



Rural Road Safety Course



Approach and Methodology to Road Safety Audit/ Audit Procedure

SAFETY AUDIT – A Definition

IRC 88: 2019

Safety Audit is a formal, systematic and detailed examination of a road project by an independent and qualified team of auditors that leads to a report of the potential safety concerns in the project



History of Road Safety Audit (RSA)

- RSA began in late 1980 in a County in England when questions were raised on the increasing number of Accidents on new roads built in Country
- A Policy was developed to check all new road designs in the County and approved for Safety by Road Safety Engineers (RSE) team prior to construction
- Similar procedures and policies spread throughout other British Road Agencies and the first “Road Safety Manual” was published by the Institution of Highways and Transportation (IHT) in late 1990s to guide and encourage the new process
- RSA expanded initially in Australia, New Zealand and Denmark and after that to other countries like Malaysia, Singapore, South Africa, India, etc

What is Safety Audit ?

- A formal process (not just an informal check)
- Conducted by persons who are independent of the design
- Conducted by persons with appropriate qualification, training and experience
- An assessment of road safety issues in a road design, a Traffic Management Plan for road works, a newly completed road scheme, or it can also be the identification of safety concerns on an existing road



What Safety Audit is Not ?

- A check of compliance with standards
- A substitute for regular design checks
- A crash investigation
- An opportunity to re-design a project
- A name for a more detailed site inspection
- A way of assessing or rating a project as good or bad



Safety Audit Vs Crash Investigation

Road safety audits are proactive – they try to identify safety issues in a road design. The objective here is accident / crash prevention

Road crash investigations are reactive – they examine known crash sites and use crash data to develop cost-effective countermeasures. The objective here is accident / crash reduction



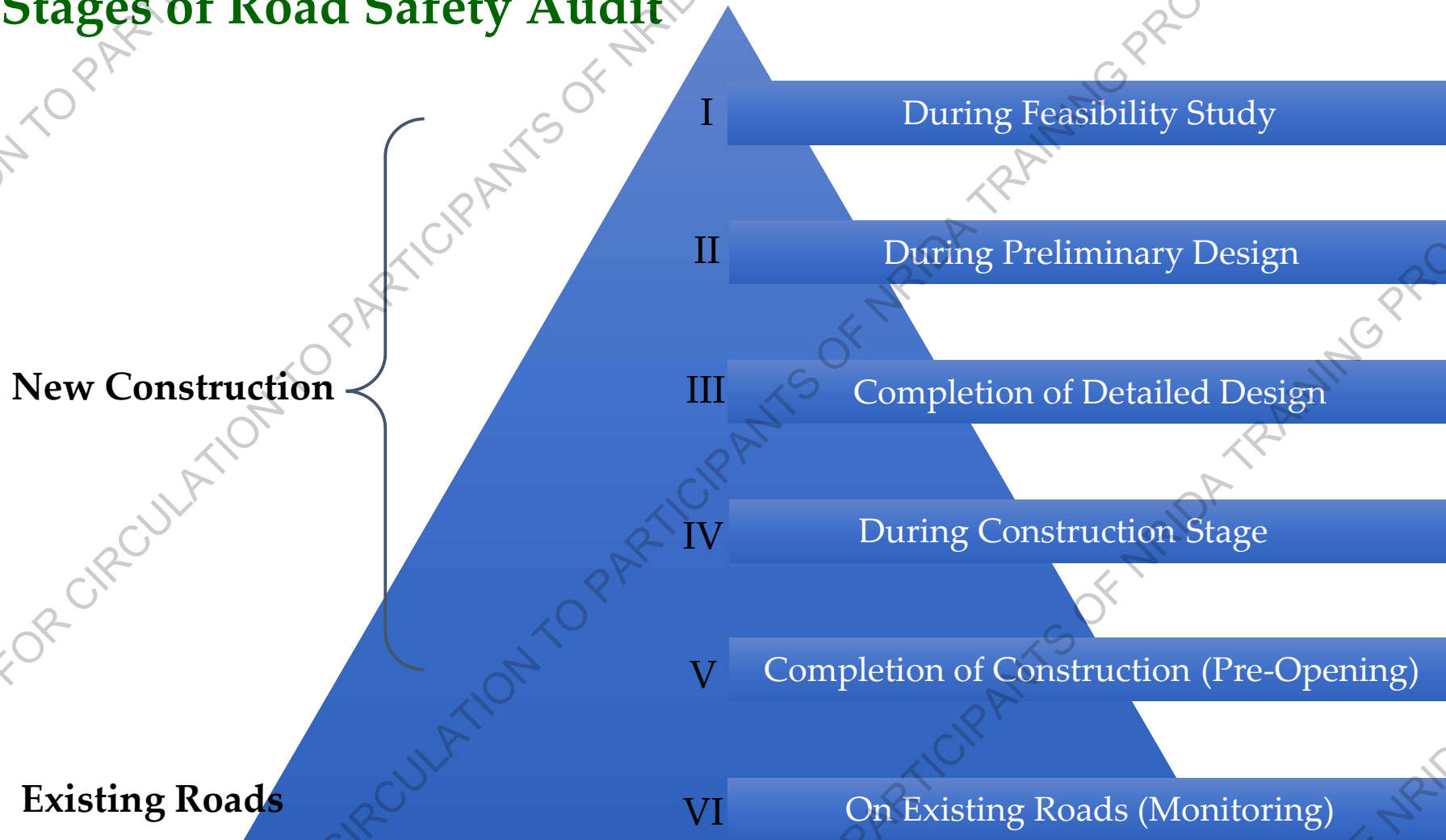
A Good Safety Audit

- Focus is on road safety issues only
- Keep relevant standards and guidelines in mind while remembering that audit is more than compliance check with standards
- Consider the needs of all road users (including pedestrians, two/three wheelers, animal drawn vehicles, depending upon their presence and proportion in the traffic) in all weather and lighting conditions
- It is thorough and comprehensive
- It is realistic and practical in findings
- But do not rule out options because of cost - it is the road authority that will decide whether the investment can be justified
- Produce audit report promptly - usually within four weeks of the audit inspection

