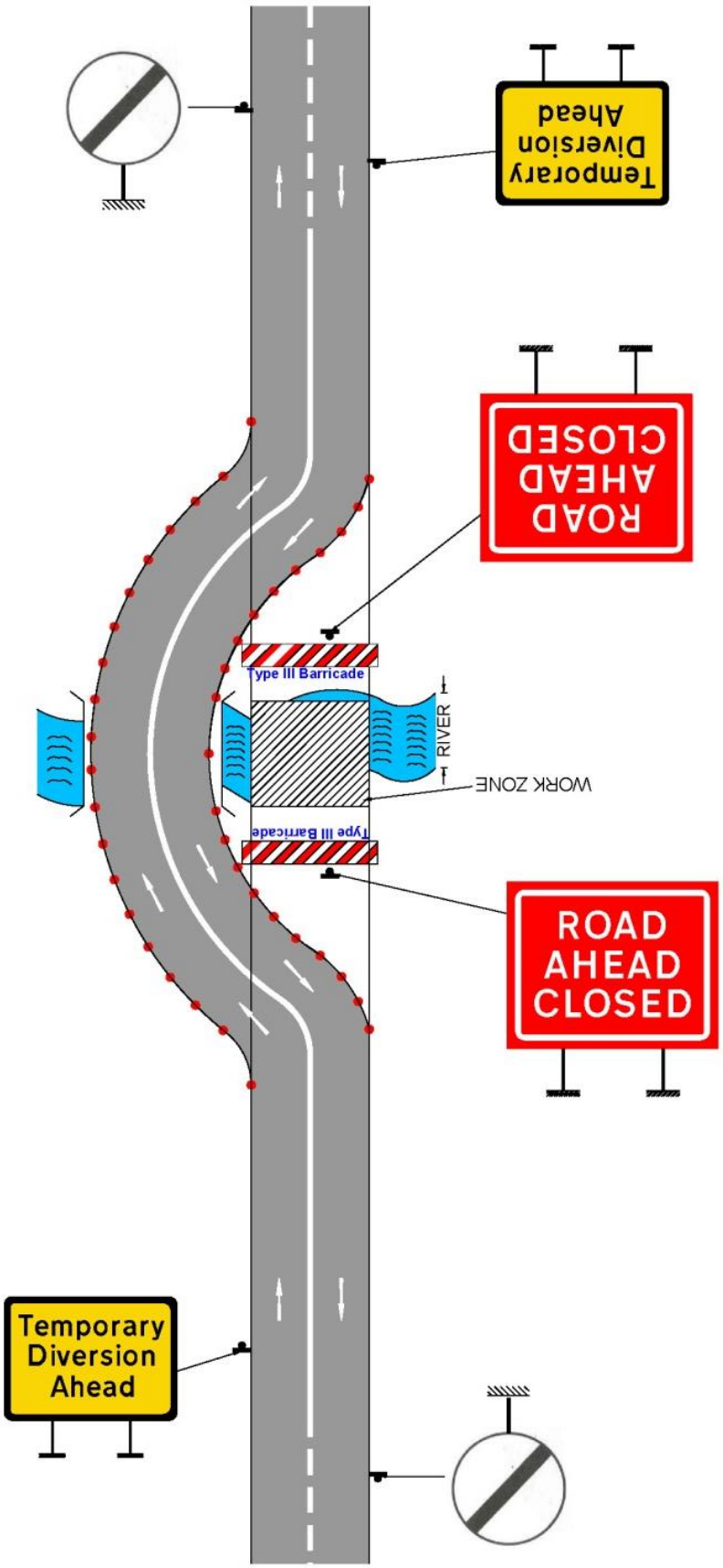


Fig. 7.6 Temporary Diversion

should be considered, which can increase implementation costs. The strategy can be adopted for a short period (hours), if barriers are not provided.

7.8 Lane Constrictions

This strategy entails reducing the width of one or more travel lanes. This strategy should be adopted when maintaining traffic with less than desirable travel lane width is preferable to other alternatives. This can raise safety concerns, and therefore, reduced speeds are critical for this strategy to be successfully implemented. Refer **Fig. 7.7.**

7.9 Median Crossovers

This strategy is most suitable on expressways and divided carriageway highways whereby two-way traffic on a normally divided facility is allowed. A number of steps are necessary to implement this strategy including

- Reducing the number of lanes in both directions of travel (lane closure);
- Routing traffic in one direction across the median to the opposite carriageway; and
- Maintaining two-way traffic on one carriageway while the opposite direction carriageway is closed.

Substantial separation of traffic from the work zone is provided by this strategy and construction of an entire one-way carriageway (e.g., travel lanes, shoulders, structures, and appurtenances) is facilitated with little conflict between main highway traffic and equipment, workers, or onsite material movement. Traffic impacts in terms of speeds, queue formation, and delay should be assessed, and overall median crossover length should be carefully considered. Clearly this strategy is only used for long term road works.

While designing curves for median cross over, the radius given for various approach speed in **Table 7.3** can be adopted. The cross over length is depended upon the radius as well as the lateral shift as shown the **Fig. 7.8.**

Table 7.3 Radius for Setting out Cross Over Length

Speed at the Start of Diversion (kmph)	Radius of Circular Curve (m)
Up to 30	20
31 to 50	30
51 to 65	90
66 to 80	165
81 to 100	250
101 to 120	400

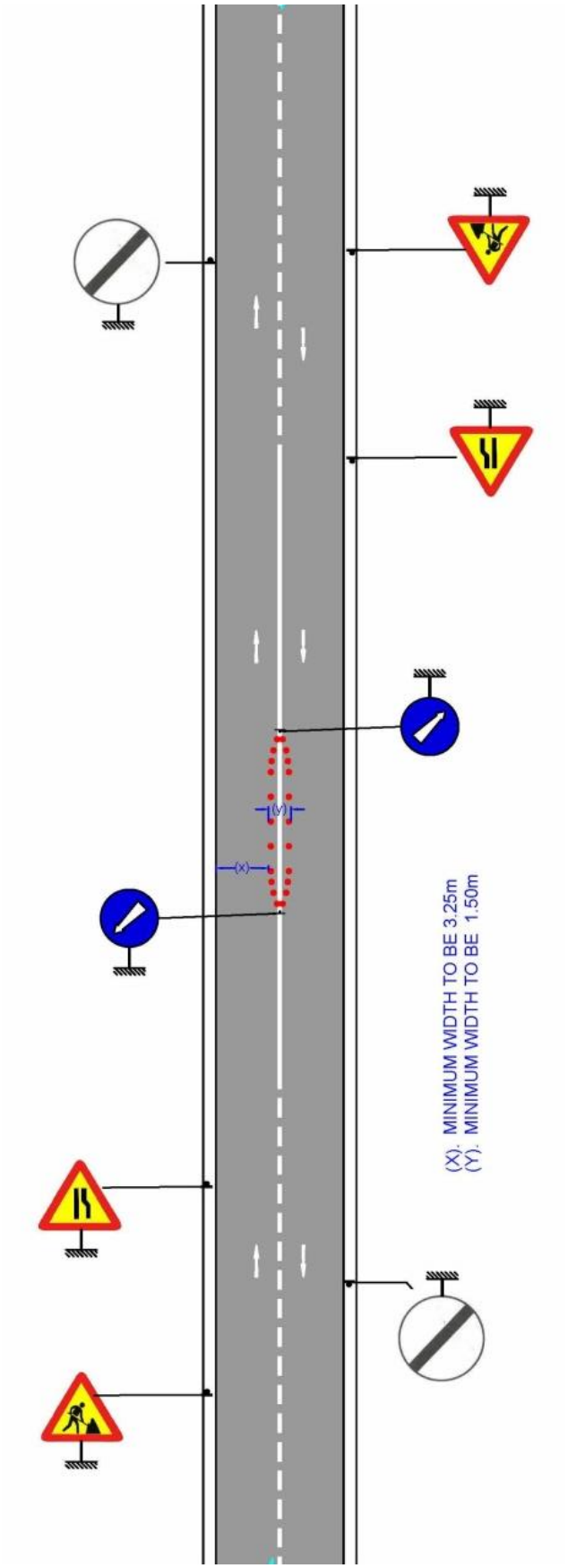


Fig. 7.7 Lane Narrowing due to Work at Centre

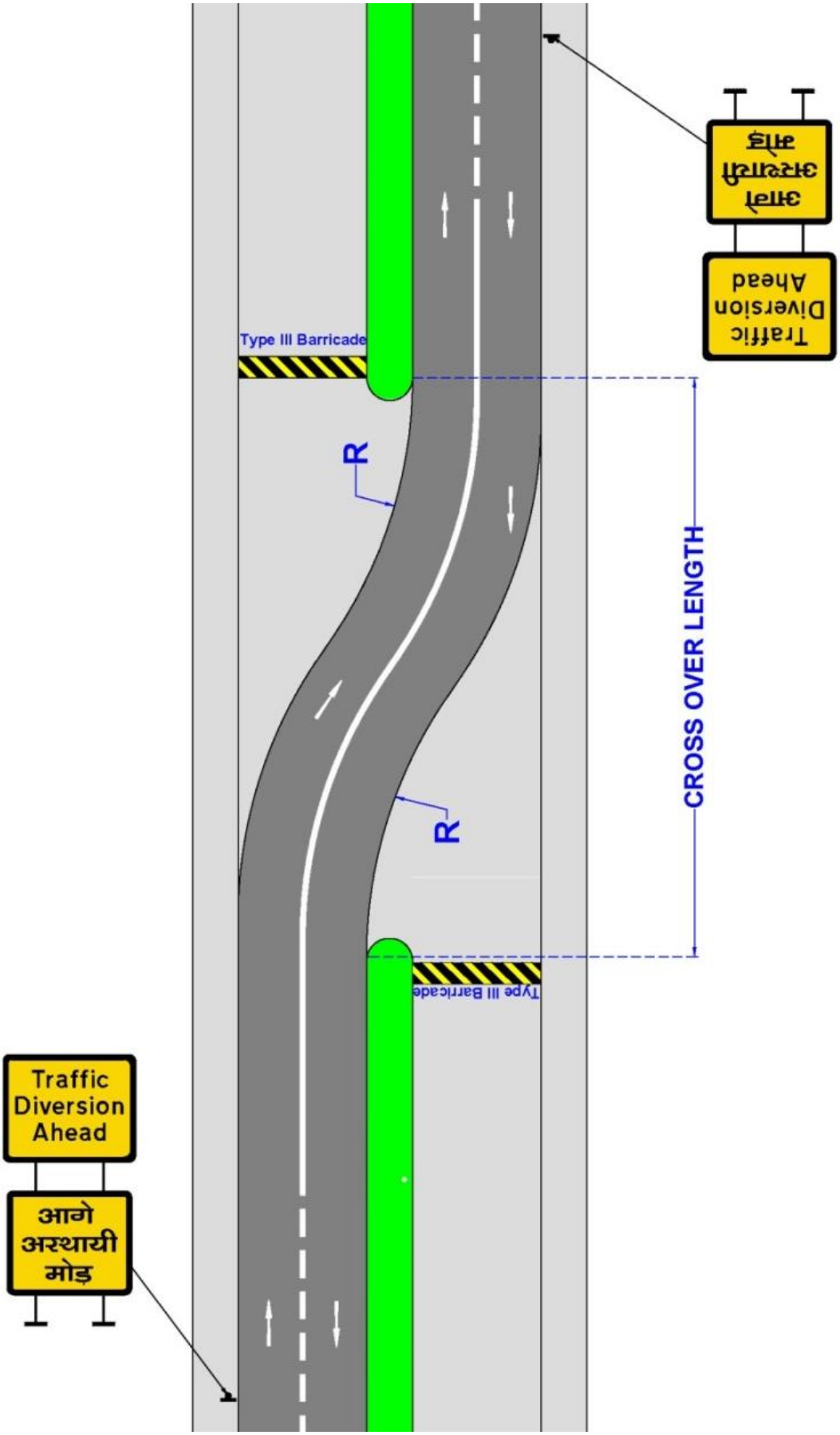


Fig. 7.8 Median Cross Over in Two-lane Dual Highway Construction

7.10 Use of Shoulder as a Travel Lane

In this strategy, the outside or inside (median) shoulder is used as a temporary traffic lane. This strategy may require constructing or upgrading shoulder pavement structures to adequately support expected traffic loads. This strategy uses existing roadway width to compensate for the capacity lost by closing a permanent travel lane and can be adopted on facilities such as divided multilane, un-divided multilane and two-lane highway (Refer **Fig. 7.9**). The existence, proximity, and nature of roadside features (e.g., bridge piers) should be considered in assessing this strategy.

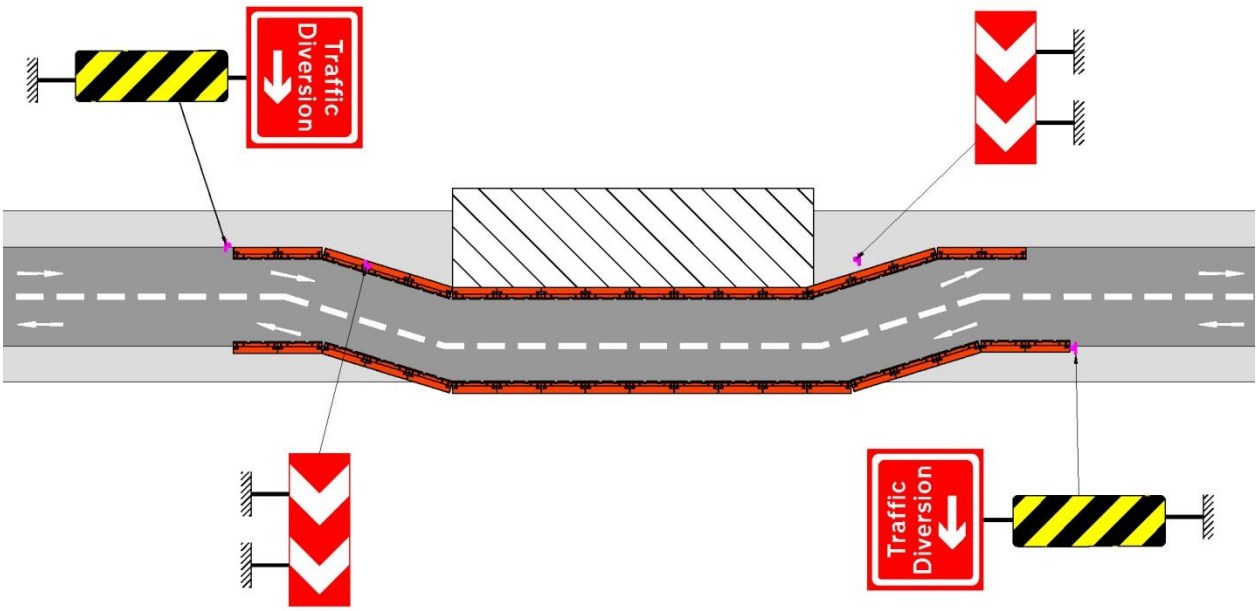


Fig. 7.9 Shoulder as Travel Lane

7.11 Night Construction

In many situations night construction may be preferred as the volume of traffic is generally lower and conflicts are minimized. Consideration must be given to the effect of night operations on the surrounding environment as well as the workers. Further, even if the work occurs at night, a lane or lanes may need to remain closed during higher traffic times.

7.12 Advantages and disadvantages of work zone design strategies

The advantages and disadvantages of work zone design strategies are shown in **Table 7.4.**

Table 7.4 Advantages and Disadvantages of Work Zone Design Strategies

No.	Strategy	Summary	Advantages	Disadvantages
1	Alternate one-way operations	Mitigates for full or intermittent closure of lanes. Used primarily with two lane facility.	Low agency cost; flexible several variations available.	Requires stopping of traffic reduces capacity.
2	Detours	Reroutes traffic onto other existing routes/ facilities of the network.	Flexible: cost varies depending on improvements to detour route.	Usually reduces capacity; detoured route may require improvement for capacity and safety.
3	Diversions	Provides a temporary roadway adjacent to construction.	Separates traffic from construction; reduced impact on traffic.	Cost may be substantial.
4	Full road closures	Closes the facility to all traffic for a specified duration.	Generally, also involves expedited construction; separates traffic from construction.	Potentially significant traffic impacts.
5	Intermittent closures	Stop traffic for a short period	Flexible and low agency cost.	Useful only for activities that can be completed in short time.
6	Lane closures	Closes one or more travel lanes.	Maintains service at fairly low agency cost if temporary barriers are omitted.	Reduces capacity: may involve traffic close to active work.
7	Lane constrictions	Reduces width of travelled way.	Maximizes number of travel lanes.	Travelled way width is less than desirable: may involve traffic close to active work.
8	Median crossovers	Maintains two-way traffic on one carriageway of a normally divided highway.	Separates traffic from construction: right of way not required.	Relatively costly; interchanges need special attention.
9	Use of shoulder as a travel lane	Uses shoulder as a travel lane.	Fairly low cost depending on shoulder preparation.	Displaces traditional refuge for disabled and emergency vehicles: cross slopes may be problematic.
10	Night Construction	Move work activities to nighttime hours.	Lower traffic volume or lower traffic impacts.	Higher agency cost; disruption of social pattern of workers; Noise pollution.

Section 8. Roles and Responsibilities

8.1 Introduction

Many agencies and professionals are involved in the safety of a work zone and to avoid confusion, it is helpful to clearly define their roles and responsibilities. Roles describe the proper and customary functions of each player, while responsibilities are linked to the obligations of that party including funding of the provisions. All the necessary responsibilities must be assigned and completed without which the safety of the work zone will be compromised.

By clearly defining the roles and responsibilities, it addresses the critical issues of **who** must do **what** and **when!** Furthermore, these concepts clearly define where the responsibility lies and assist in ensuring that important safety issues are not overlooked at any time.

8.2 Critical Players or Stakeholders

Critical players in road construction and maintenance activities are:

- Road Authority
- Road Operator
- Project Director/ Engineer In-charge
- Designers
- Road Safety Auditors
- Concessionaire in PPP projects
- Contractor
- Supervision Consultant / Independent/ Resident Engineer
- Local Police
- Road User
- General Public / Communities

8.2.1 Road Authority

The road authorities with the support of politicians and/or decision /policy makers must support and demand:

- Responsible work zone planning and design from transportation professionals.
- Safe behavior within the work zone from the workers; and
- Safe driving through the work zone from the travelling public.

Political support and commitment are crucial in the supervision and enforcement of standards in road works, otherwise, even the best designs and plans cannot logically provide for the safety of road users and workers.

Road Authorities should support appropriate legal and safety requirements, standards and regulations for work zones and clearly establish the responsibilities of the parties involved. They would ensure that other Agencies, such as local police and local administration etc. share and act in accordance with the requirements of WTMP. The authorities are also responsible, in the long

run, for ensuring that sufficient funding is provided not only for safety in work zones, but for overall road safety. The authority is also responsible for educating and informing the public about safety in work zones to promote responsible driving, through outreach and safety campaigns. The Road Authority shall ensure that the provisions for all traffic control devices of WTMP are included in the Bill of Quantity (BoQ) while preparing the estimate for projects taken up under PPP or non-PPP modes of implementation.

8.2.2 Road Operator

The road operator must insist that the legal and safety requirements, standards, and regulations for work zone safety that have been established by the authorities are compiled in letter and spirit. The Road Operator should ensure that the Work zone Traffic Management Plan has been prepared before taking up the work of building and or improving the road and being implemented effectively. If necessary, the road operator may demand additional requirements that should be in writing and publicly available. These additional demands regarding safety and traffic management issues include:

- Requiring additional safety equipment such as barriers for worker's safety, channelizing traffic flow, traffic guidance, and additional signs (with clearly defined sizes and colors prescribed in these Guidelines and based on the traffic environment).
- Defining set of working hours, like 24 hours or 12 hours on busy roads (depending on the level of technology used in the process of work).
- Maximum length of detours and minimum requirements or conditions for determining if a bypass is needed; and
- Requirements for the roadway that will be used for detours (including design and pavement standards and capacity requirements to ensure that safety is not compromised)

Before the road works begin, the road operator, in coordination with the contactor/ concessionaire (for PPP projects) as the case may be, must inform the public and residents of the location, about duration and possible deviation and time of road closure. Police and emergency services should also be fully engaged in understanding where and how a work zone is being implemented, along with the type of work being done and any detour, etc., that are planned.

The road operator can demand that the contractor (or whoever requires a work zone to implement their work, such as the laying of cables, pipes, utilities, etc.), design and implement a safe work zone and use all necessary means to ensure safety for workers and road users, as well as sufficient traffic capacity. The operator may ask the contractor to take on the responsibility for informing the general public and surrounding community of important information such as the work zone location and duration, the access issues, possible detours and other means of travelling through the area.