Road Safety Audit



Stages of Road Safety Audit



Suggested Road Safety Audit Policy (IRC SP88)

Audit	Tollways / Expressways	National Highways	State Highways	Major District Roads	Urban Arterial, Sub Arterial and Collector Roads	Local Streets, Rural Roads
Planning	✓	Optional	Optional	Optional	Optional	N/A
(DPR) Design*	✓	✓	✓	✓	✓	✓
Construction	✓	✓	✓	Optional	Optional	Optional
Pre-opening	✓	✓	✓	Optional	✓	Optional
Existing Roads	According to local policy and resources					

Setting up this policy is very important

Planning/Feasibility Stage Audit

An audit on completion of the planning or feasibility study stage will examine features such as

- Design standards
- Horizontal and vertical alignments,
- Cross sections
- Interchange/intersection layouts
- Careful auditing at this early design stage can help to reduce the costs and lost time associated with changes that may otherwise be brought about during later audits

Why Planning Stage Safety Audit ?

- Works on a principle of “Prevention is better than cure”
- Aims to identify safety concerns in road design while they are still pencil lines on a piece of paper
- By making changes at the Design Stage we aim:
 - To reduce/minimize risks to future road users of that road
 - To reduce long term cost of scheme. Unsafe designs may be expensive or even impossible to correct at a later stage

Detailed Design Stage Audit

This occurs on completion of the detailed road design (the final DPR) but before the preparation of contract documents. This stage will examine features such as

- Geometric layout
- Pavement markings
- Signals
- Lighting
- Road signages
- Intersection/Interchange designs
- Clearances to roadside objects (Crash barriers)
- Provision for vulnerable road users

Table 2.2 Width of Median

Type of Section	Minimum Width of Median (m)		
	Plain and Rolling terrain		Mountainous and Steep terrain
	Raised*	Depressed median	Raised*
Open country with isolated built-up area	5.0	7.0	2.50
Built up area	2.50	Not Applicable	2.50
Approach to grade separated structures	5.0	Not Applicable	2.50

Table 2.5 Extra Width of Pavement and Roadway in Each Carriageway

Radius of Curve	Extra Width
75-100 m	0.9 m
101-300 m	0.6 m

Super Elevation shall be limited to 7 percent, if radius of curve is less than desirable minimum radius. It shall be limited to 5 percent, if radius is more than desirable minimum.

Table 2.6 Radii of Horizontal Curves

Nature of Terrain	Desirable Minimum Radius	Absolute Minimum Radius
Plain and Rolling	400 m	250 m
Mountainous and Steep	150 m	75 m

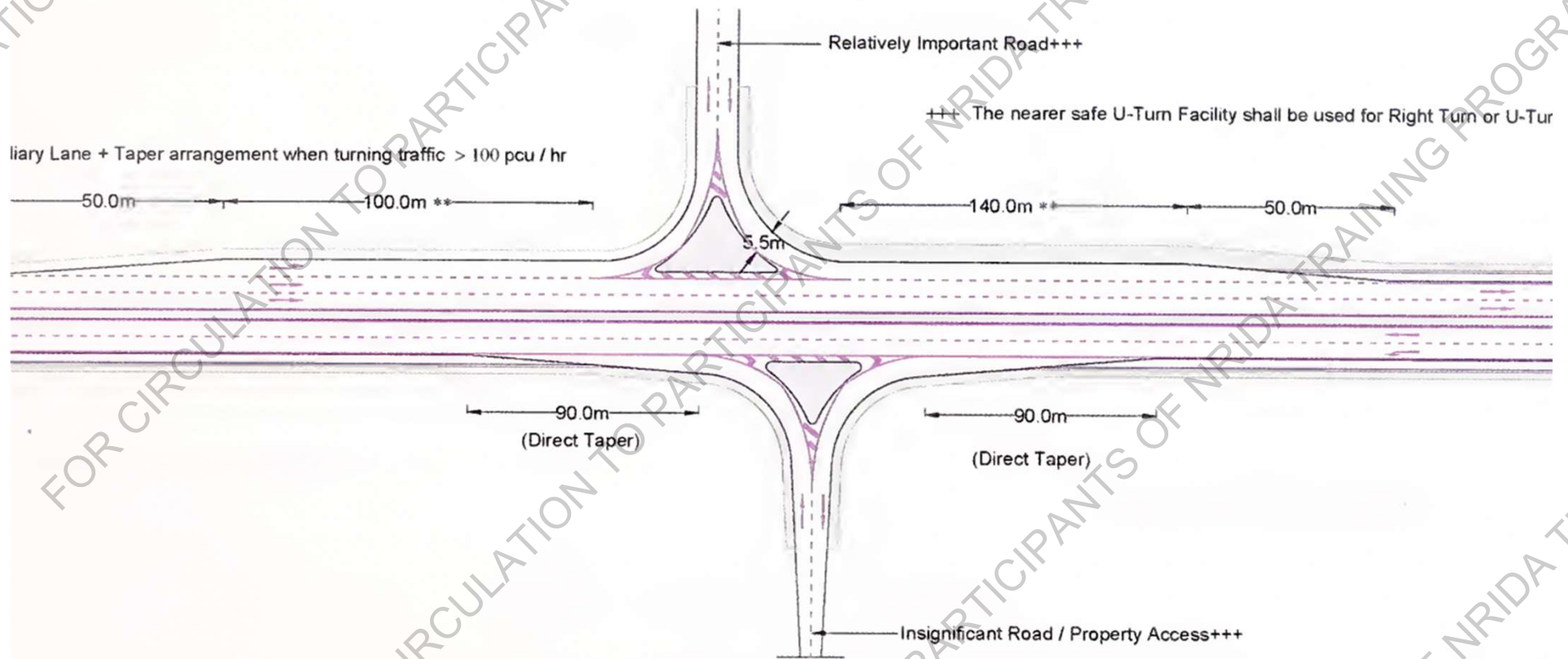


Fig 3.5 : Left-in/Left out Arrangement

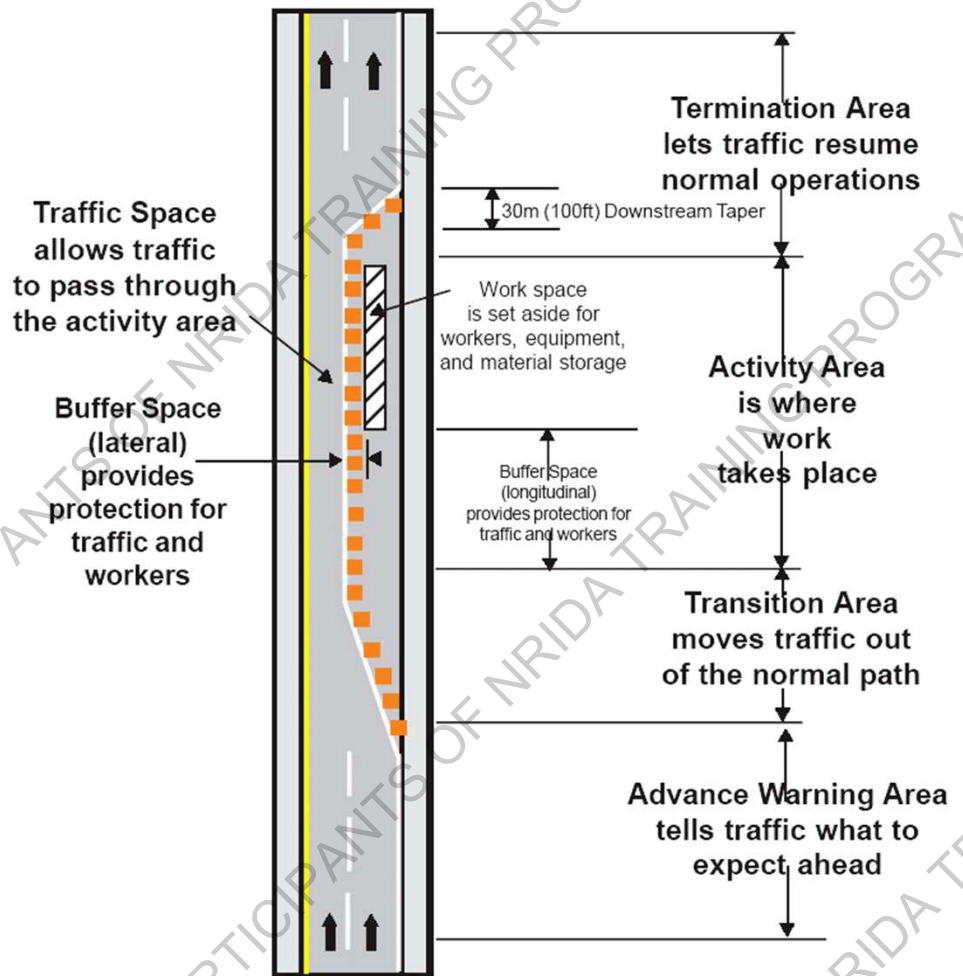
Construction Stage Safety Audit

This takes place during construction of the road works. This stage will examine features such as

- Safety of the traffic management plans for each phase of construction for large road projects (i.e. before the works begin)
- Inspects the provisions for road safety at the road work site during the construction period
- Provisions for pedestrian safety
- Advanced warning zones, adequate transition zone lengths
- Worker safety
- Effective numbers of reflective signs
- Safe delineation