A variety of methods should be considered to inform the general public and surrounding community, including media (radio, TV, newspaper, websites) or through public gatherings or hearings. The permission of the road operator must be gained for any intervention along the roadway, including issues related to access management. Thus, the road operator will order the contractor to design and implement a safe work zone. The road operator can request that the supervisor pay particular attention to a work zone that is particularly complex, demonstrates clear risks, or has a history of accidents or incidents.

8.2.3 Project Director/ In-charge

The Project Directors/ In-charge shall be responsible for overseeing and ensuring adherence to the norms/guidelines and contractual provisions required to be complied with by the consultants and the contractors/ concessionaires. He would review the site specific WTMP prepared and ensure its implementation effectively.

The Project Director may designate one of the officers from his team to be responsible for safety besides environment and social aspects.

8.2.4 Designer

The “approved” designer should be a company (or individual) that has expertise and knowledge of (and, if appropriate, certification in) work zone design and safety issues. The designer’s primary responsibility is to include all required provisions in the design to ensure traffic safety for road users and workers. The designer should alert the road operator to key issues about safety.

The designer will be responsible for ensuring that all technical solutions are described and can be implemented in accordance with the appropriate laws and standards. The designer will be the legally responsible party for the work zone layouts. The designer must:

- Gather all necessary information on traffic volume, traffic mix, and types of road users that are expected;
- Understand technical elements of the site of the work zone, as well as roads that might be used for detours/diversions/bypasses;
- Coordinate and manage detours;
- Consider road signs and markings, including existing permanent signs that might need to be removed or covered as well as to provide necessary work zone signs;
- Harmonize the technical and scheduling aspects of the work zone with regard to implementing, managing and removing the work zone; and
- Identify the necessary lighting of the work zone if night work is considered.

The designer should develop a work zone that allows emergency vehicles sufficient access and passage of transit vehicles. If a road is closed and emergency vehicles must use a detour, the designer should provide that information in writing. Furthermore, transit agencies should be informed in advance before detours are established so that they can plan their trips and stops. The designer is likely to take on the responsibility of participating in public hearings or community outreach meetings to explain the work zone to the community.

8.2.5 Road Safety Auditors

The road safety auditors shall be independent of design and execution process and will carry out safety audits to identify the potential safety deficiencies in the Work zone Traffic Management Plan (WTMPs) at its design stage. The observations and safety concerns along with specific recommendations will be forwarded by the road safety auditors to the Road Authority, Road Operator, Concessionaire, and Contractor as the case may be. The road safety auditors while undertaking the field audit will come up with recommendations which are either due to non-compliance of approved WTMPs or sometimes due to distortions in the traffic control devices caused by poor maintenance regime for WTMPs. Since the deficiencies observed by safety

auditors have a direct impact upon the safety of road users and construction workers, the recommendations made by the auditors shall be complied with without fail. On the other hand, the road safety auditor shall be liable for any irresponsible recommendations made through the worksite safety audit report, which are illogical and are not suitable for site condition or not approved at the time of design of WTMP.

8.2.6 Contractor

The contractor has a contract with the road operator to execute the work zone and conduct the work. He is responsible for the preparation of WTMP and for coordinating with the designer to ensure that they understand how the work zone should be set up and operated over the course of the work. If the contractor is not qualified to install, operate, maintain, and remove the work zone, then they must hire a special contractor which is qualified for these critical activities.

An expert on safety or an engineer trained in work zone safety from a qualified company should be named to implement the work zone, including installing, operating, maintaining, and removing the work zone. The work zone must be checked daily (or more frequently, if necessary) to ensure it meets the designer's scheme. Daily meetings should take place to ensure that all workers and staff are knowledgeable about the work zone activities and the damaged equipment must be immediately replaced.

It is the contractor's responsibility to qualify and train the workers and ensure that they have the necessary safety equipment (see chapter 7). Those working on roads in the presence of operating traffic should have proper knowledge and training and should wear high-visibility clothing with light reflecting material. Those managing the traffic flow (flaggers) should have knowledge of the guiding of traffic and (if appropriate based on national standards) be certified. In general, all workers should have proper knowledge and be trained in how to avoid risks and maintain work safely; and the contractor is responsible for ensuring that the workers have that knowledge.

8.2.7 Concessionaire

For PPP projects, the Concessionaire shall observe his obligations, responsibilities and requirements as spelt out in the Model Concession Agreement (for road sector) as well as in the Concession Agreement, during the design, development, construction, operation, and maintenance. He shall ensure that safety of road users and workers remains the paramount consideration in planning and executing the project implementation, and findings of the deficiencies by Safety Auditor are promptly rectified.

For PPP projects, the Concessionaire shall prepare detailed layouts for temporary traffic management plan (WTMP) with all traffic control devices and submit to the competent authority as per the Concession Agreement for their review and approval before taking up works on the ground.

8.2.8 Supervision Consultant/ Independent/ Resident Engineer

The Supervision Consultant/ Independent/ Resident Engineer must have a highly trained road safety expert. They must be officially approved and certified through the relevant institute or agency for conducting training on work zone safety.

He should have responsibility to the agency hiring them (the authority, the road operator or the contractor) to check the work zone design and to ensure that it is implemented in a way that safety needs are realized.

He will check the actual work zone to ensure that it is set up (signs, markings, and other equipment) consistent with the approved design of WTMP and

- It consists of legal requirements; and
- It provides safety for road users and workers.

If it is found that the design is deficient, he or she should advise the designer to make the necessary design improvements. If the actual work zone is not set up in accordance with the design, the supervisor should ask the contractor to make the necessary changes.

He should coordinate with local police to pay extra attention to work zones, with particular emphasis on vehicle speeds.

8.2.9 Local Police

Local police shall provide all the required support for the enforcement of the necessary restrictions, if imposed, and for the safety measures as warranted by WTMP. The control of speeding and careless driving in work zones should be strictly enforced.

Road user

All road users need to pay particular attention while travelling in work zones. Drivers need to appreciate and respect that workers often have very little physical protection from fast-moving vehicles that are travelling past their place of work. They should drive with such caution that they do not pose a threat to other traffic or to workers. Drivers should be educated about the risks of travelling in work zones and fully informed that safe driving behaviors will be strictly enforced by the police. They shall respect and observe any restriction, especially for vehicle speed.

8.2.10 General public / Community

The community has a responsibility to participate in public hearings and be informed about work zones, detours, and possible transportation options. As they have the best knowledge of their environment, they can contribute to improving work zone safety by providing information about the situation, especially with regard to detours.

Section 9. Safety compliance and deployment of safety personnel

9.1 Introduction

Many individuals are involved in the safety of a work zone and to avoid confusion, it is advisable to deploy specific and assigned personnel for controlling the traffic during the peak and off-peak hours of traffic flow at the construction zones.

9.2 Deployment of Flagman

The flagmen or flaggers shall be deployed where:

- Workers or equipment intermittently block an unprotected traffic lane.
- One lane is used for two directions of traffic.
- Guidance, warning and control of traffic is considered necessary.

The flagman shall be physically fit, well trained, alert, and capable enough to effectively perform the assigned duties. Flagman shall be provided with hand signaling devices such as flags and sign paddles. Flagmen must be provided with and must wear warning garments, safety headgear, footwear, and gloves for their protection and for conspicuity, while flagging. Warning garments worn at night must be reflective material. Flags for signaling shall be minimum 600 mm x 600 mm in size and made of good red cloth and securely fastened to a staff of approximately 1 m. in length. Sign paddles should be at least 600 mm wide provided with a rigid handle. The background color of STOP should be red, and its shape shall be octagonal conforming to IRC: 67. The word STOP would be in white color. Similarly, the background of SLOW sign should be yellow with black letters, and the GO sign should be with green background with white letters.

Control of traffic through the work area is an essential part of road construction and maintenance operations. Flagmen with hand signaling devices such as sign paddles play crucial role in this context. STOP, SLOW and GO paddles are used, and in some cases temporary traffic lights are used in controlling traffic through the work area.

a) Besides red and green flags, octagonal and round shaped hand paddles of 600 mm× 600 mm should be used with red, yellow, and green retro reflective Class B sheeting as per IRC: 67, if used in nighttime, whereas red and green flags can be of visible fabric materials for daytime usage.

b) Since, Flagmen are responsible for safety of road users and the workers, it is important that qualified personnel be selected. The flagmen at the work sites are expected to stop traffic intermittently and to maintain continuous traffic flow at worksite at reduced speeds to help protect the workmen. For both functions, the flagmen must, always be clearly visible to approaching traffic for a distance sufficient to permit proper response by the drivers to the flagging instruction and to permit traffic to reduce speed before entering the worksite. This distance is basically related to approach speed and site conditions; however, 60 m to 100 m is desirable. In urban areas, this distance shall be reduced to 20 m to 50 m. The use of sign paddle is illustrated in **Fig. 9.1**. Another modern method is Marshalling torches as shown in **Fig. 9.2**, and are:

(i) Hand flashers are tough and durable working on normal or rechargeable batteries with LED bulbs.

(ii) To provide warning signals for impending hazard or danger on construction work zones, repair sites, trenches, digging of road tunnels etc.

Fig. 9.1 Warning Sign on Hand Paddles

Fig. 9.2 Marshalling Torch

9.3 Reflective Clothing

In the work zones and construction sites, all the workers, supervisors and inspecting officers should wear high-visibility fluorescent clothing with retro-reflective material, so that their presence is conspicuous from a distance of even 100m. Clothing may be in the form of vests, T-shirts, jackets, pants and raincoats etc., depending upon weather conditions and ease of usage. The suggested color to be used for the safety jackets shall be as given in **Table 9.1.**

Table 9.1 Color of Safety Jacket

User	Color of Fluorescent Jacket
Workers exposed to traffic	Red - Orange
Operators of road construction machineries	Orange
Supervising engineer and visiting higher officials	Yellow

The reflective clothing shall have reflective bands of width appropriate for the garments, viz. vests, T-shirts, jackets, pants, and raincoats. It shall have 360 º visibilities with at least one retro-reflective band encircling the torso. There shall be appropriate separation distances of vertical and horizontal bands placed on torso, sleeves, and trouser areas. The garment shall be free of roughness and sharp edges so as not to cause excessive irritation, and the wearer should get the best possible degree of comfort and protection. The reflective clothing shall meet the requirements of standards set up in IS 15809-2008 or EN 471: 2003.

9.4 Roll Up Signs

Roll up signs are used in construction work zones to guide the traffic and in roadways for meeting emergency situations. Roll up signs shall be portable, changeable and shall have provisions for application on different objects depending on the need for temporary sign. Such sign shall be made of retro-reflective sheeting, which shall conform to Class B as per IRC: 67.

a) Mounting of the roll up sign on the portable stand

The roll up sign shall have the back support ribs to fix on the portable stand and the roll up sign stand shall have knobs to receive the short rib of the sign fascia. The back support ribs shall be inserted into the clamp provided on the stand and tightened using the knobs. The sign ribs shall be moved up and down to adjust the height of the sign.

b) Mounting of the roll up sign on construction or maintenance vehicles

The roll up signs shall have necessary attachments to mount it on the work zone maintenance vehicles. The back support ribs shall have dual lock high bonding tapes; mechanical fastening or snap fit clips or attached magnets. The receiving part of the dual lock tape, clips, or metallic attachment should be affixed to the vehicle surface where the roll-up sign is to be mounted. The sign mounting mechanism shall withstand the weight and movement of the vehicle.

c) Mounting of the roll up sign on barricades

The roll up signs shall have necessary attachments to mount it on Barricades. The ribs at the back side of the signs shall have dual lock high bonding tapes or a mechanical fastening system which can be removed and reapplied multiple times. The receiving part of the tape of fastener shall be applied on the barricade. The locking portion of the tape or the fastener shall be permanently fixed on the ribs of the roll up signs as shown in **Fig. 9.3**.

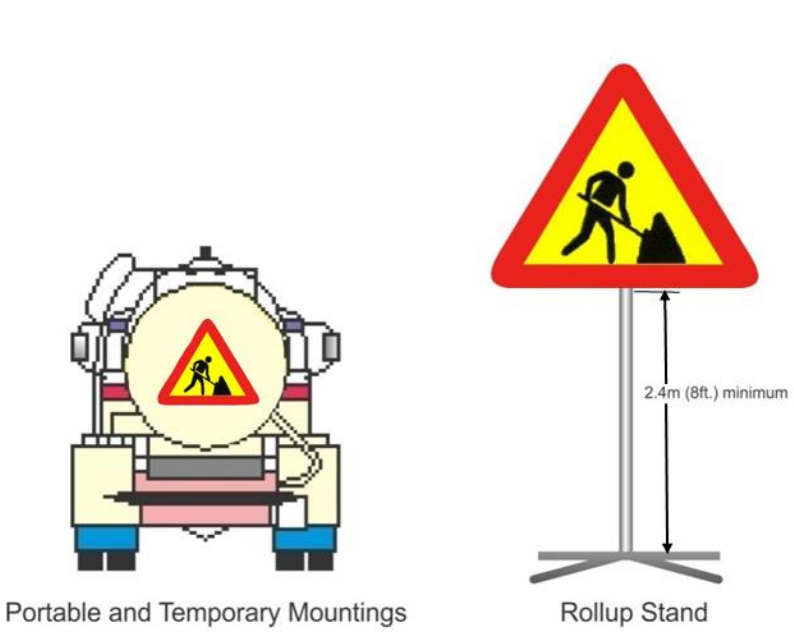


Fig. 9.3 Temporary Installation of Signs on Maintenance Vehicle & Rollup Stand

9.5 Protective Gears for Workers

All the workers, exposed to moving roadway traffic or equipment in road construction zones, will wear high-visibility safety apparel, headgear, boots, gloves, and protective gear for their protection. The safety headgear or protective helmet shall protect the wearer against falling objects and possible serious injury. It shall address requirements of shock absorption, and having resistance to penetration, flame resistance, chin strap anchorages, comfortable wearing and shall meet the requirements of Bureau of Indian Standards (IS 2925). The safety shoes or boots shall provide personal protection from any possible hazard posed by the activity being done and provide comfortable wearing without giving any hindrance in the expected tasks. The work gloves shall provide protection against any personal injury that could be caused by the activities to be performed and comfort in wearing without giving any hindrance in the expected tasks. If the worker is to be exposed to dust in the work zone, he shall have respiratory protection by dust mask meeting the requirements of IS 9473-2008. Depending upon the task, workers engaged in welding operations shall have eye protection through passive welding sheet meeting the requirements of EN 175 or auto darkening sheet meeting the requirement of EN 379 / EN 169. Some illustrative safety jackets, head gear, and footwear for workers are shown in **Fig. 9.4**

Fig. 9.4 Illustrative safety jacket, head gear, footwear for workers

9.6 Noncompliance Penalties

In view of the commitment of Road Construction Agency towards work zone safety, it is reiterated here that any lapse on the part of contractor/Engineer should be viewed seriously. For noncompliance, penalties of approximately 1.5 to 2 times the manufacturing cost of the traffic control appurtenances can be imposed, and this should be included as part of the contract.

Section 10. Typical Applications

10.1 Introduction

Some typical construction scenarios are presented in the section to serve as guide in preparing site specific Work Zone Traffic Management Plans (WTMPs). The signs, markings and traffic control devices shown herein are indicative only and more are required to be added to cater to the specific road environment and road users likely to use. Highway and Traffic Engineers are required to prepare WTMPs and if required, advice from a road safety expert may be sought for this.

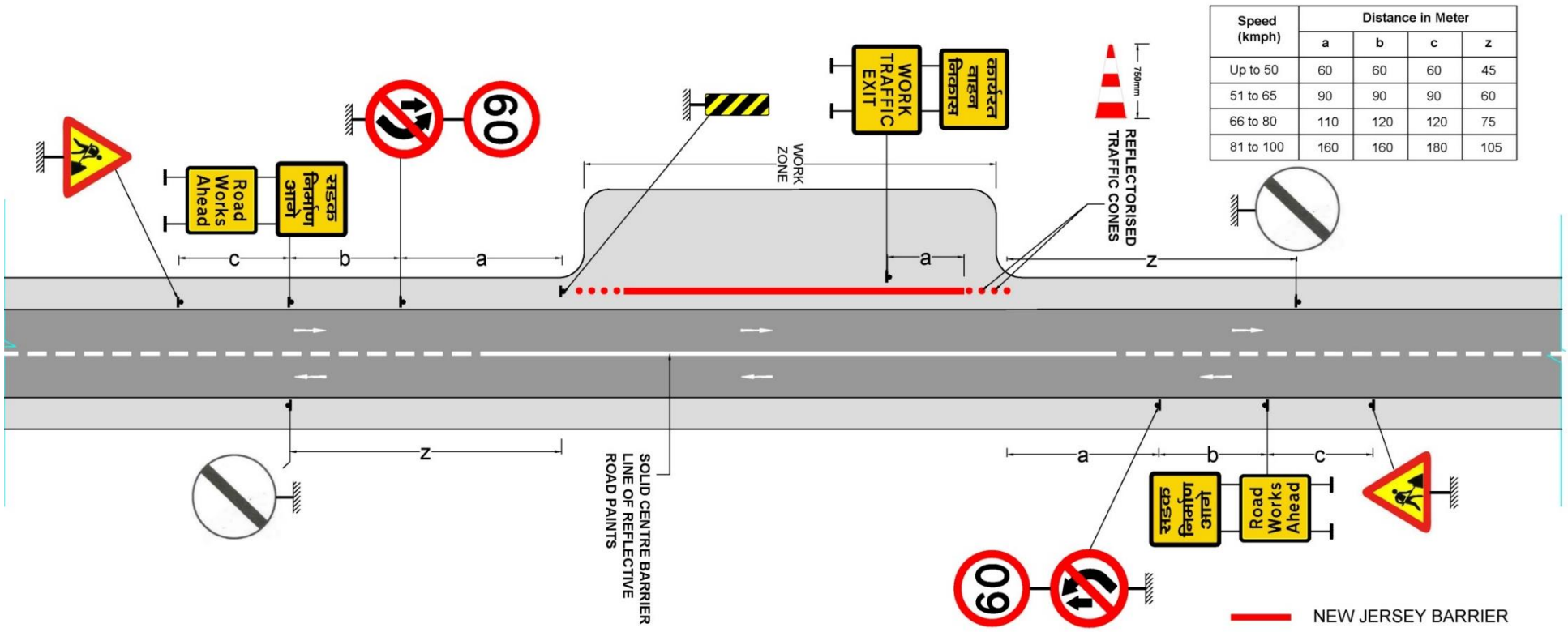
10.2 Typical Layouts

The commonly occurring work zone situations in the field are listed in Table 10.1 and are presented in drawing format as mentioned in the table. But these templates are not the only ones.