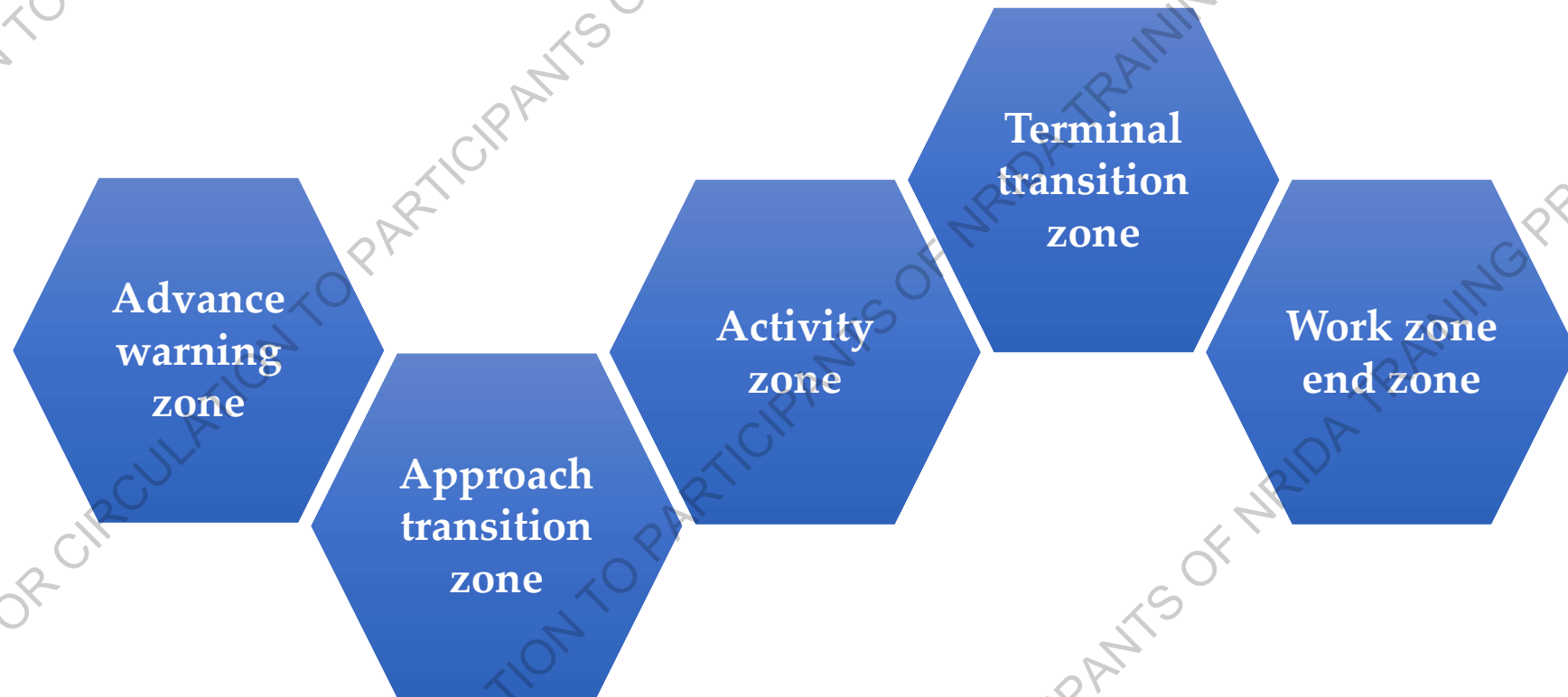
Temporary Traffic Control Zones

- Temporary Traffic Control Zone means the area of a roadway where traffic conditions are changed temporarily by the use of temporary traffic control devices, flaggers, police or other authorized personnel for facilitating the road works and to manage 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 Zones

Elements of Temporary Traffic Control Zones



Temporary Traffic Control Zones



Elements of Temporary Traffic Control Zones

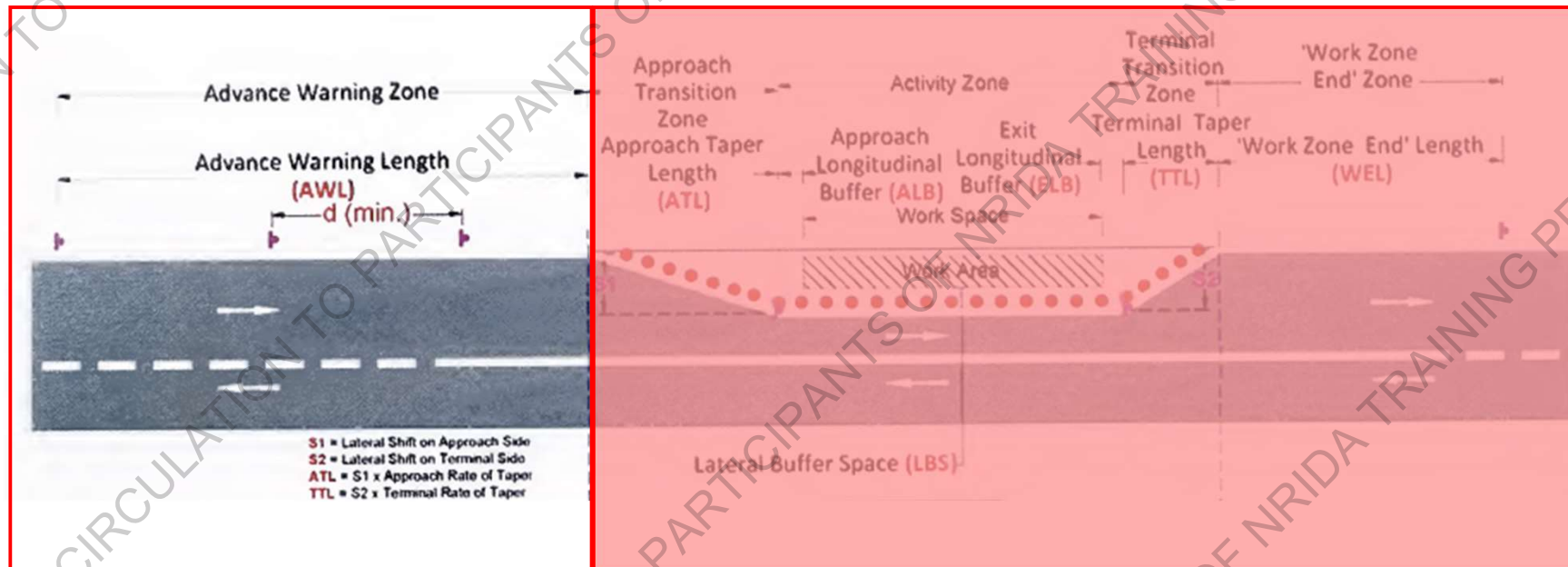
- The "Advance Warning Zone" is the area to warn the road user of the approaching hazard and to prepare them for the change in driving conditions.
- It should provide information on:
 - ✓ The presence of the hazard through the "Men at Work" sign, accompanied by the distance to the hazard;
 - ✓ Any change 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);
 - ✓ The type of hazard etc.
- The advance warning zone is where the reduction in speed of vehicles should be notified.
- The information in this zone is conveyed through a series of traffic signs along the length of the zone.



Temporary Traffic Control Zones

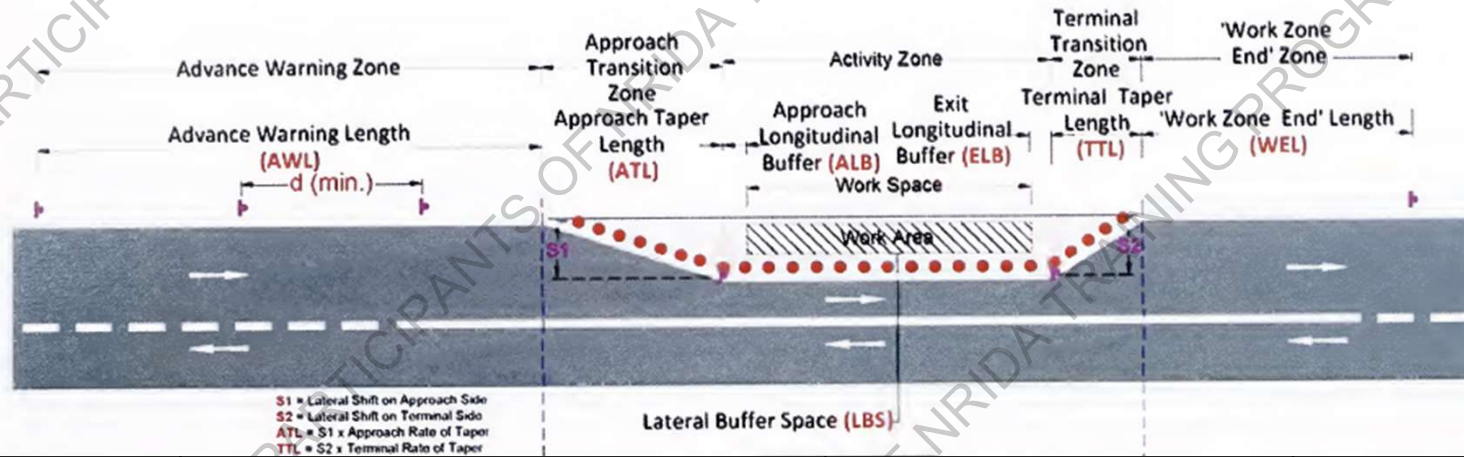


Elements of Temporary Traffic Control Zones



Advance warning zone

Temporary Traffic Control Zones



Speed at the start of traffic Control Zones (kmph)	Advance Warning Zone		Transition Zone						Activity Zone				Work end Zone	Distance Between Sites in Km		
	Advance warning Length (AWL) (m.)	Min. Distance between two successive signs, d (m.)	Approach Taper length (ATL) (m.)				Terminal Taper length (TTL) (m.)		Radius in Case of Circular curves (m.)	Buffer Space			Work Space	Work Zone End Length (WEL)	Desirable	Exceptional
			Rate of Taper	For width of hazard (S1) (m.)		Rate of Taper	For Lateral Shift (S1) (m.)			Min. Approach longitudinal Buffer (ALB) (m)	Min. exit longitudinal Buffer (ELB) (m)	Min. Lateral Buffer Space (LBS) (m)				
				2	4		2	4								
Up to 50	180	40	1:12	24	48	1:10	20	40	30	10	5	0.5	Varies	45	2	1
51 to 65	270	55	1:15	30	60	1:12	24	48	90	15	10	0.9		60	5	2
66 to 80	350	80	1:18	36	72	1:15	30	60	165	30	15	1.2		75	10	5
81 to 100	500	100	1:20	40	80	1:18	36	72	250	60	30	1.2		105	10	5
101 to 120	1100	120	1:25	50	100	1:20	40	80	400	100	60	1.5		135	10	5

Temporary Traffic Control Zones



Elements of Temporary Traffic Control Zones



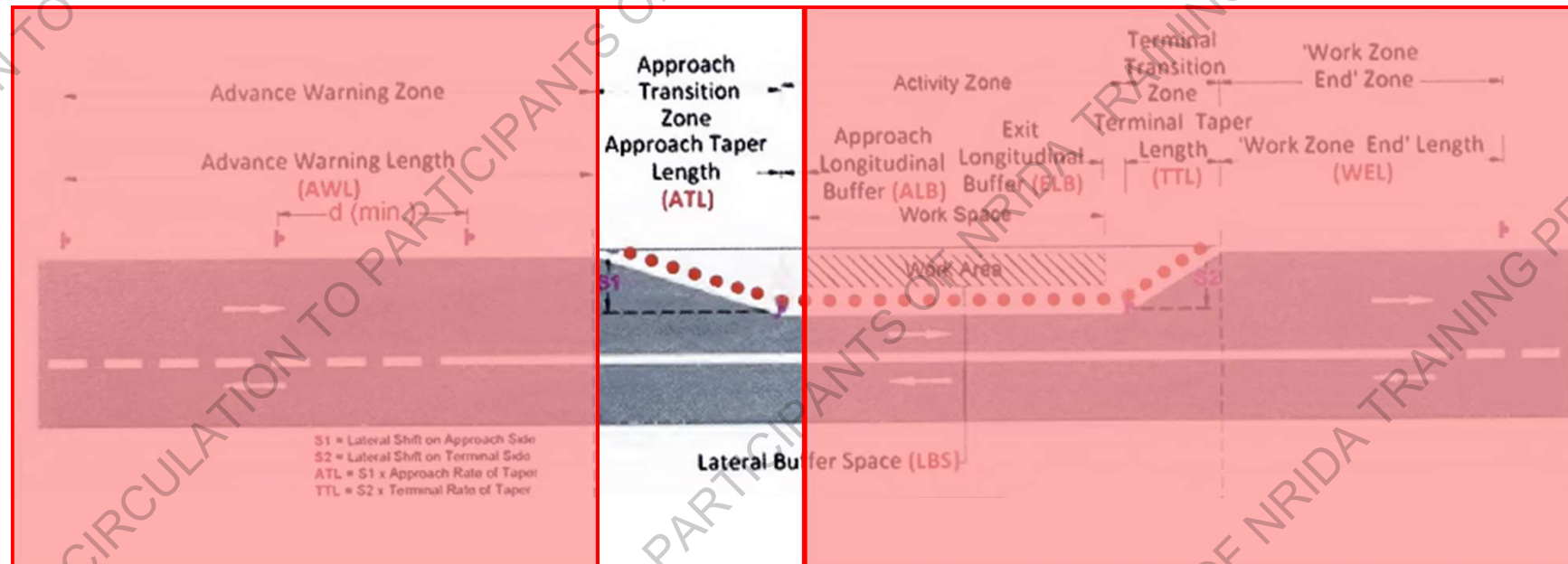
Approach
transition
zone

- 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 vehicle from the normal pathway can be achieved by strategic use of tapers or with circular curves.
- Tapers are created by using a series of channelizing devices and/or pavement markings to move traffic out of or into the normal path.

Temporary Traffic Control Zones



Elements of Temporary Traffic Control Zones



Approach
transition
zone

Temporary Traffic Control Zones



Elements of Temporary Traffic Control Zones



- The activity zone is the section of the highway where the construction activity takes place.
- It comprises the work space, the traffic space, and the buffer space.
- **Work Space**
 - ✓ The work space is that portion of the highway closed to road users and set aside for workers, equipment, and material.
 - ✓ Work spaces are usually delineated for road users by channelizing devices or to exclude vehicles and pedestrians in the work space by temporary barriers.
 - ✓ The work space may be stationary or may move as work progresses, and therefore, the length of the work space may vary.