Table 10.1 List various work zone templates

Fig. Nos	Work zone templates for different scenarios
Fig. 10.1	Two-lane to Four-lane (Eccentric Widening)
Fig. 10.2	Two-lane to Four-lane (Shifting of Traffic from One Carriageway to Other)
Fig. 10.3	Two-lane to Four-lane Concentric Widening, Scenario-1
Fig. 10.4	Two-lane to Four-lane/six-lane Concentric Widening
Fig. 10.5	Two-lane to Four-lane Concentric Widening, Scenario-2
Fig. 10.6	Four-lane to Six-lane Concentric Widening, Scenario-1
Fig. 10.7	Four-lane to Six lane Concentric Widening, Scenario-2
Fig. 10.8	Stage-1 of upgrading Single/Intermediate Lane Road to Two-lane with Shoulders
Fig. 10.9	Stage-2 of upgrading Single/Intermediate Lane Road to Two-lane with Shoulders
Fig. 10.10	Temporary Diversion for Reconstruction of CD works
Fig. 10.11	Roadwork in Junction Area
Fig. 10.12	Roadwork on the Central Area of T-Intersection
Fig. 10.13	Work at Center of Carriageway
Fig. 10.14	One Direction for Major Work at the Centre of Road
Fig. 10.15	Road work with Detour/Bypassing
Fig. 10.16	Stage -1 of Flyover/VUP Construction
Fig. 10.17	Stage -2 of Flyover/VUP Construction
Fig. 10.18	Fast Lane Taken up for work
Fig. 10.19	Roadwork affecting both carriageways of Expressway
Fig. 10.20	Roadwork at the Centre of a Junction
Fig. 10.21	Roadwork at the Corner of a Junction with Temporary Signal Control
Fig. 10.22	Road Work at Roundabout with Constricted Circulatory Carriageway
Fig. 10.23	Road works at Level Crossing with Traffic Control with Stop/Go Boards
Fig. 10.24	Hard Shoulder in a Multilane Highway Taken up for Works
Fig. 10.25	Major Works with Entry/Exit Provisions for Works Traffic
Fig. 10.26	Roadwork with Complicated Diversions & Contra Flow
Fig. 10.27	Roadwork vehicle, Truck Attenuators & Shadow Vehicle
Fig. 10.28	Roadwork near the entry ramps with Arrow Panel Display

Fig. 10.29	Stage-1 of Developing Major Cross Road Junction to a Cloverleaf Interchange
Fig. 10.30	Stage-2 of Developing Major Cross Road Junction to a Cloverleaf Interchange

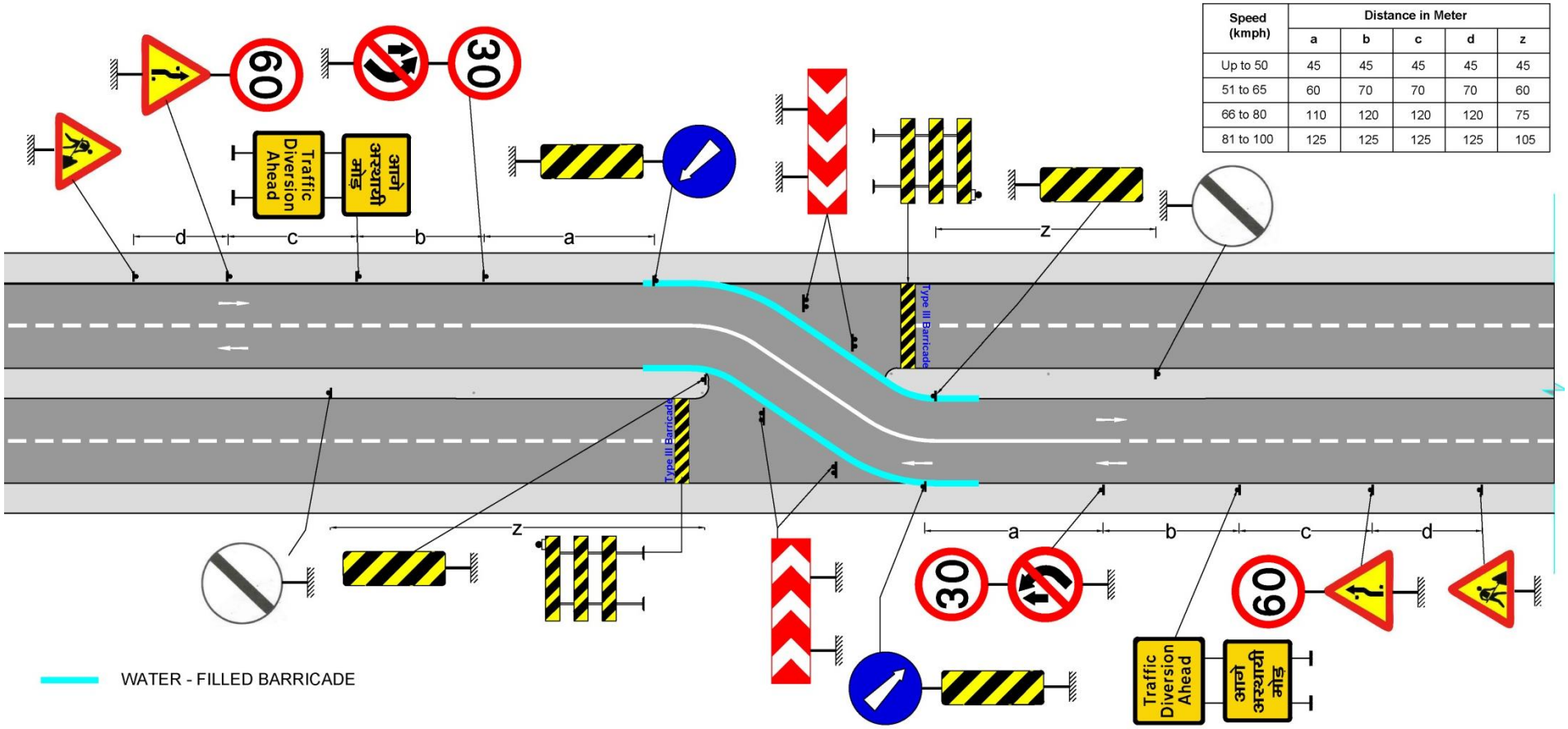


Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

Fig. 10.1 Two-lane to Four-lane (Eccentric Widening)

APPLICATION:

The layout shown is applicable when a two-lane highway is upgraded to four-lane, with eccentric widening. In the first stage, the new carriageway would be constructed on the sides. While the new carriageway is being constructed, the traffic will continue to ply through the existing road. The layout of signs and barriers would be as shown.



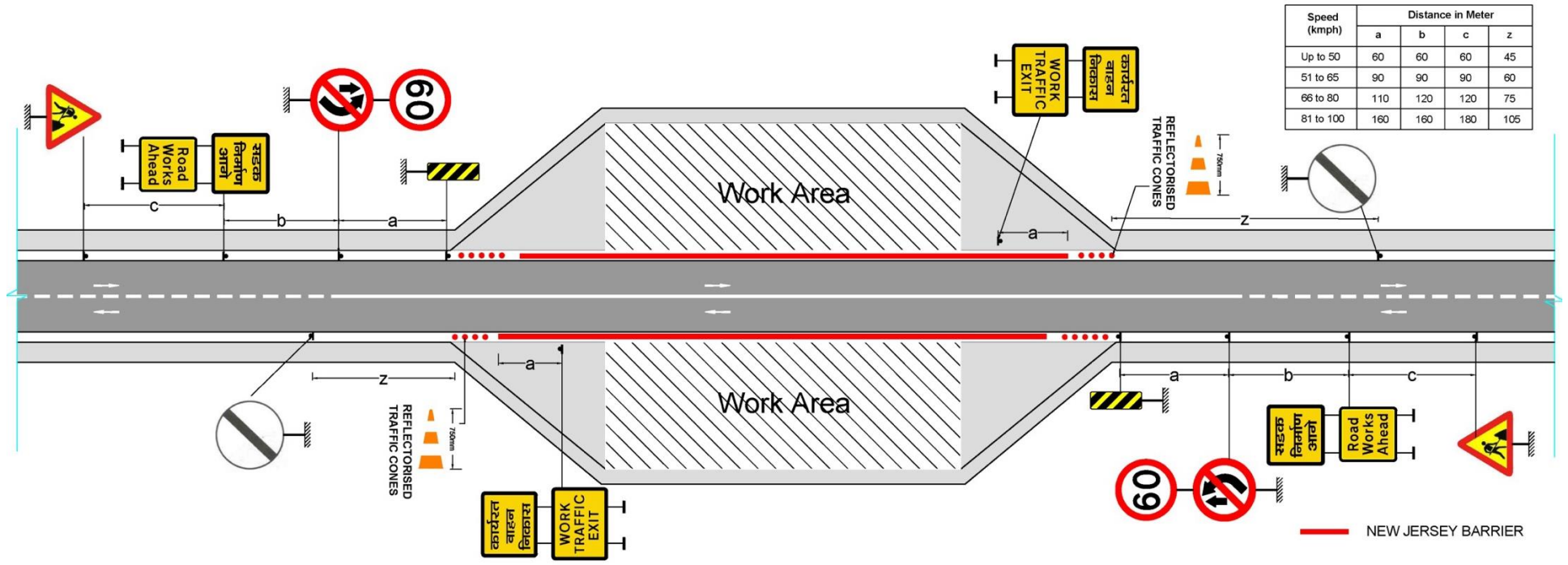
Speed (kmph)	Distance in Meter				
	a	b	c	d	z
Up to 50	45	45	45	45	45
51 to 65	60	70	70	70	60
66 to 80	110	120	120	120	75
81 to 100	125	125	125	125	105

Fig. 10.2 Two-lane to Four-lane (Shifting of Traffic from One Carriageway to Other)

APPLICATION:

The layout is applicable for the second stage of eccentric widening when a new carriageway has been constructed and the existing carriageway is taken up for strengthening or overlay, where traffic must be shifted from one carriageway to another. In shifting traffic from one carriageway to other, the cross over length is critical and shall be carefully provided, meeting the site requirements such that the layout is clearly visible with adequate signs and markings in a well guided way, to be visible both day and night. In the crossover length the camber also shall be properly given for safe transfer to avoid overturn

due to reverse camber. It would be advisable to bring about a gradual reduction in speed by adopting traffic calming measures (IRC 99-2018 Guidelines for Traffic Calming Measures in Urban and Rural Areas). The layout of signs and barriers would be as shown.



Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

Fig. 10.3 Two-lane to Four-lane Concentric Widening, Scenario-1

APPLICATION:

The layout shown is applicable for concentric widening of a two-lane highway to four-lane highway. In the first stage, construction of service road or diversion road would be taken up on the sides and traffic would continue to move on main highway in both directions.

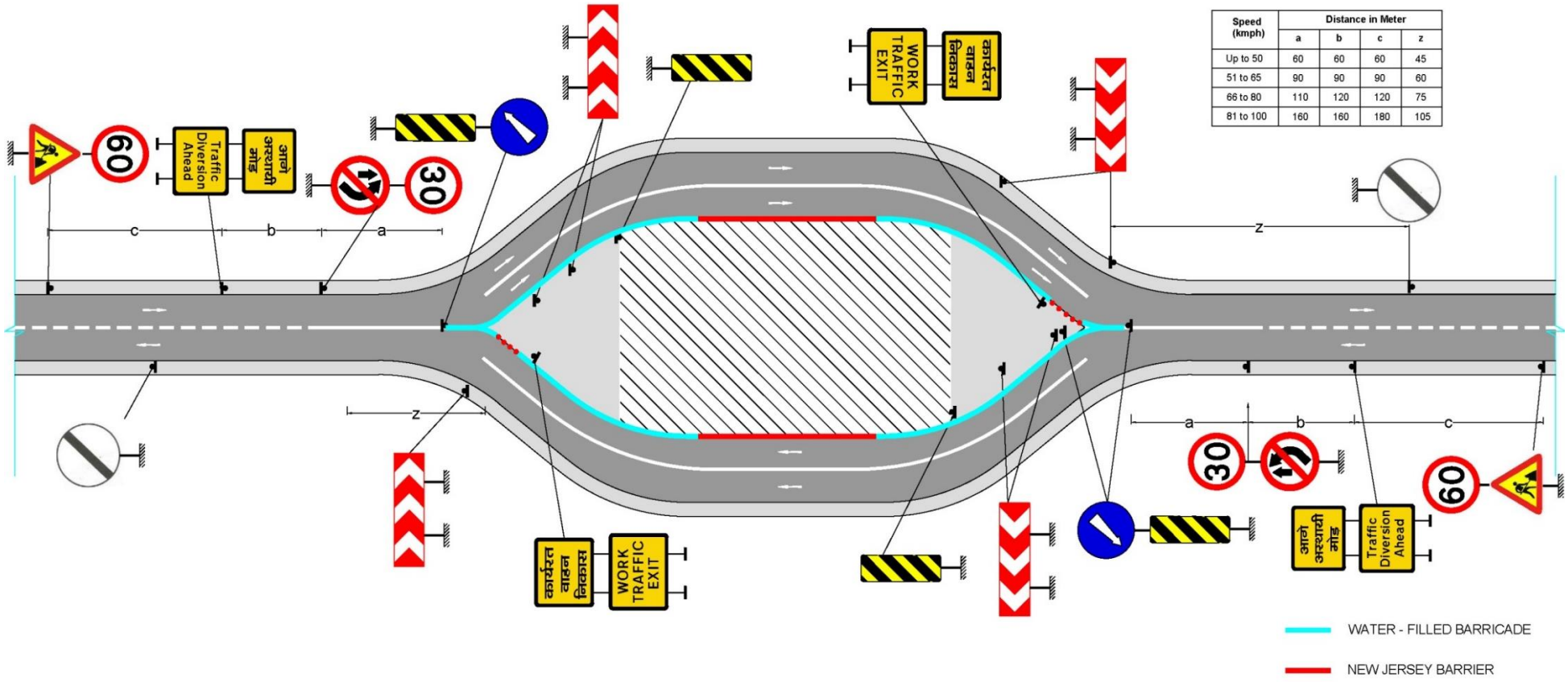


Fig. 10.4 Two-lane to Four-lane/Six-lane Concentric Widening

APPLICATION:

The layout is applicable for the second stage of upgrading a two-lane highway to four-lane. The traffic would move on newly constructed service/diversion roads in each direction and widening work on both carriageways including median is done in the central cordoned portion. Necessary warning signs will be given to inform people of roadwork being undertaken. The layout for signs and barriers would be as shown.

Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

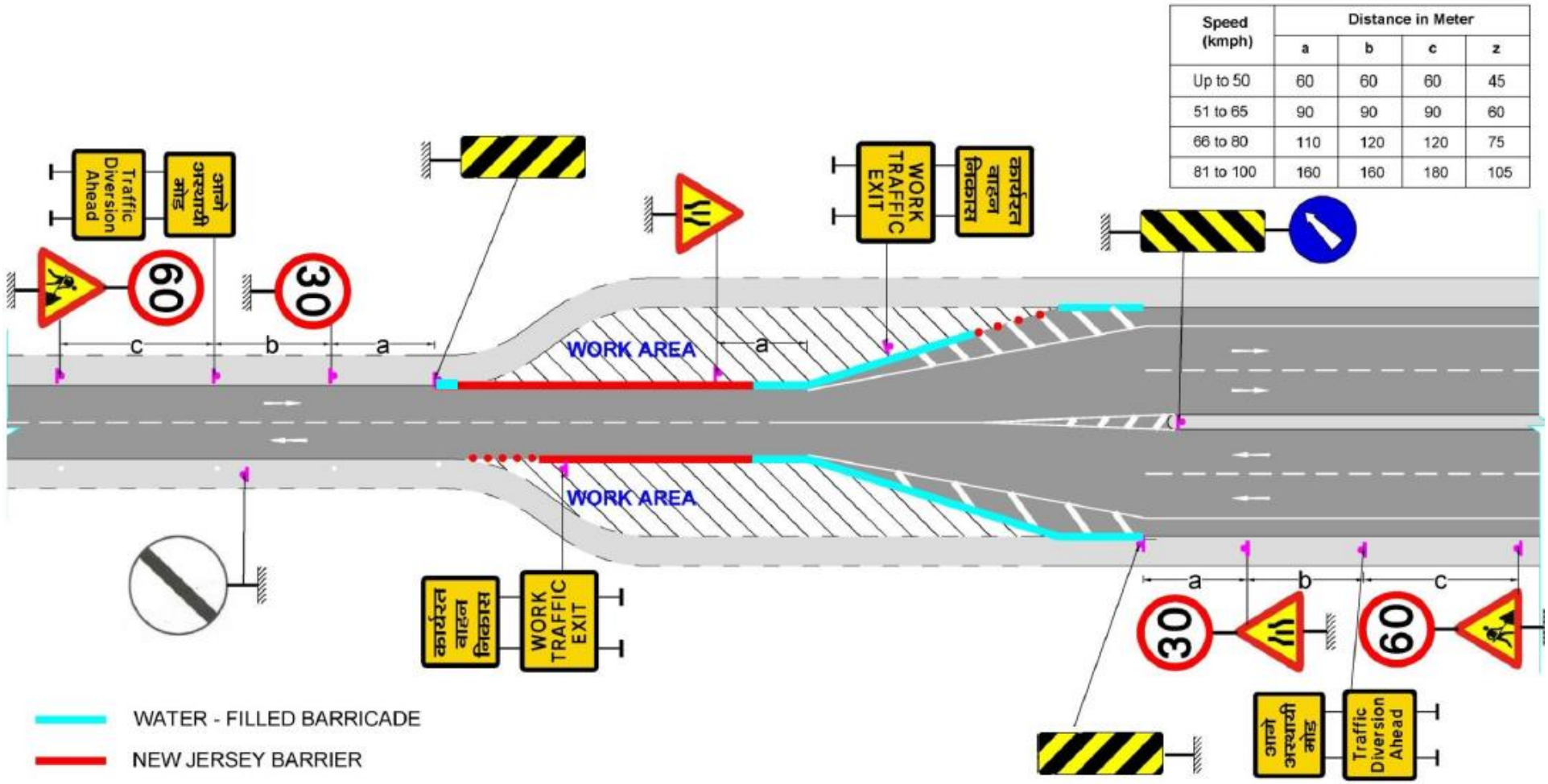


Fig. 10.5 Two-lane to Four-lane Concentric Widening, Scenario-2

APPLICATION:

The layout is the third stage of concentric widening of a two-lane highway to four-lane showing the shifting/ forward movement of work zone to the next stretch for progress of construction activities.

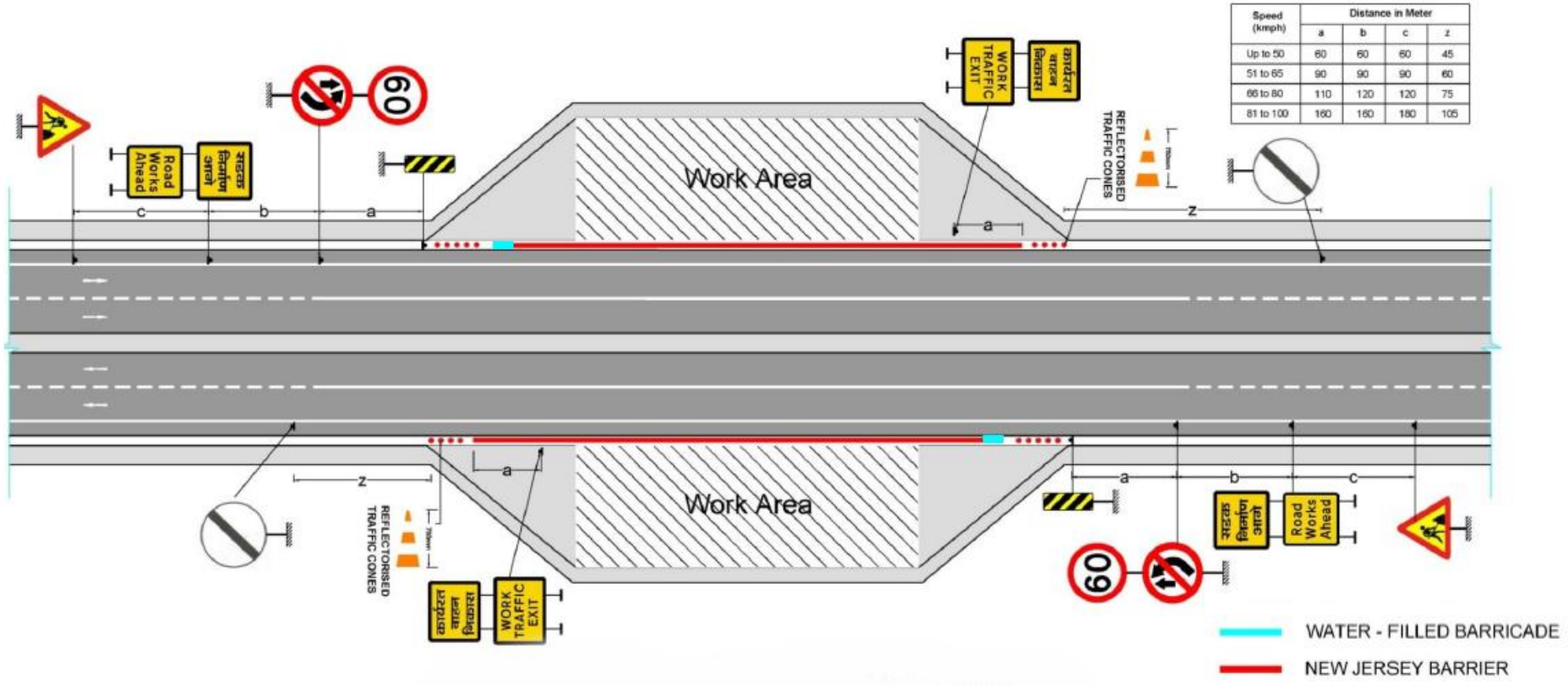


Fig. 10.6 Four-lane to Six-lane Concentric Widening, Scenario-1

APPLICATION:

The layout is applicable in cases of concentric widening from four lanes to six lanes. In the first stage service roads will be constructed on both sides, while traffic continues to ply through the existing four-lane highway. Warning signs and barriers will be installed as shown to inform people of road works being undertaken.