Temporary Traffic Control Zones



Elements of Temporary Traffic Control Zones

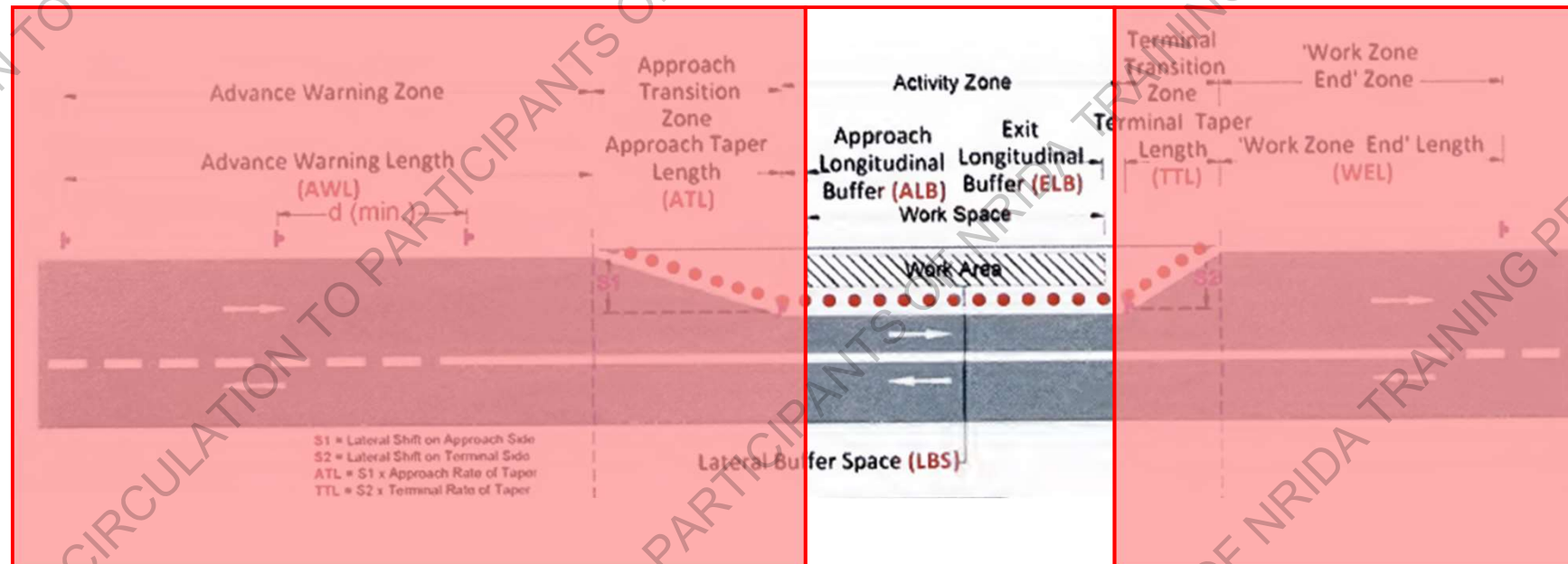


- **Traffic Space**
 - ✓ The traffic space is the portion of highway in which road users are routed through the activity zone.
 - ✓ This space should be determined and designed keeping in mind the traffic expected to move through the activity zone.
- **Buffer Space**
 - ✓ The buffer space is a lateral and/or longitudinal length/width that separates the normal traffic flow from the work space or an unsafe area, and might include some recovery space for an errant vehicle.
 - ✓ Neither work activity nor storage of equipment, vehicles, material should occur within buffer space.
 - ✓ Buffer spaces may be positioned either longitudinally or laterally with respect to the direction of traffic flow.

Temporary Traffic Control Zones

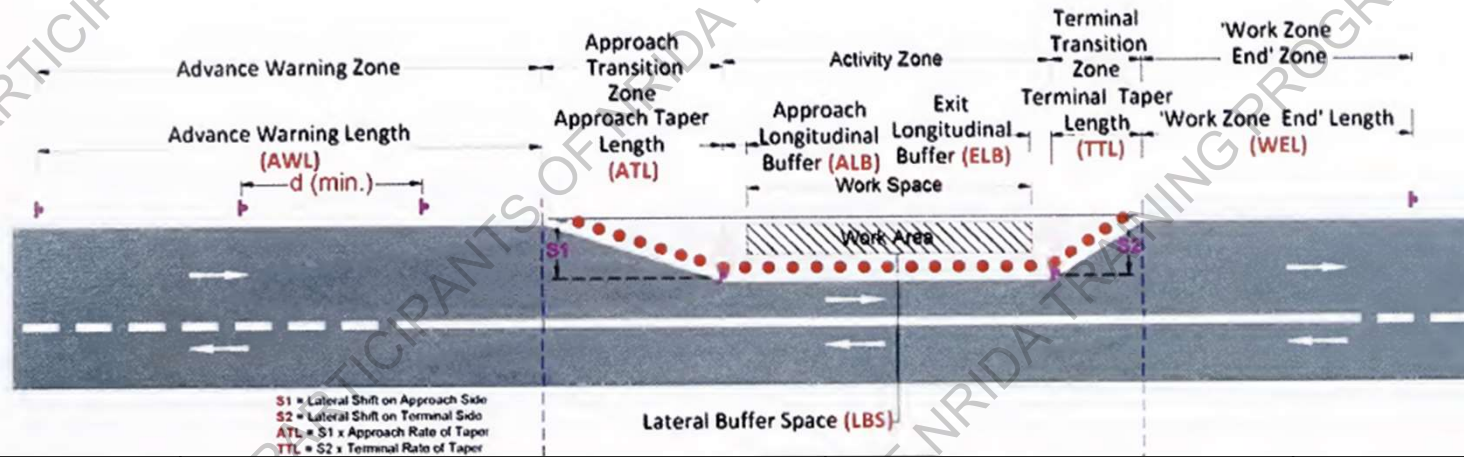


Elements of Temporary Traffic Control Zones



Activity
zone

Temporary Traffic Control Zones



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Temporary Traffic Control Zones



Elements of Temporary Traffic Control Zones

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.
- It also can be achieved through tapering or through circular curves.

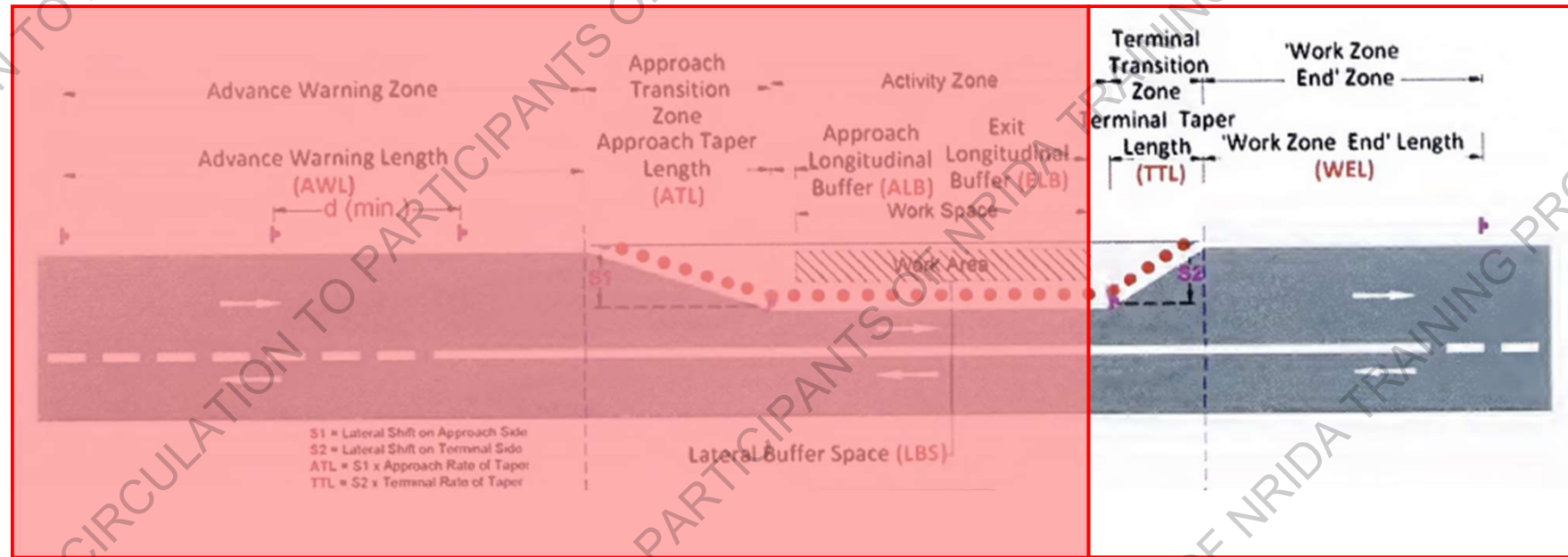
Work zone end zone

- 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.
- 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.

Temporary Traffic Control Zones



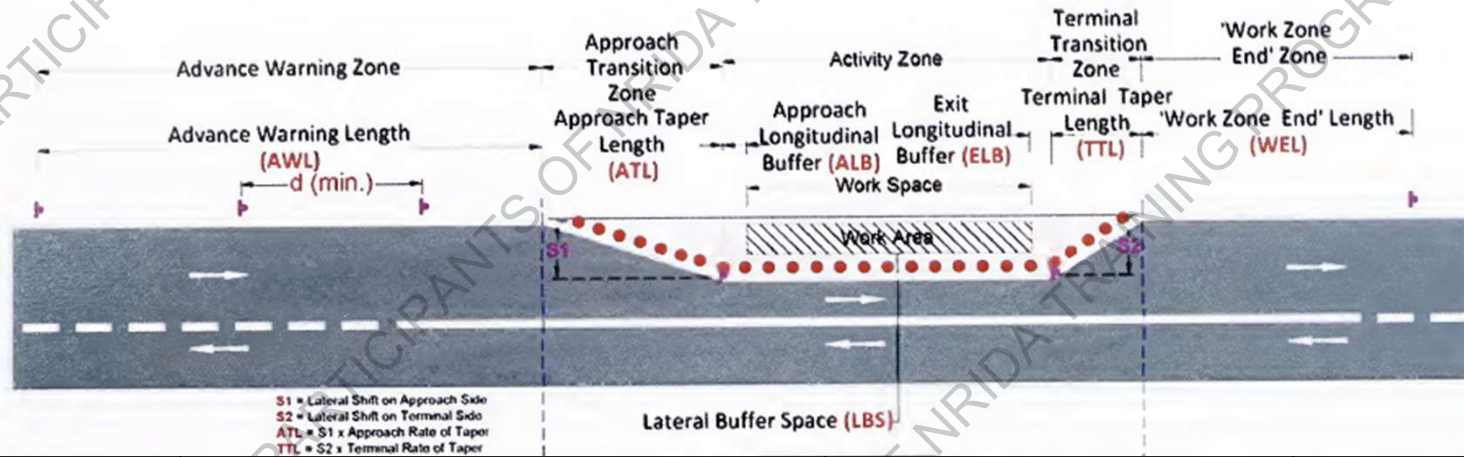
Elements of Temporary Traffic Control Zones