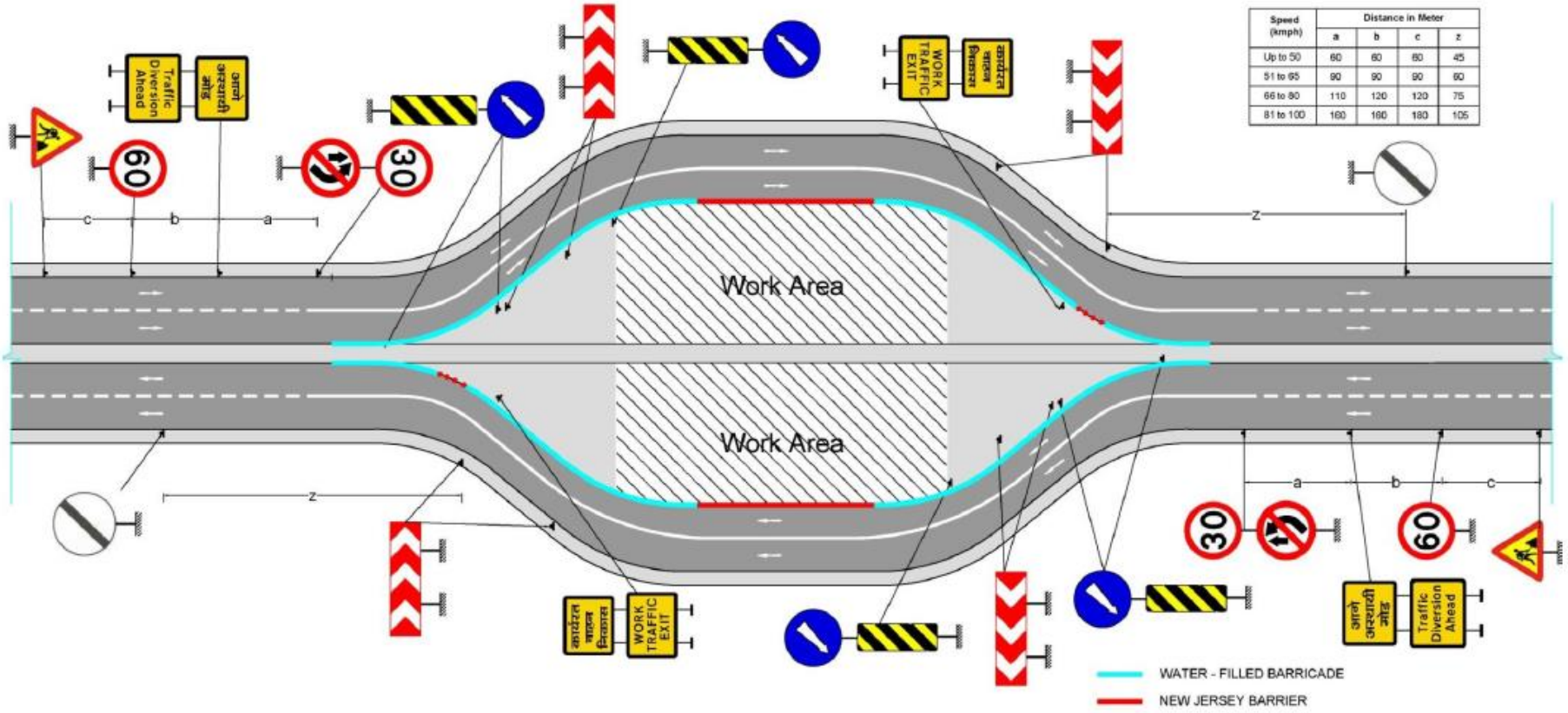
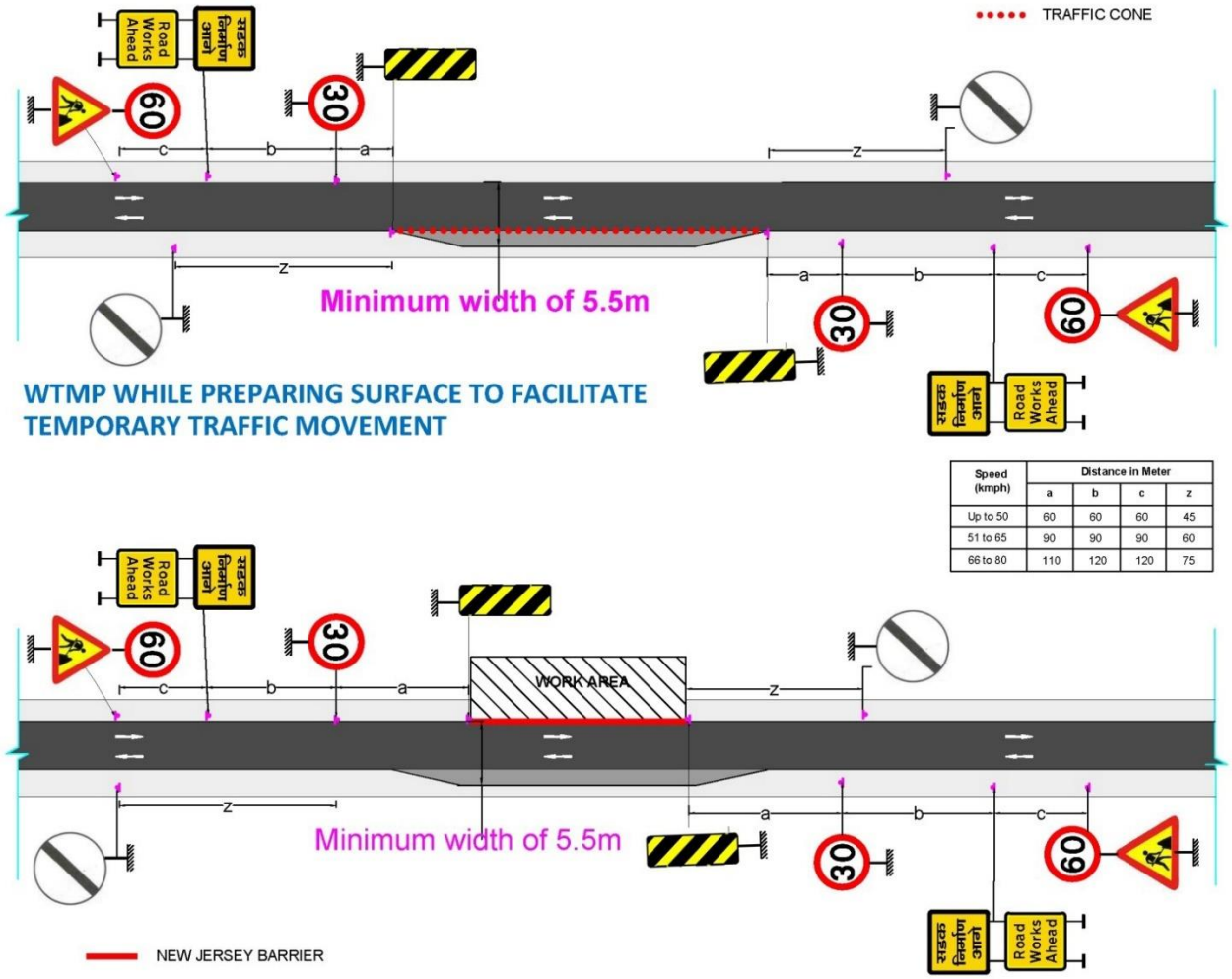


Fig. 10.7 Four-lane to Six-lane Concentric Widening, Scenario-2

APPLICATION:

In the second stage, the traffic will be shifted to service road so constructed. The construction of an additional one lane on each carriageway along with the median would be taken up in as shown in the layout. The transition from the existing main carriageway to service road shall be carefully planned as per site condition for safe negotiation of traffic. The layout of signs and barriers would be as shown. Further progression of work would be similar as shown in Fig 10.5.



Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75

WTMP WHILE PREPARING SURFACE TO FACILITATE TEMPORARY TRAFFIC MOVEMENT: The layout shown is applicable (if at all required) to prepare additional width to achieve 5.5m width to facilitate two directional traffic movement with the pavement composition and thickness which can withstand the temporarily diverted traffic for a length from transition zone to termination zone. Layout of signs and barriers would be as shown.

Fig. 10.8 Stage-1 of Single/Intermediate Lane Road into Two-lane with Shoulders

APPLICATION: The layout shown is applicable when a single lane or intermediate or two-lane carriageway is upgraded to standard two lanes with paved or earthen shoulder. In this stage, the work will be taken up adjacent to existing traffic movement with traffic control measures. The layout of signs and barriers would be as shown.

Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75

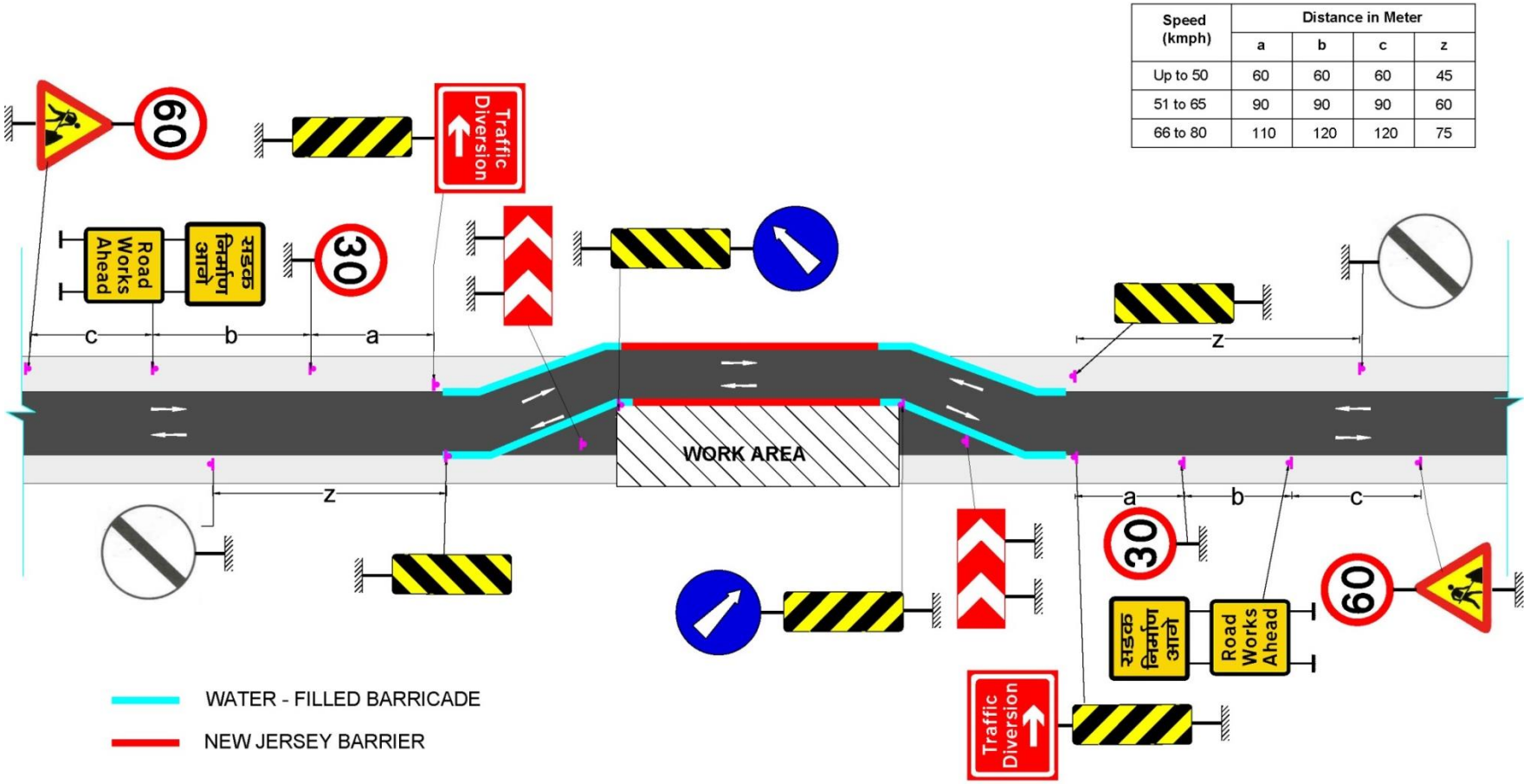


Fig. 10.9 Stage-2 of Single/Intermediate Lane Road into Two-lane with Shoulders

APPLICATION:

In the subsequent stage, the traffic will be diverted to the portion of carriageway and shoulder developed during the first stage. The layout of signs and barriers would be as shown.

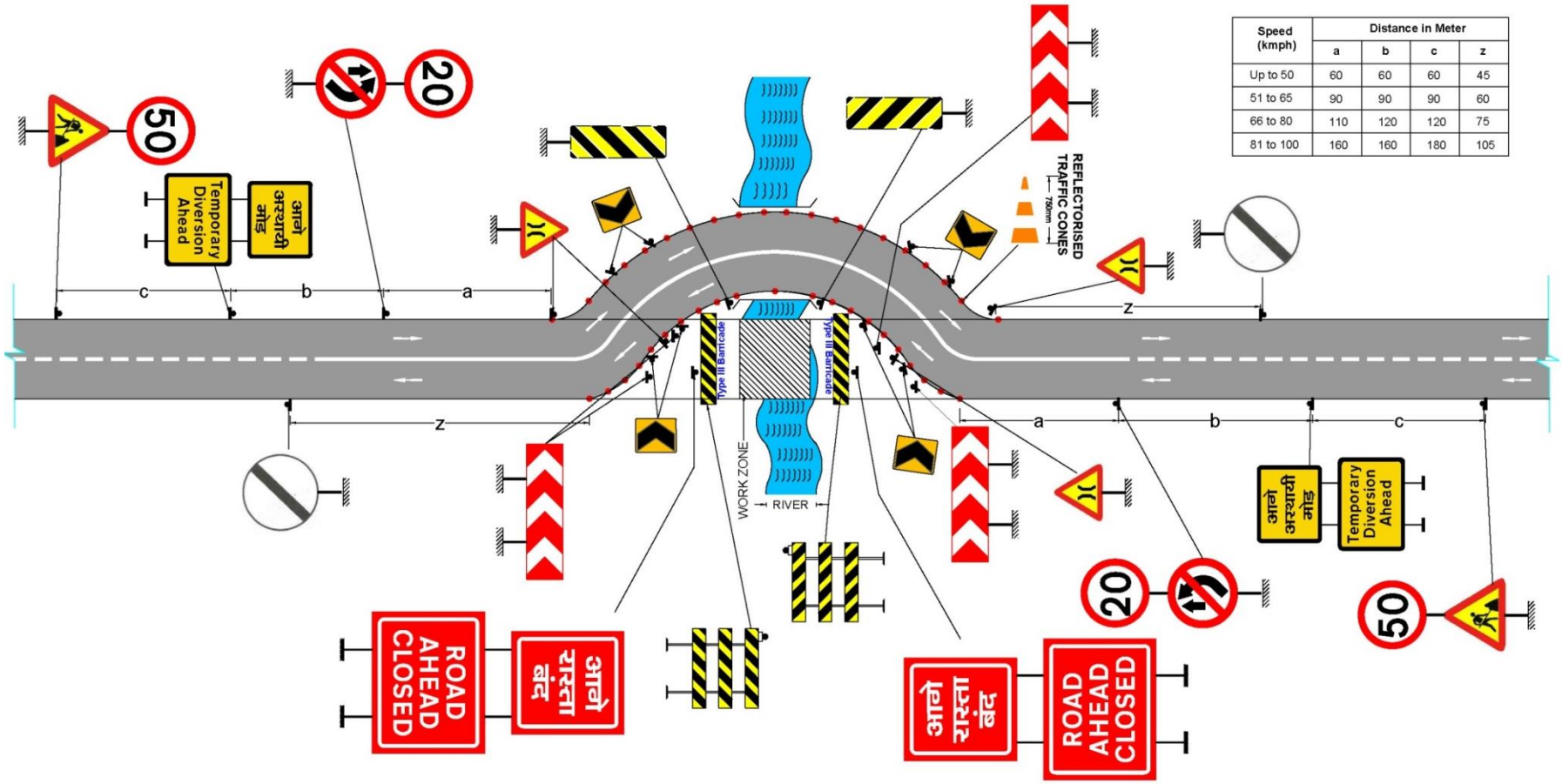
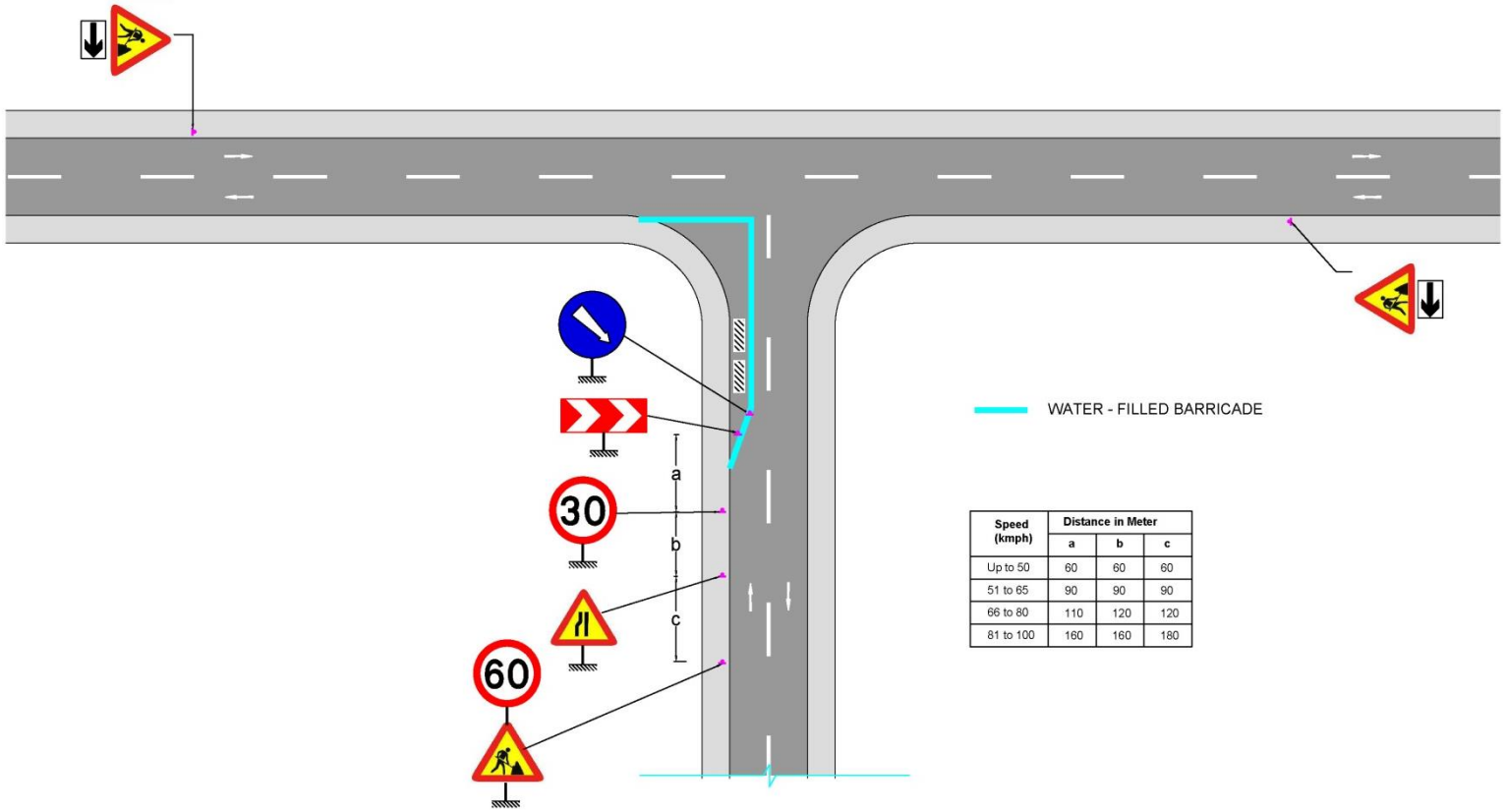


Fig. 10.10 Temporary Diversion for Reconstruction of CD Works

APPLICATION:

The layout shown is applicable when a Cross Drainage structure must be constructed and where a temporary diversion will need to be constructed for maintaining the traffic flow. The diversion in most cases would be on embankment; therefore, delineation is essential for both day and nighttime. Temporary diversion shall be developed and maintained to accommodate all types of vehicles likely to ply through the road. The layout of signs and barriers would be as shown.

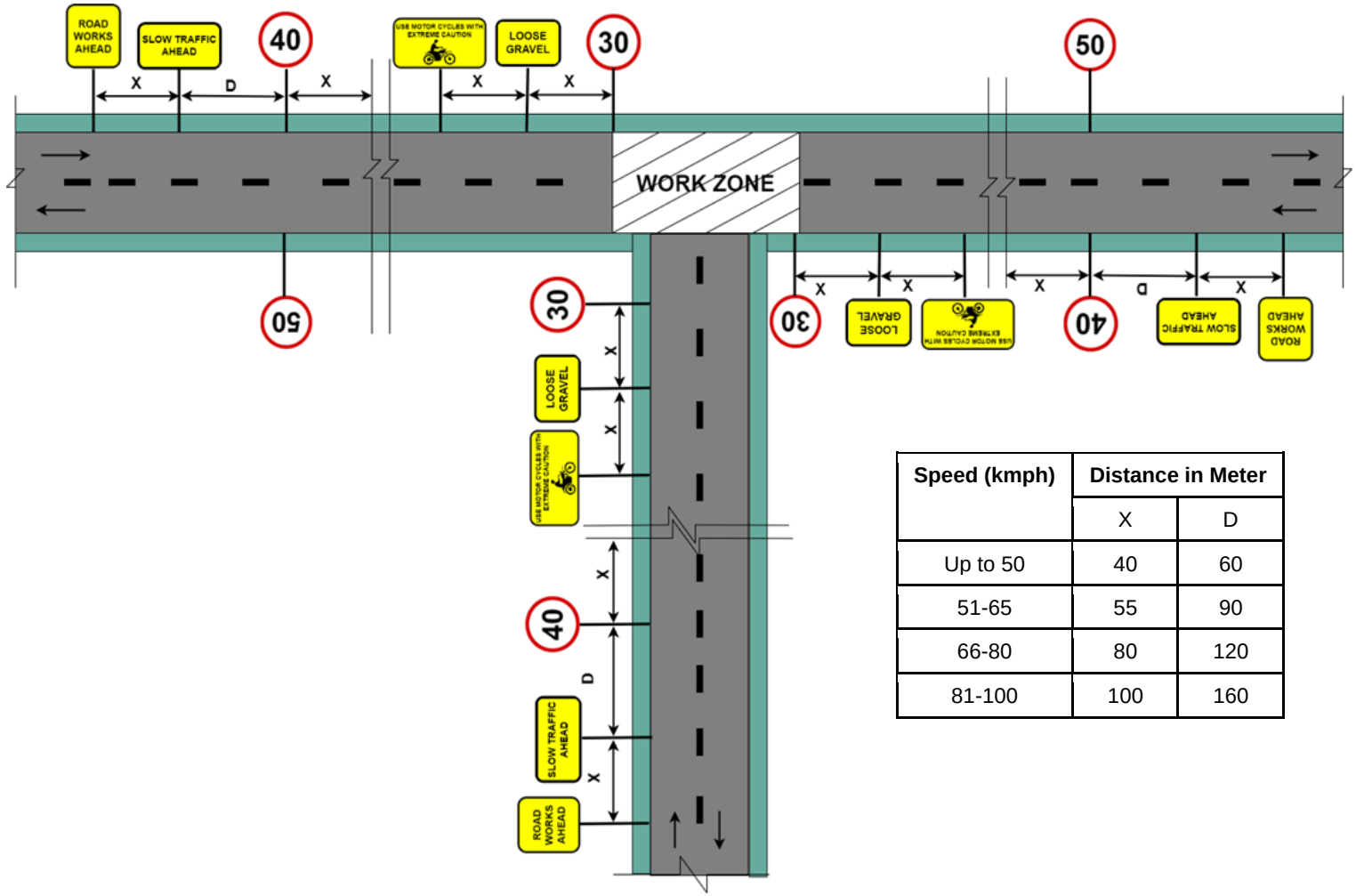


Speed (kmph)	Distance in Meter		
	a	b	c
Up to 50	60	60	60
51 to 65	90	90	90
66 to 80	110	120	120
81 to 100	160	160	180

Fig. 10.11 Roadwork in Junction Area

APPLICATION:

The layout shown is applicable to some work at the junction area involving deflection of traffic.

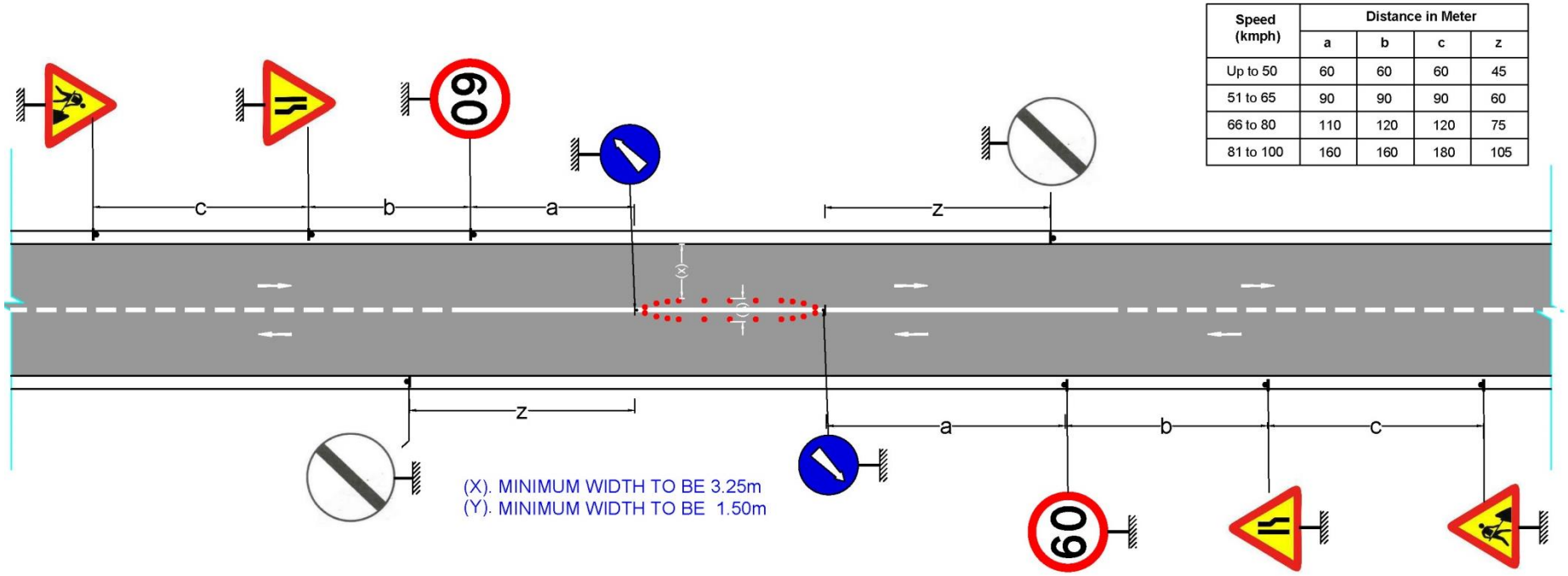


Speed (kmph)	Distance in Meter	
	X	D
Up to 50	40	60
51-65	55	90
66-80	80	120
81-100	100	160

Fig. 10.12 Roadwork on the Central Area of T-Intersection

APPLICATION:

The layout shown is applicable if the central area of T-Intersection is involved with minor work. In this case, traffic is allowed on all three legs with cautionary signs and reduced speed limits.

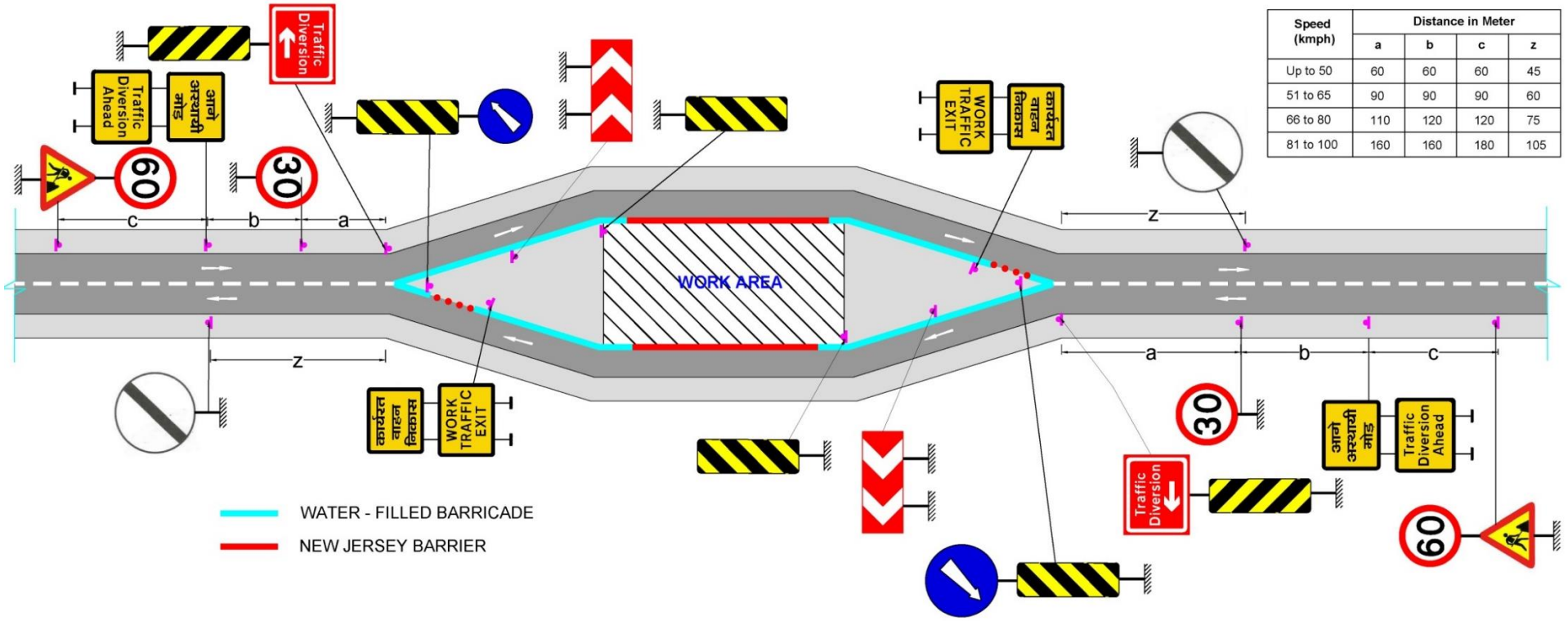


Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

Fig. 10.13 Work at Center of Carriageway

APPLICATION:

The layout shown is applicable for short-term maintenance activities at the center of a carriageway. Generally, traffic cones are used that can be placed and removed easily.



Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

Fig. 10.14 One Direction for Major Work at the Centre of Road

APPLICATION:

This situation may arise for major works on roads in urban areas. At the first stage, diversion road would be constructed for both direction one way traffic movement as shown in layout for safe movement of through traffic and actual work will be undertaken subsequently in the central portion.

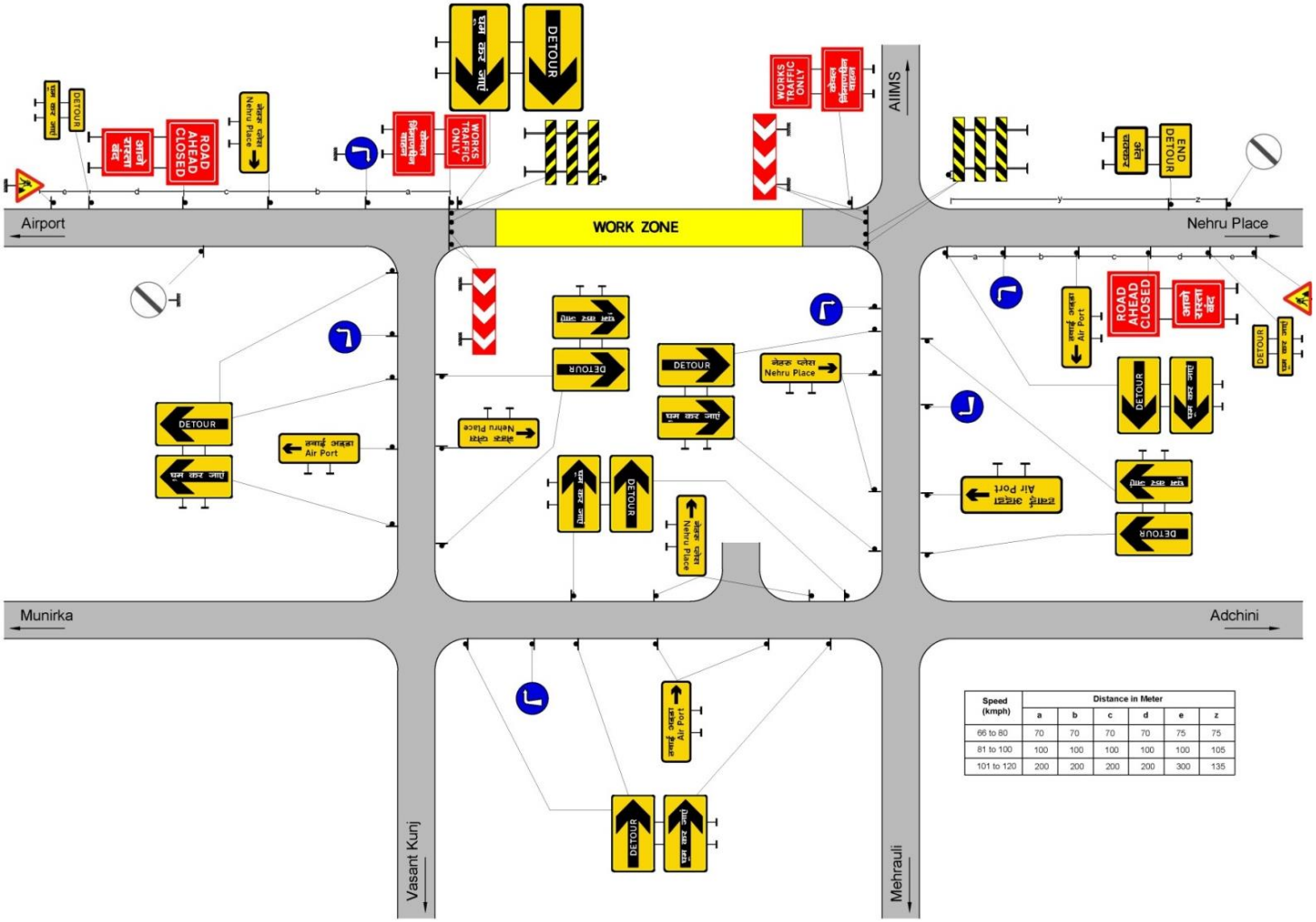


Fig. 10.15 Road construction with Detour / Bypassing

APPLICATION:

The layout shown is applicable when a mid-block of a main route is taken up for total reconstruction necessitating road closer and traffic must detour through other adjacent roads of the network.

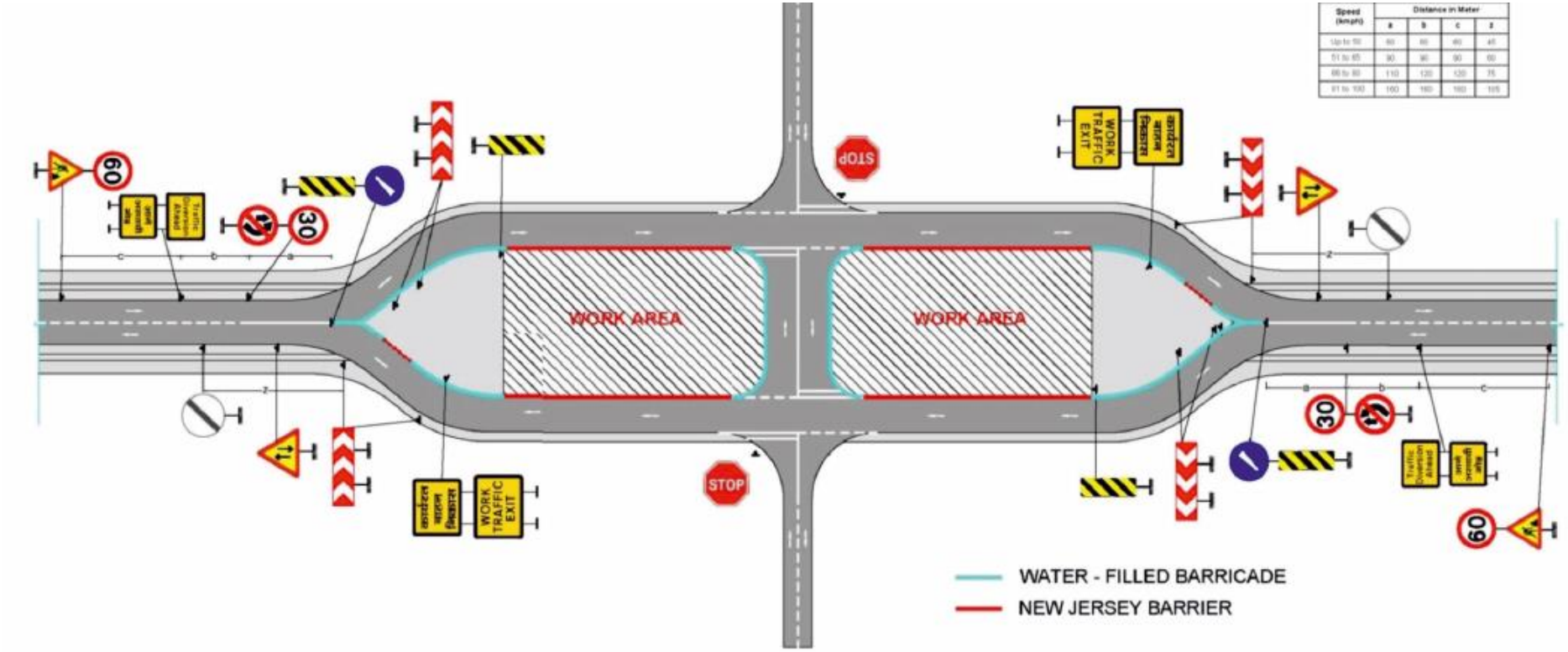


Fig. 10.16 Stage-1 of Flyover/VUP Construction

APPLICATION:

The layout shows the Stage-1 in flyover/VUP construction. In the first stage, the traffic will be diverted to a service road or temporary road. The turning movements would continue at the existing intersection and construction of piers/embankment/RE wall would be taken up in the cordoned portion. Carefully planned pedestrian markings on the roads and protected safe passage for crossing of pedestrians shall be provided through the work area. Barricading should be provided to prevent construction material falling on the diversion on the moving traffic.

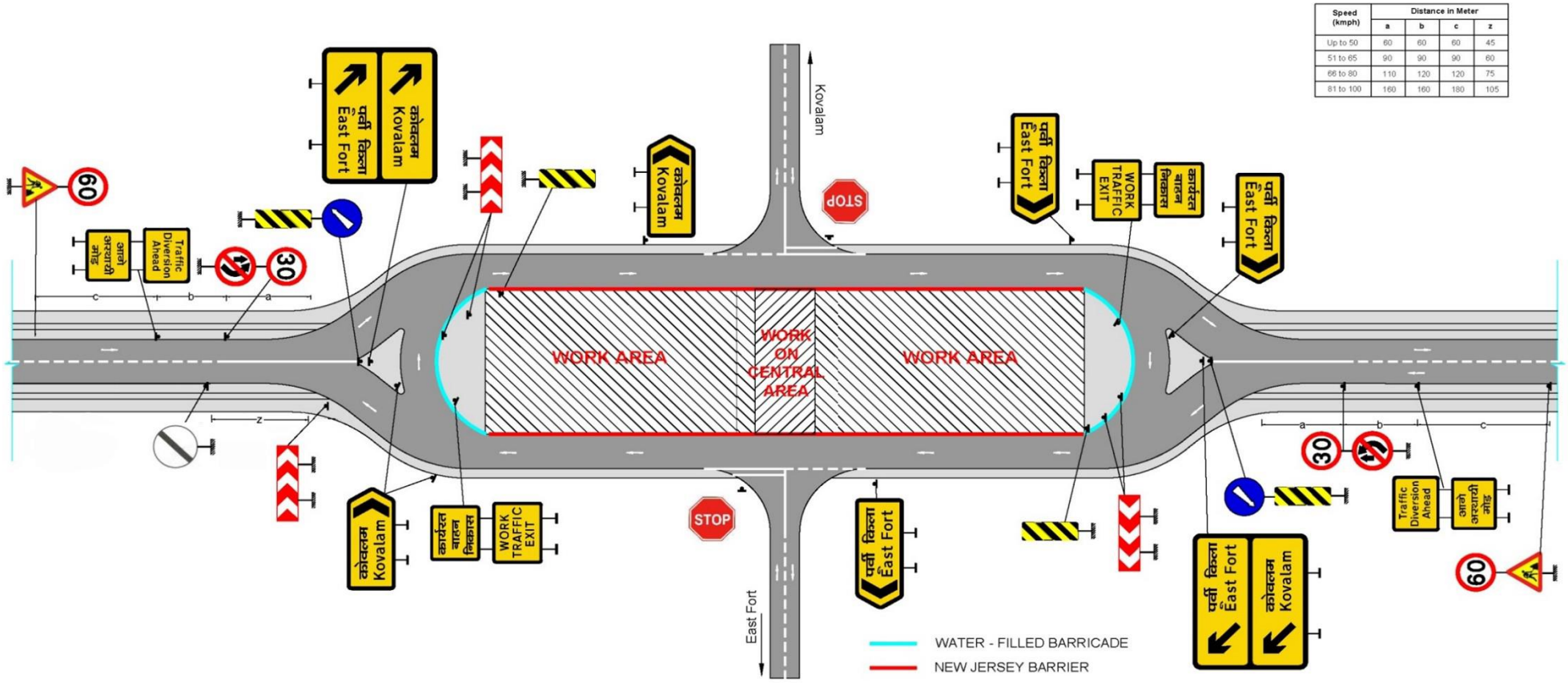


Fig. 10.17 Stage-2 of Flyover/VUP Construction

APPLICATION:

The layout shows Stage-2 of flyover/VUP construction. In the second stage, the central portion will be taken up and junction will be blocked for direct crossroad movement. During this short period of time, crossroad movement will be accommodated like a circulatory movement using U-turn, whereas the through traffic will continue to ply through service road/temporary road. Direction signs would be carefully planned and installed. Carefully planned pedestrian markings on the roads and protected safe passage for crossing of pedestrians shall be provided through the work area. Barricading should be provided to prevent construction material falling on the diversion on the moving traffic.

Speed (kmph)	Distance in Meter					
	a	b	c	d	e	z
66 to 80	70	70	70	70	75	75
81 to 100	100	100	100	100	100	105
101 to 120	200	200	200	200	300	135

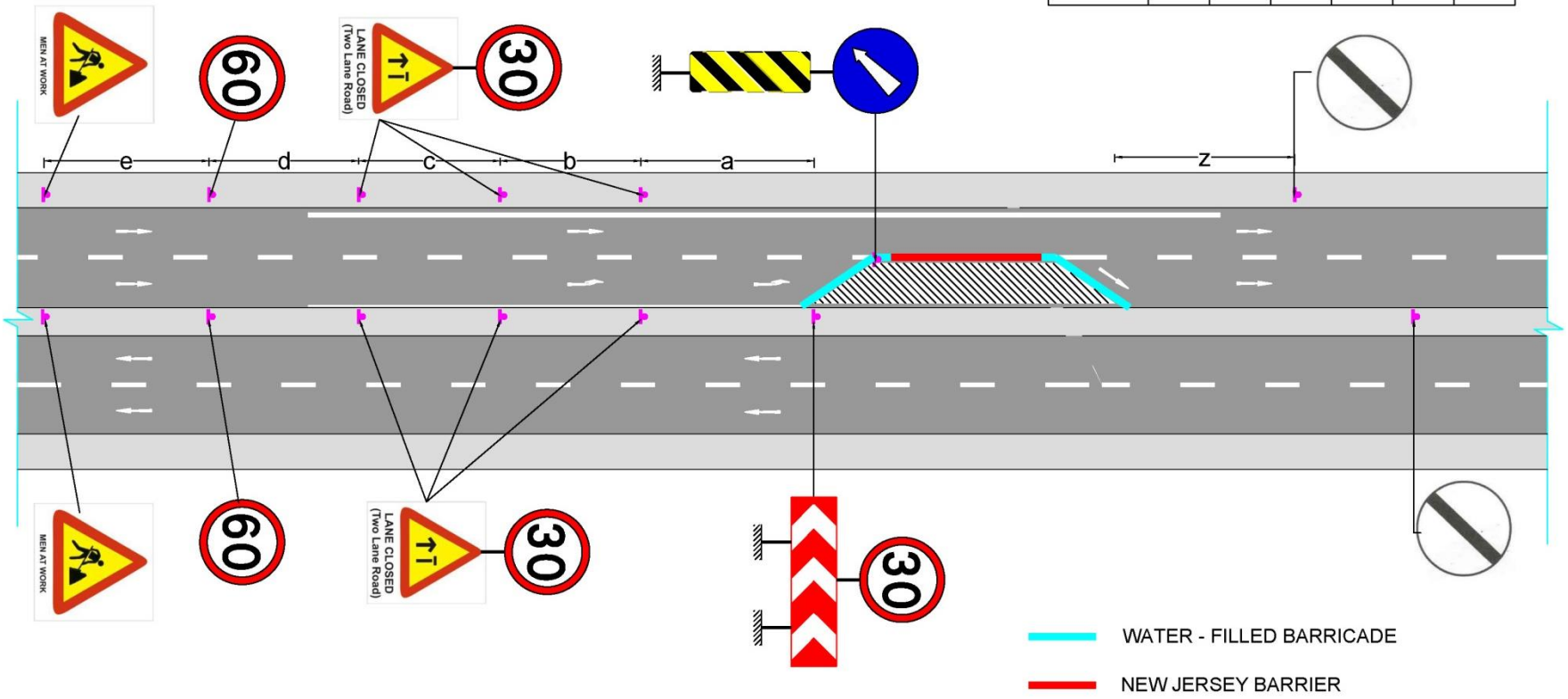


Fig. 10.18 Fast Lane Taken up for Work

APPLICATION:

The layout shown is applicable when the fast extreme right lane in a multi-lane highway is taken up for work.

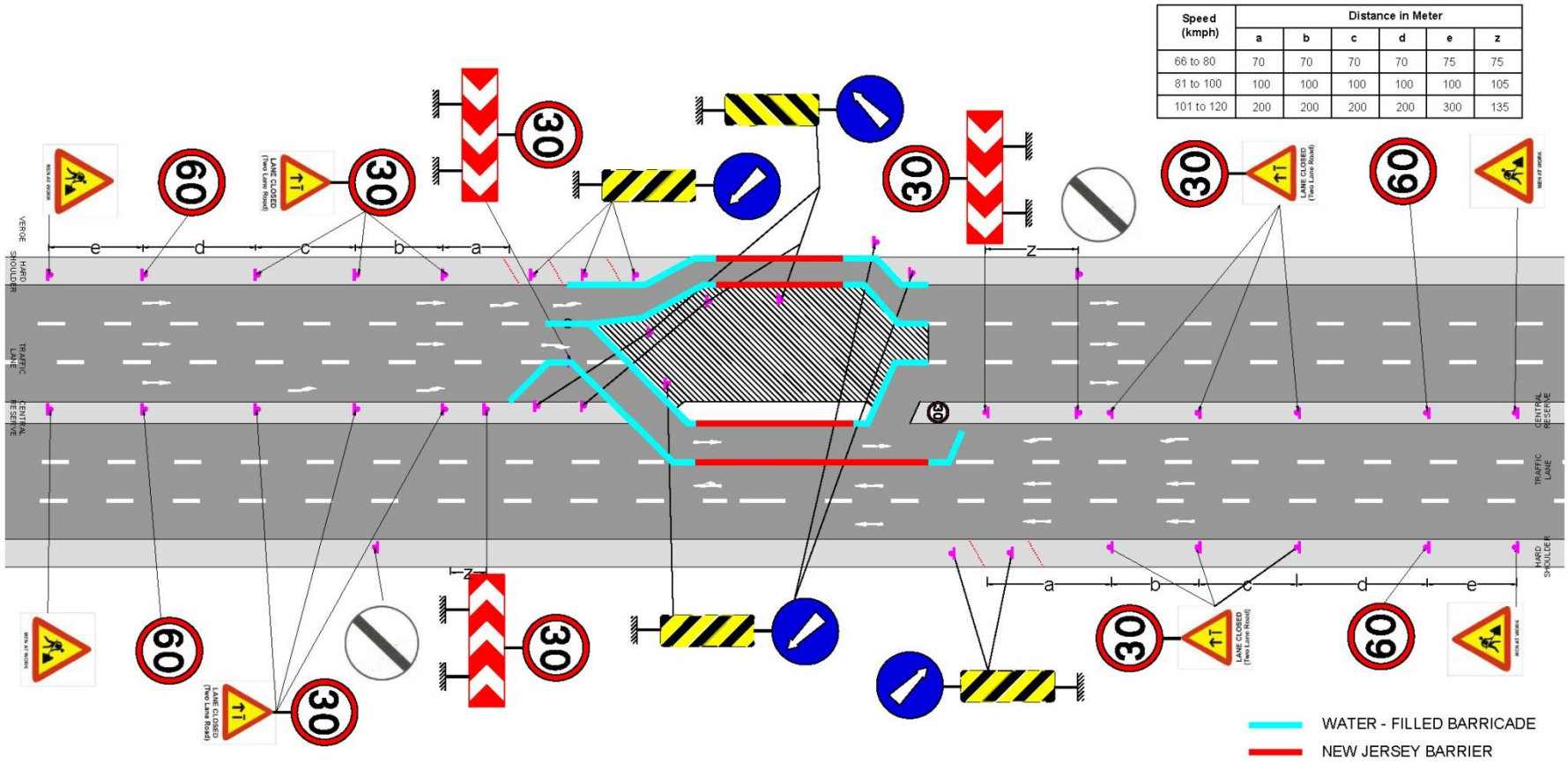


Fig. 10.19 Roadwork affecting both carriageways of Expressway

APPLICATION:

The layout shown is applicable in an access-controlled expressway as the ongoing work affects both carriageways, involving delicate diversions. The speed reduction shall be facilitated by appropriate traffic calming measures (IRC 99-2018)

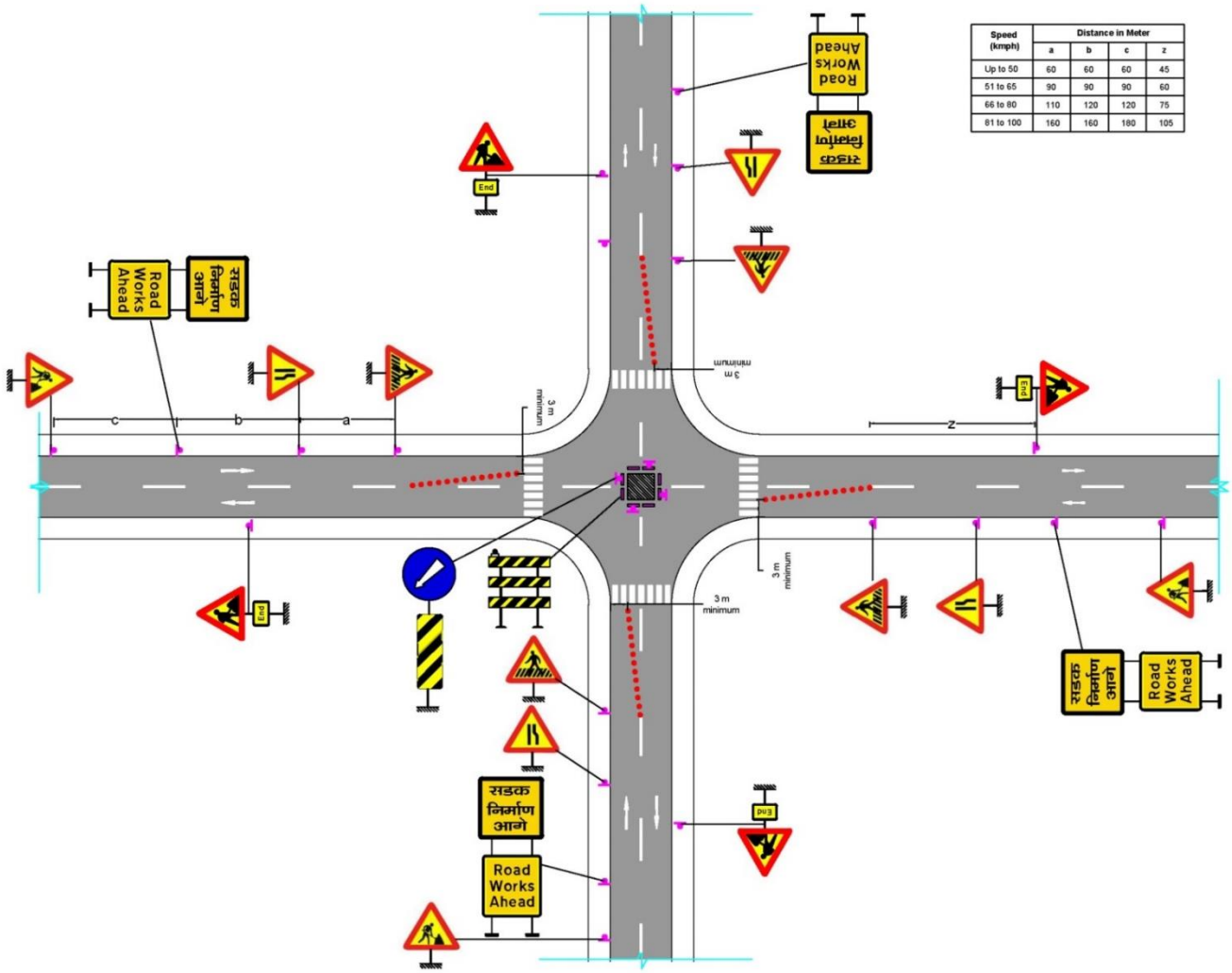


Fig. 10.20 Roadwork at the Centre of a Junction

APPLICATION:

The layout shown is applicable when works are to be carried out at the center of the junction.

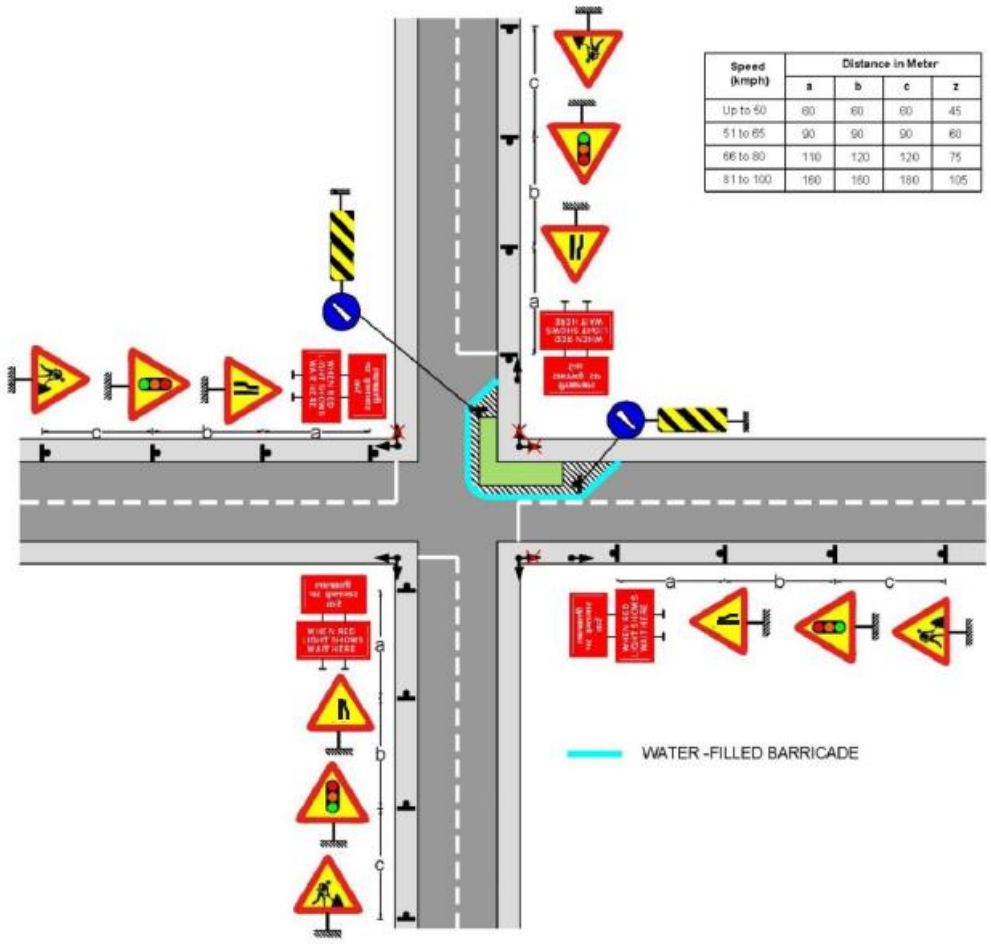
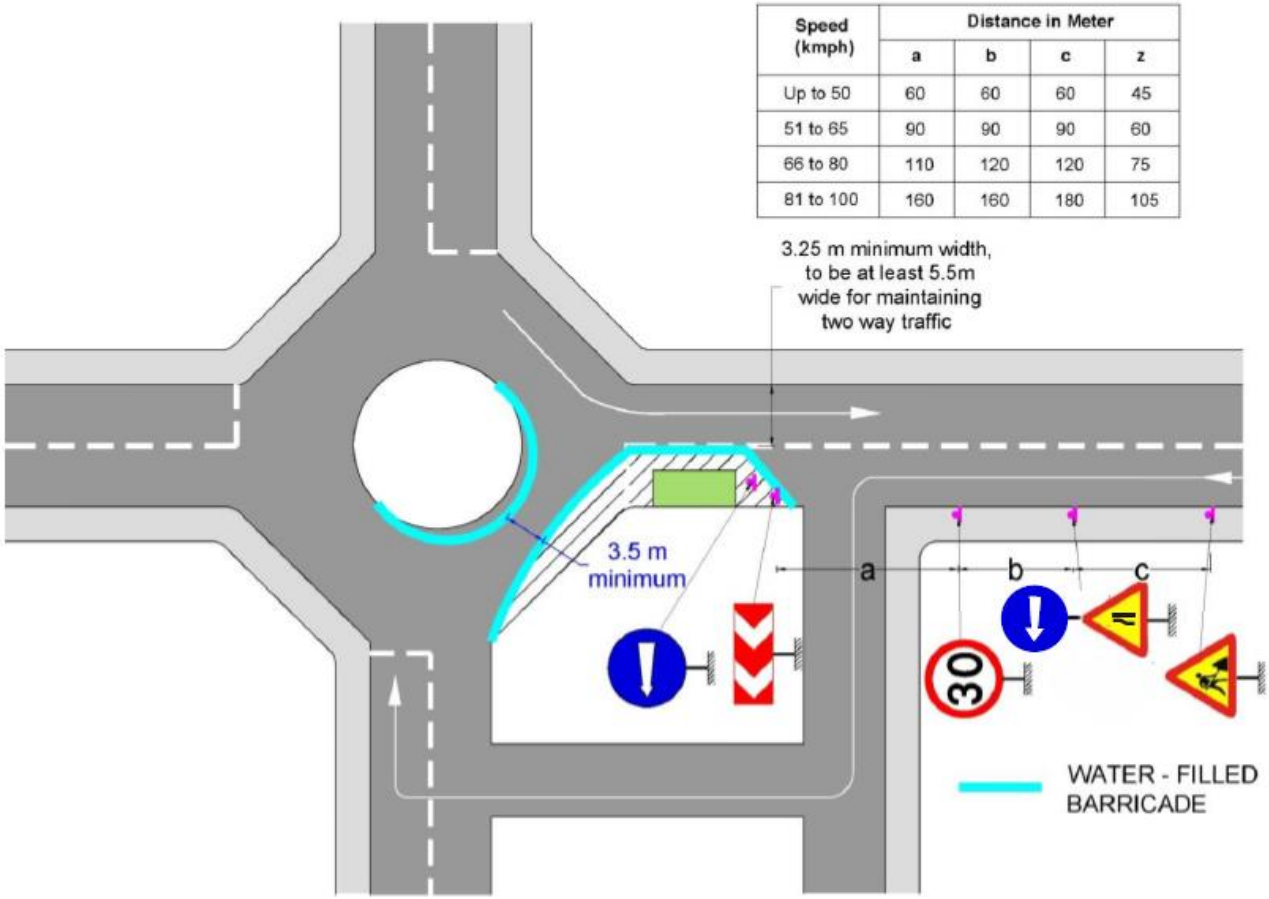


Fig. 10.21 Roadwork at the Corner of a Junction with Temporary Signal Control

APPLICATION:

The layout shown is applicable when some works to be carried out at the corner with temporary signal control arrangement.

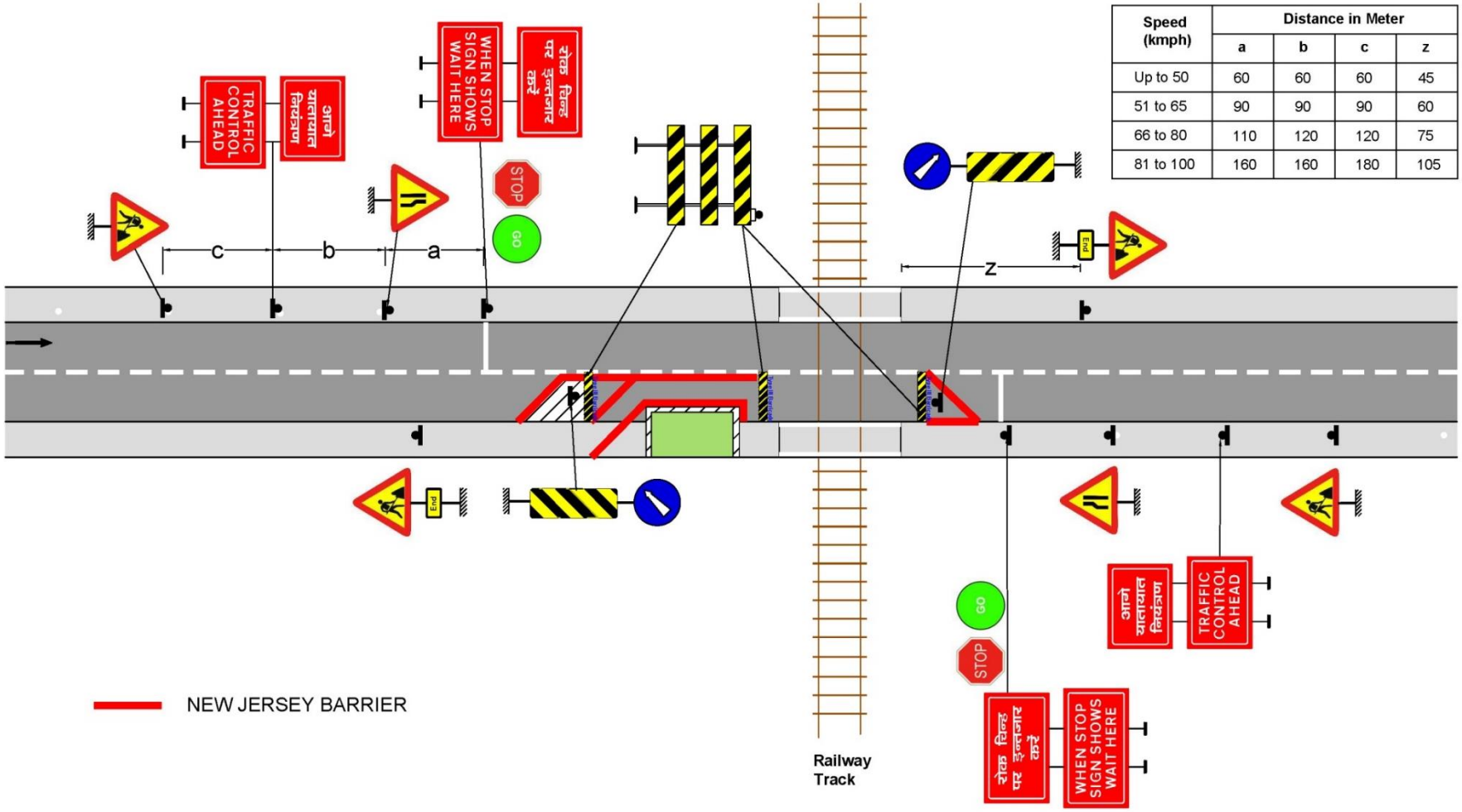


Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

Fig. 10.22 Road Work at Roundabout with Constricted Circulatory Carriageway

APPLICATION:

The layout shown is applicable where there are activities at corner of the roundabout and the circulatory carriageway can hardly allow one lane movement only due to repair work at central island, where traffic in one approach will be redirected through an adjacent street.



Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

Fig. 10.23 Road works at Level Crossing with Traffic Control with Stop/Go Boards

APPLICATION:

The layout shown is applicable for roadworks at level crossings with manual traffic control with Stop/Go boards. The layout of signs and barriers would be as shown.

Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

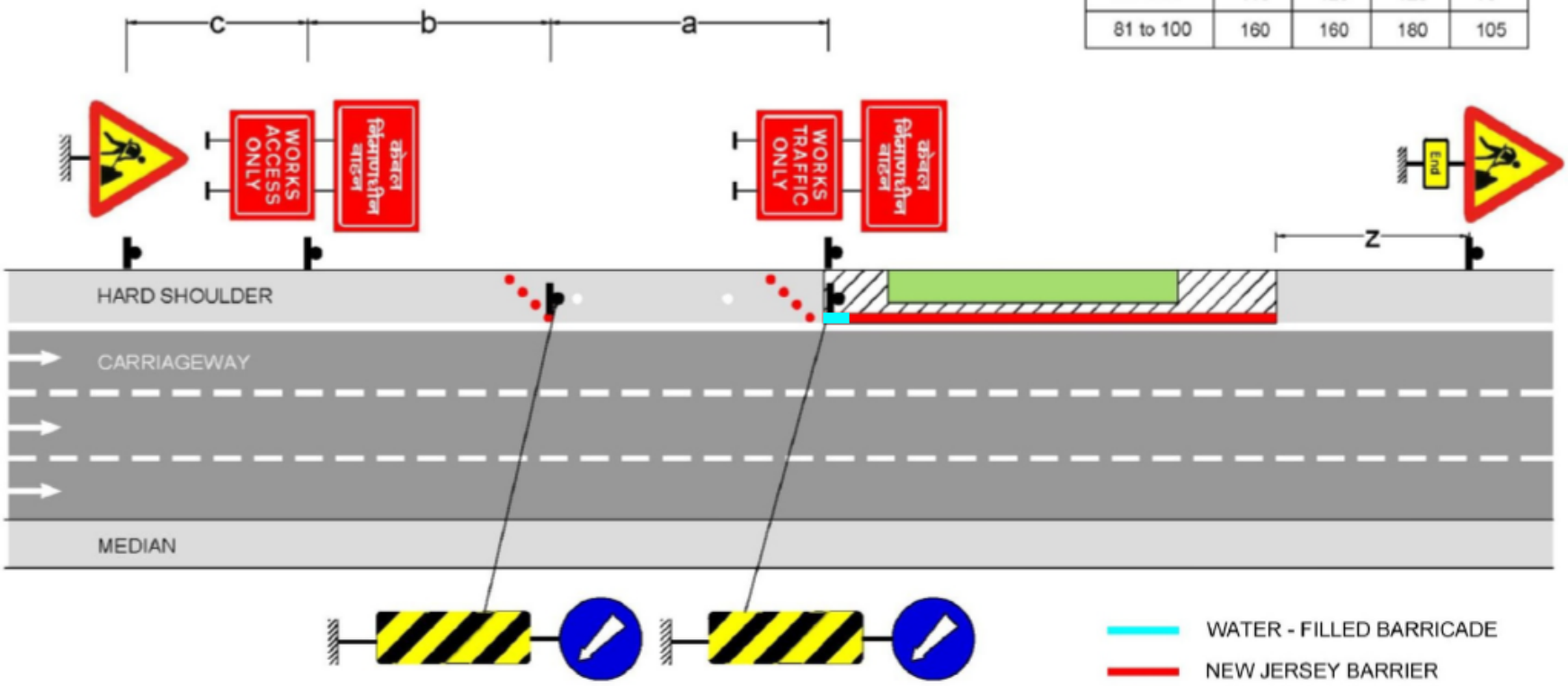


Fig. 10.24 Hard Shoulder in a Multilane Highway Taken up for Works

APPLICATION:

The layout shown is applicable when the hard shoulder in a multi-lane is taken up for work, where the trafficable carriageway is no way affected or encroached. The layout of signs and barriers would be as shown.

Speed (kmph)	Distance in Meter					
	a	b	c	d	e	z
66 to 80	70	70	70	70	75	75
81 to 100	100	100	100	100	100	105
101 to 120	200	200	200	200	300	135

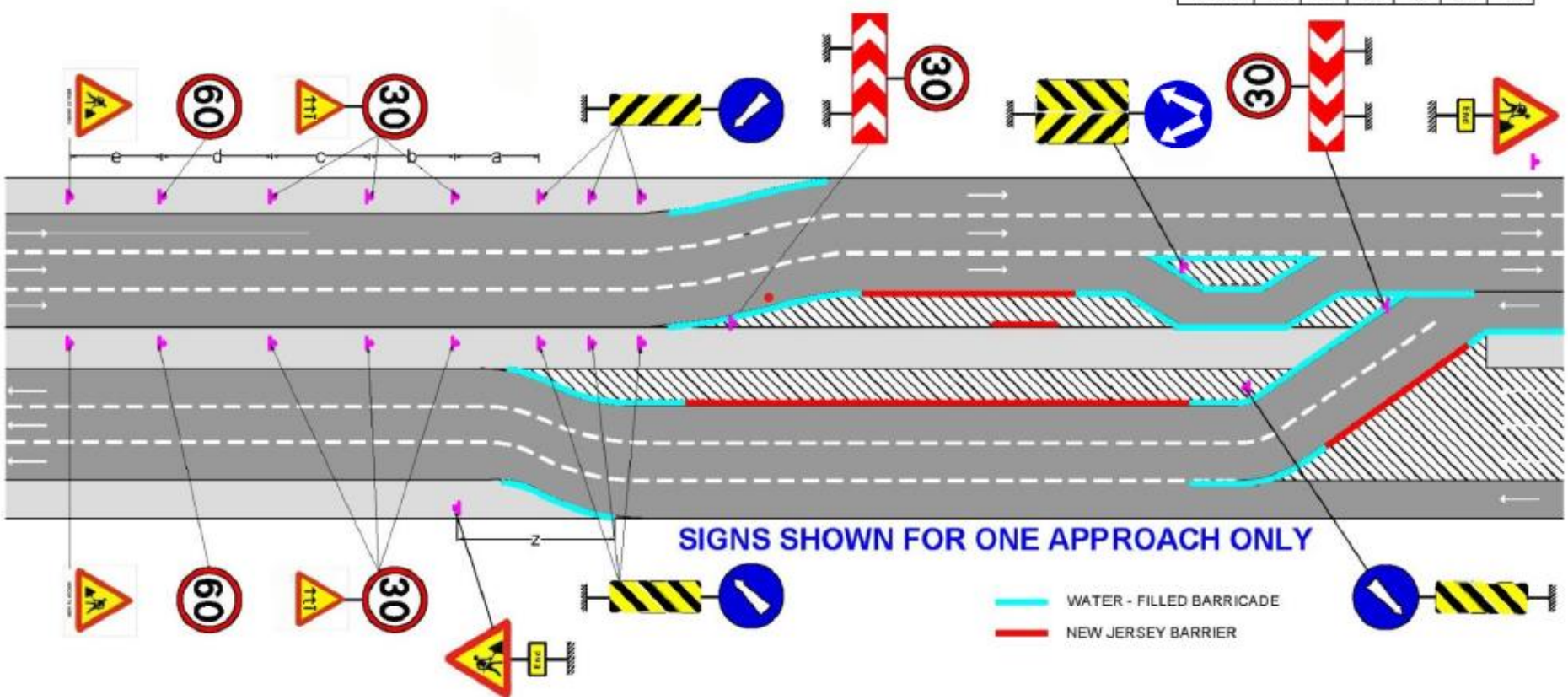


Fig. 10.25 Major Works with Entry/Exit Provisions for Works Traffic

APPLICATION:

The layout shown is applicable to major road situations where two lanes out of three lanes have been blocked for works activities, involving delicate diversion, and also showing entry/exit provisions for Work Traffic. The layout of signs and barriers would be as shown.

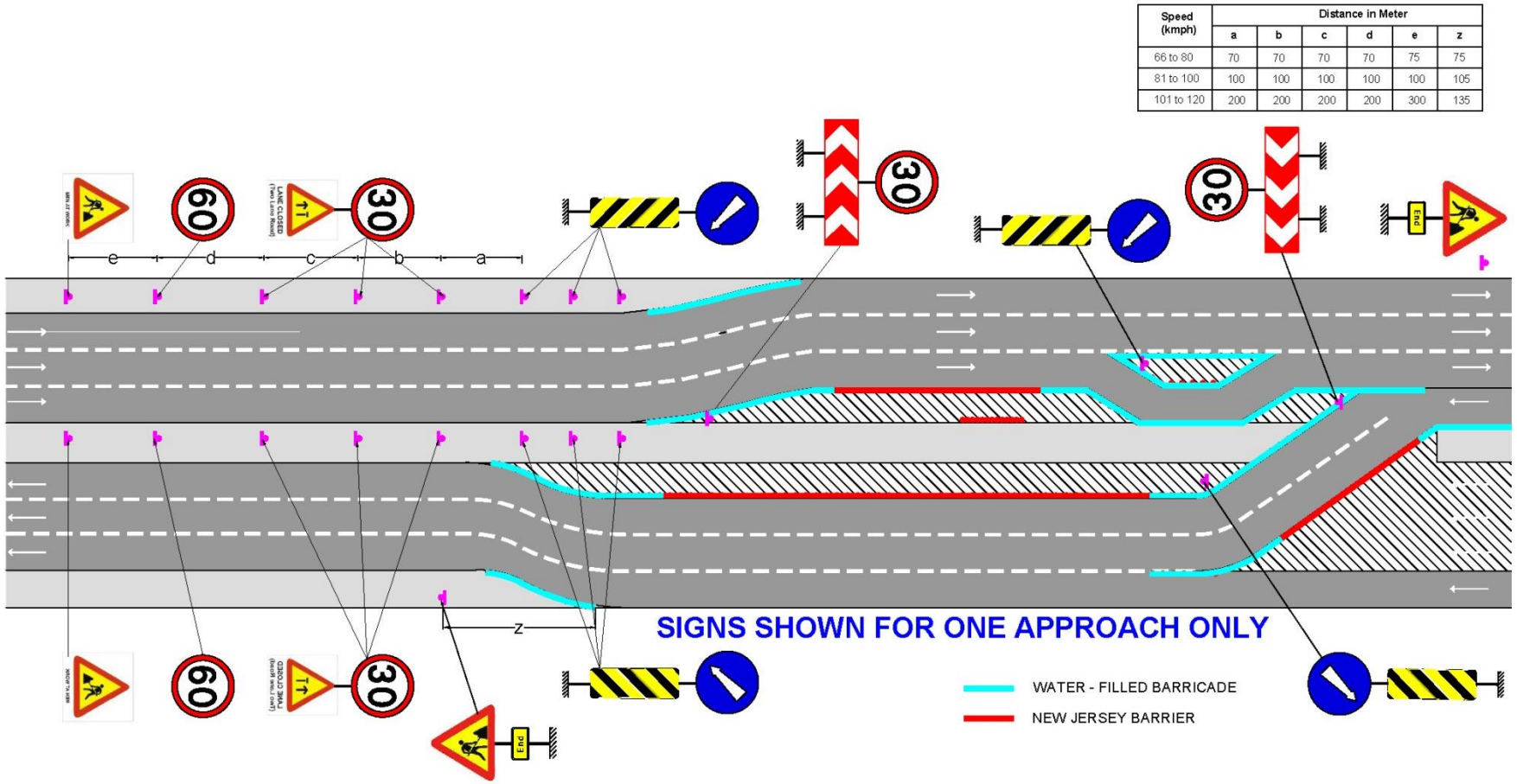


Fig. 10.26 Roadwork with Complicated Diversions & Contra Flow

APPLICATION:

The layout shown is applicable in a multi-lane highway where road works are in bits-and-piece like some works at median side and some in the center of carriageway involving even contra flow. The layout of signs and barriers would be as shown for one approach only.

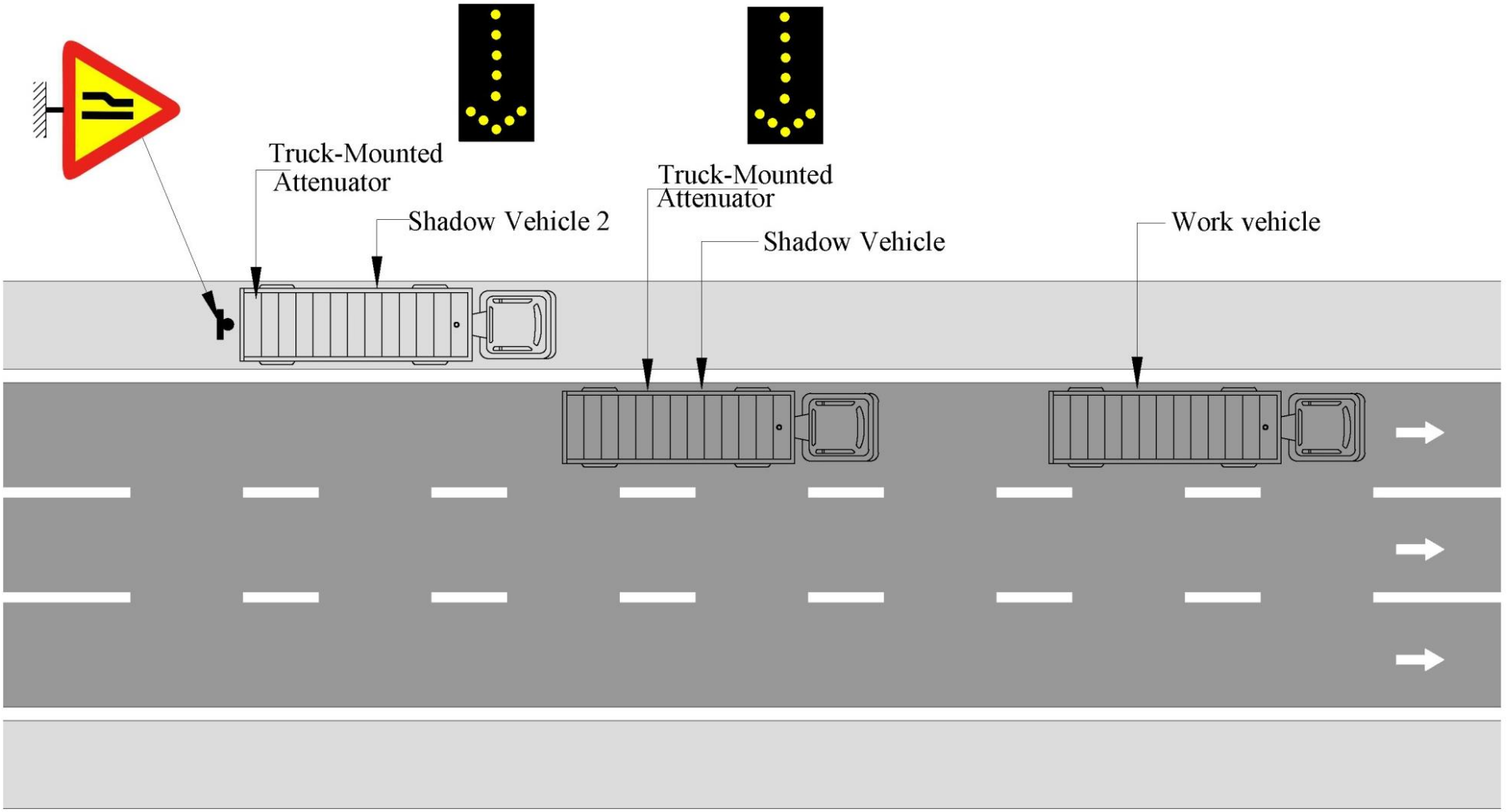


Fig. 10.27 Roadwork vehicle, Truck Attenuators & Shadow Vehicle

APPLICATION:

The layout shown is applicable in a multi-lane high speed highway showing work vehicles, shadow vehicles and truck mounted attenuators (CDC, 2003)

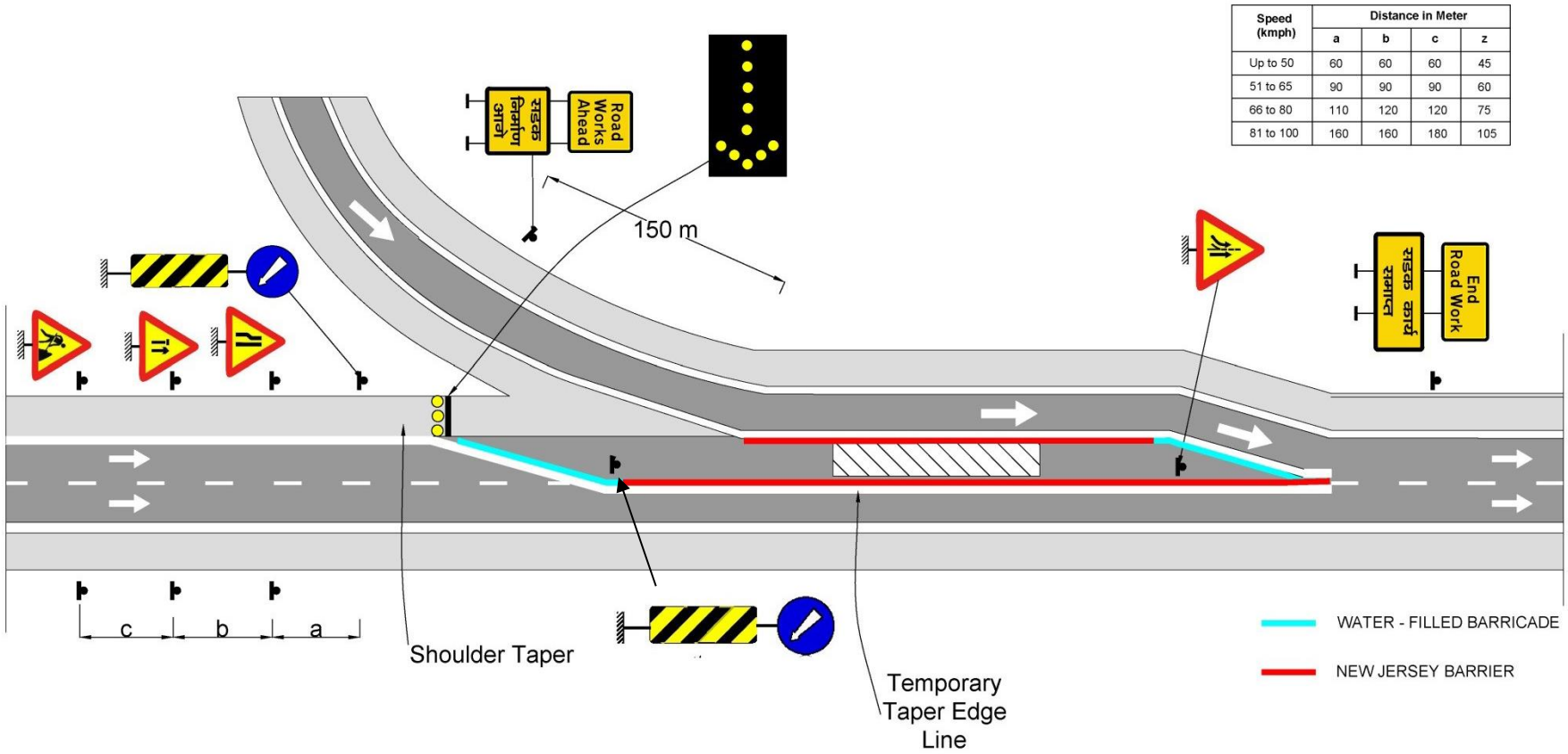
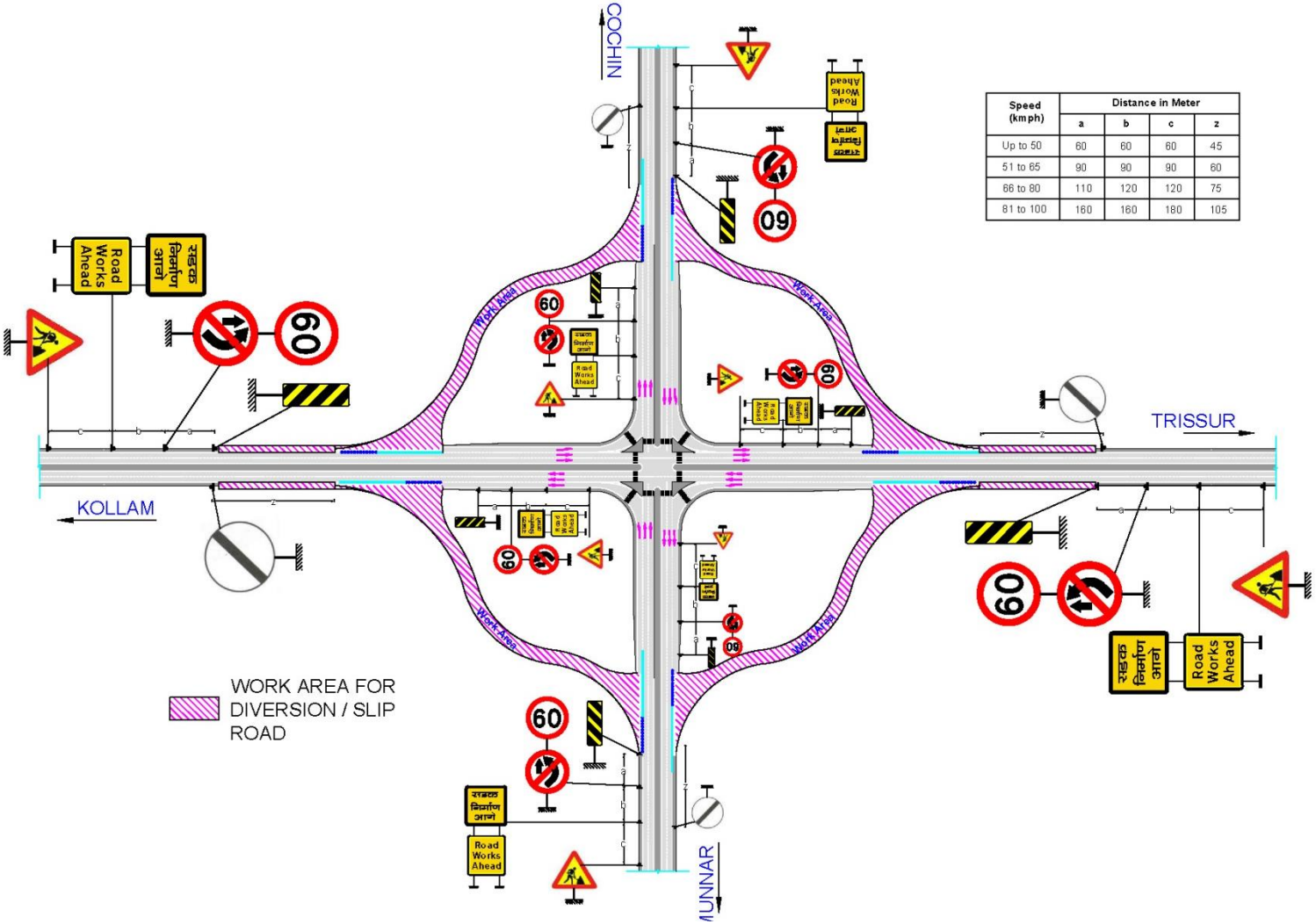


Fig. 10.28 Roadwork near entry ramps with Arrow Panel Display

APPLICATION:

The layout shown is applicable for works involving curtailing of one lane for through movement warned with arrow displayed messages near an entry ramp.



Speed (kmph)	Distance in Meter			
	a	b	c	z
Up to 50	60	60	60	45
51 to 65	90	90	90	60
66 to 80	110	120	120	75
81 to 100	160	160	180	105

Fig. 10.29 Stage-1 of Developing Major Cross Road Junction to a Cloverleaf Interchange

APPLICATION: In the first stage of the development of a heavy trafficked major road junction to grade separated full cloverleaf interchange, the slip road in four quadrants will be constructed along with acceleration and deceleration lanes for the two major roads. During this stage, traffic will continue to ply through the existing roads and the junction. The layout of signs and barriers would be as shown.

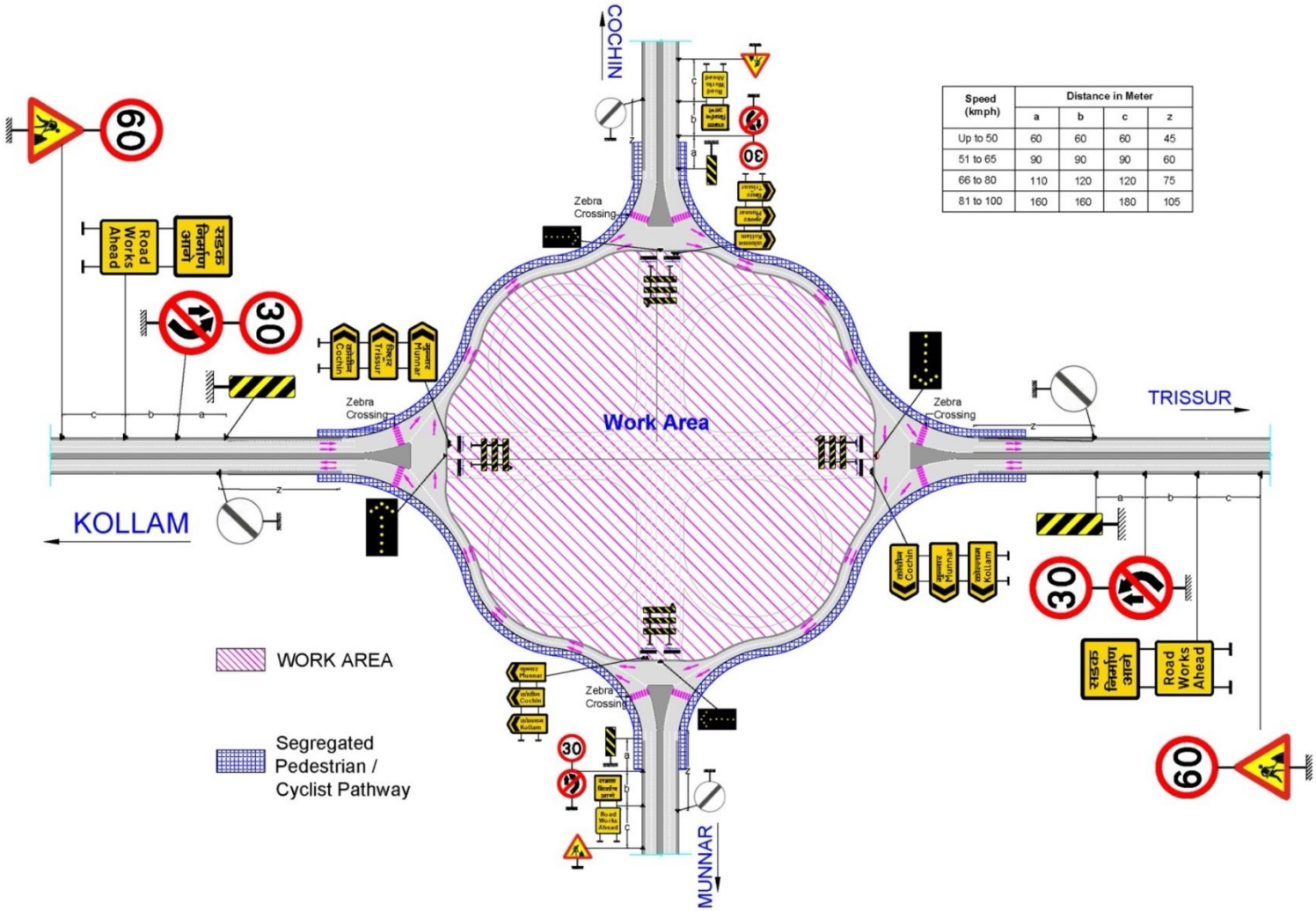


Fig. 10.30 Stage-2 of Developing Major Cross Road Junction to a Cloverleaf Interchange

APPLICATION: Once the slip roads in four quadrants are constructed, in the second stage, the traffic will be diverted into these newly developed slip roads. The major road movements through the junction will now become a circulatory system around the work area as shown in the layout, with proper direction information signs. During this stage, the central area will be taken up for construction of the structures and loops.

Section 11. Best Practices

The implementation of safety measures in highway work zones is crucial to mitigate accidents and injuries that may involve workers, motorists, pedestrians, and equipment. These safety practices encompass a set of guidelines, tips, and measures that are designed to prevent or minimize such occurrences. Highway work zones refer to locations where activities such as road construction, maintenance or utility work are being carried out on or in close proximity to a highway.

11.1 Traffic Management

a. Temporary traffic control (TTC) devices

The use of traffic control devices like cones, barrels, and barricades is essential in facilitating the smooth flow of traffic through work zones, according to the Manual on Uniform Traffic Control Devices (2009). According to the guidelines the Federal Highway Administration (FHWA) established in 2009, the use of these devices is governed by the FHWA in order to reduce confusion and ensure safety.

b. Intelligent Transportation Systems (ITS)

Chen (2013) claims that by providing current traffic data and managing traffic flow, the implementation of Intelligent Transportation Systems (ITS) has been shown to increase safety and reduce traffic congestion in work zones. Examples of traffic management technologies, such as queue warning systems, traffic monitoring cameras, and variable message signs, are given in the cited sources. (Benekohal et al., 2012; Chen, 2013).

c. Lane closures and traffic shifts

Lane closures and traffic shifts can be implemented as a useful strategy for controlling traffic in construction zones, claim Ozkul et al. (2017). To avoid avoidable delays and dangers, however, careful planning and communication are essential. According to Ozkul et al. (2017), a number of strategies are used to manage traffic flow, including alternating lane closures, contraflow operations, and temporary roadway diversions.

11.2 Safety Measures

d. Speed enforcement

The implementation of lower speed limits in work zones has improved safety measures for both drivers and workers, according to Garber and Zhao's (2002) research. Retting et al. (2008) found that automated systems for enforcing speed limits, like speed cameras, were successful in reducing speeding.

e. Work zone signage and visibility

Zech et al. (2010) assert that the use of effective signage can effectively inform drivers of the presence of work zones, ultimately resulting in a reduction in the likelihood of accidents. Schneider et al. (2016) claim that the use of high-visibility clothing and tools can improve worker safety.

f. Pedestrian and bicyclist accommodations

Effective planning and design strategies can reduce potential conflicts between motorists, pedestrians, and bicyclists in construction zones, claim Zegeer et al. (2011). The installation of temporary sidewalks, bike lanes and clearly marked crossings is essential for ensuring accessibility and safety, according to Zegeer et al. (2011).

11.3 Worker Protection

g. Worker training

Wang et al. (2012) claim that implementing training programs centered on hazard recognition, work zone safety, and emergency response has the potential to improve worker safety. Guidelines for the implementation of such programs have been established by OSHA, an organization tasked with ensuring safe and healthy working conditions for employees (OSHA, 2011).

h. Personal protective equipment (PPE)

Personal Protective Equipment (PPE) like safety goggles, high-visibility vests, and hard hats can significantly reduce the risk of harm to workers, according to Schneider et al. (2016). Personal protective equipment (PPE) must undergo routine inspections and maintenance, according to Schneider et al. (2016), to ensure its effectiveness.

11.4 Conclusion

These are a few illustrations and suggestions for the best safety measures for road construction zones that can improve their functionality and outcomes. Before implementing any suggested course of action, users must take into account the specific requirements and characteristics of the given scenario. It is recommended for users to consult experts or other sources for guidance and additional information.

Some examples of highway work zone safety best practices are:

- **5 Highway Work Zone Safety Best Practices** (urbint.com): provides a list of best practices for worker safety in highway work zones, such as:
    - Ensure proper work zone layout
    - Prioritize work zone safety training
    - Scrutinize clothing and equipment
    - Create an internal traffic control plan
    - Control for aggressive driving
- **Highway Work Zone Safety** This resource offers guidance and materials to enhance the safety of highway work zones for workers, employers, researchers, and partners. The resource additionally furnishes statistical information and data pertaining to fatalities and injuries occurring in highway work zones, alongside details concerning the visibility of construction equipment.
- **Work Zones Safety Tips** provides tips for drivers to stay safe while traveling through work zones, such as:
    - Research your route and avoid work zones when possible
    - Pay attention to signs, signals, and flaggers
    - Slow down and obey speed limits
    - Keep a safe distance from other vehicles and workers

  - Expect the unexpected and be prepared to stop
- **Few Steps to Improve Highway Work Zone Safety** provides suggestions for contractors and project owners to enhance highway work zone safety, such as:
  - Set up work zones in a way that maximizes protection for workers.
  - Complete work at night whenever possible to minimize traffic volume and distractions.
  - Use technology and innovation to improve communication and visibility.

Section 12. References

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Annexure – I

In designing work zone regulatory and warning signs, as well as informatory and temporary direction information signs, the size of lettering and the location of road signs must be appropriately related to the expected point of action and the approach speed to that point. Drivers traveling at different speeds must be able to see and read the sign, allowing them time to react and maintain adequate control of their vehicle by seeing the sign far enough ahead of the action point. The letter sizes given in **Table 5.3** for the upper case based on the minimum clear visibility distance and speed operation can be obtained using the Equations 1-3 and **Fig. I.1.**

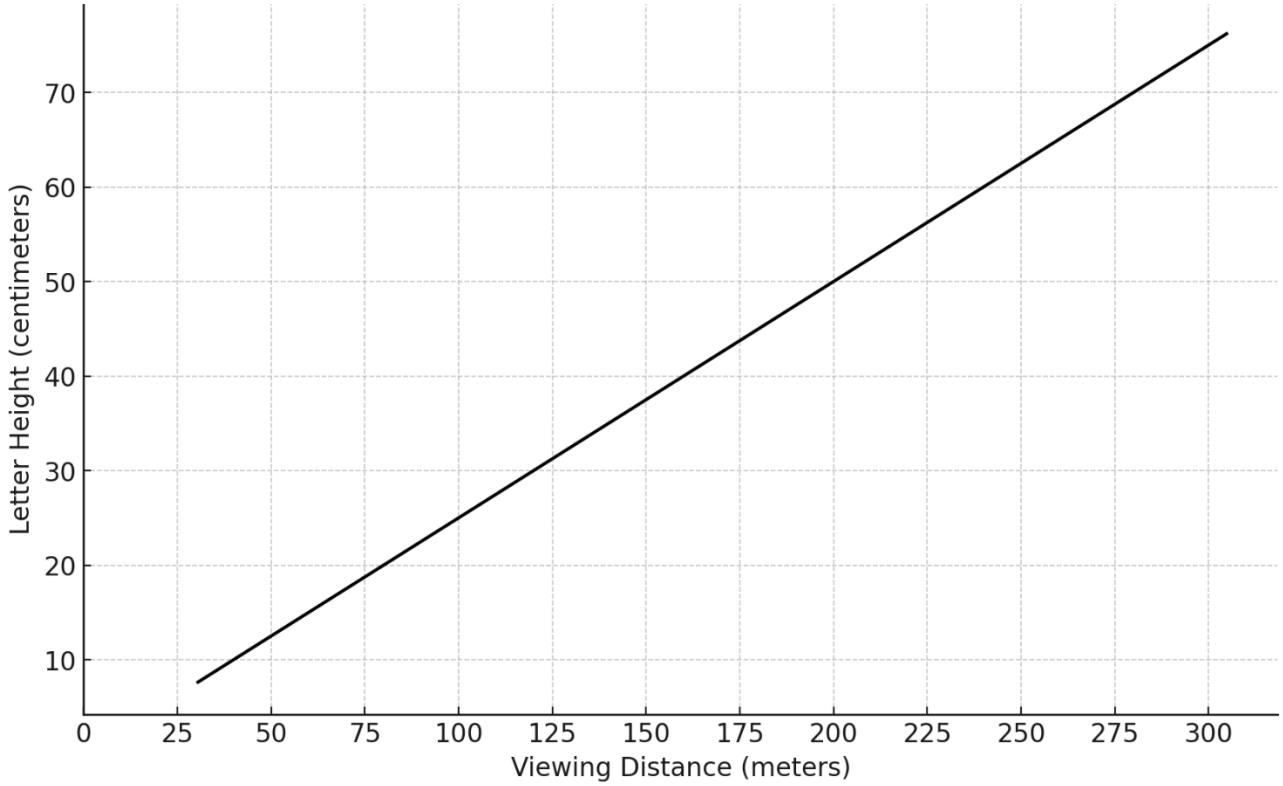

Fig. I.1 Minimum letter size recommended for the design of sign boards (Source: Woodson and Conover 1966)