Terminal transition zone

Work zone end zone







Temporary Traffic Control Zones



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Traffic Control Devices

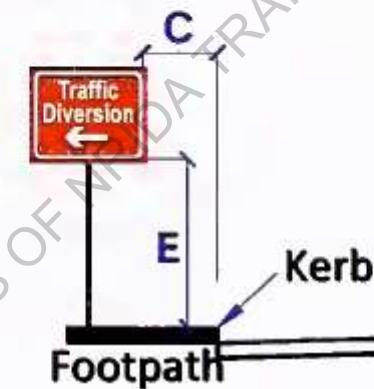
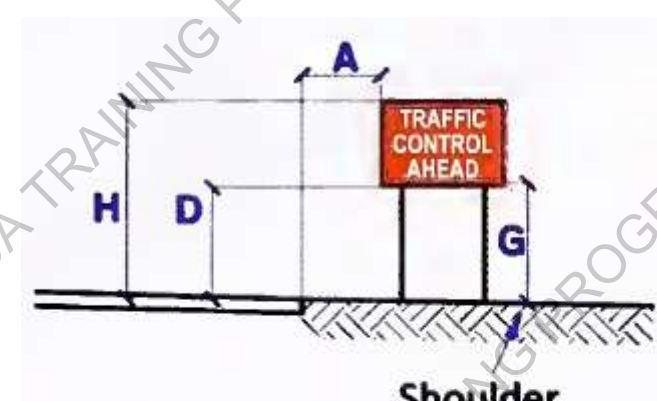
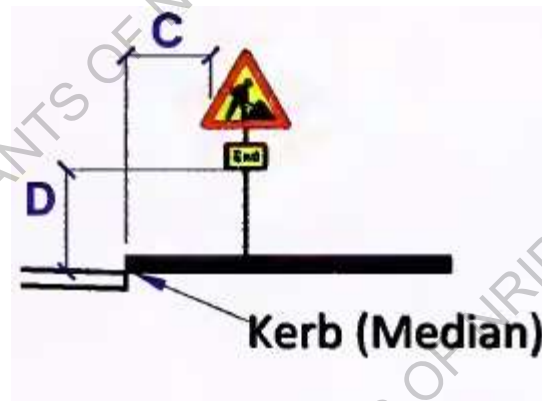
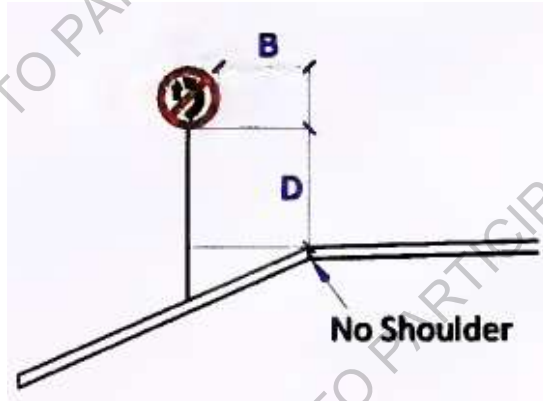
Road Signs - Shape color of signs in WTMP

Category		Color	Shape	Examples
Regulatory/ Mandatory	Normal Regulatory (NR) Signs	As given in IRC:67-2012	Circular	
	Work Zone Regulatory (WR) Signs	Red & White	Rectangular	
Warning Sign	Normal Warning (NW) Signs	As given in IRC:67-2012 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 on Signs (DS)	Black & Yellow	Rectangular	

Traffic Control Devices



Road Signs – Lateral & Vertical Clearance



	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

Traffic Control Devices



Road Signs – Regulatory Signs

These signs are used in work zones to instruct road users of traffic laws or regulations and to indicate the applicability of legal requirements that would not otherwise be apparent.



Stop sign is used where traffic is required to stop as per temporary traffic management plan.

Give way sign used to assign right-of-way to the vehicles controlled by the sign must give way to other traffic having the right of way due to road works.



No Parking sign is used on the roads to prevent any parking of vehicles on the main carriageway which will lead to congestion.

Speed limit is used to prescribe the speed limit and warrants reduction in the speed on approaches.



Pedestrian sign is used where only pedestrians are allowed and the traffic is not allowed on this portion of street due to temporary traffic management.

Traffic Control Devices



Road Signs – Warning Signs

- The warning signs in work zone are classified into two categories namely normal triangular warning signs and work zone specific warning signs.
- 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 work zone warning sign shall be in black arrows/border/text in yellow background.



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



Sign to warn that school in work zone area.



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

Sign to indicate road suddenly narrows due to road Construction.



Sign is displayed when men or machines are working on the road or adjacent to it.



Traffic Control Devices



Road Signs – Informatory Signs

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.



Sign to indicate the footpath for pedestrian to walk.



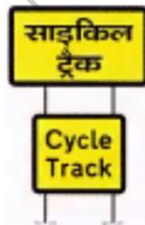
Sign to warn that footpath has been closed due to roadwork.



Sign is to inform that priority has been given to forward movement and traffic in opposite direction is expected to yield.



Sign to inform pedestrians to proceed the arrow leading to.



Sign to inform of cycle track and for a facility for cyclist to avail.

Traffic Control Devices



Channelizing Devices

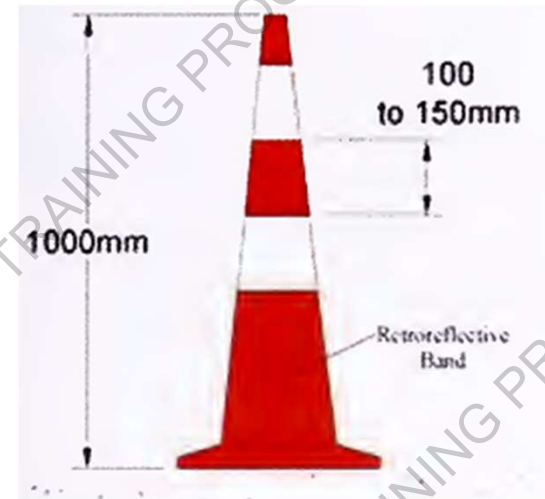
- Channelizing devices facilitate smooth and gradual movement of road user from one lane to another, onto a bypass or detour, or into a narrower traveled way.
- They are also used to separate vehicular traffic from the work space, pavement drop-offs, pedestrian or shared-use paths, or opposing directions of vehicular traffic.
- These devices shall be detectable to road users and visible to persons having low vision.
- 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.

Traffic Control Devices



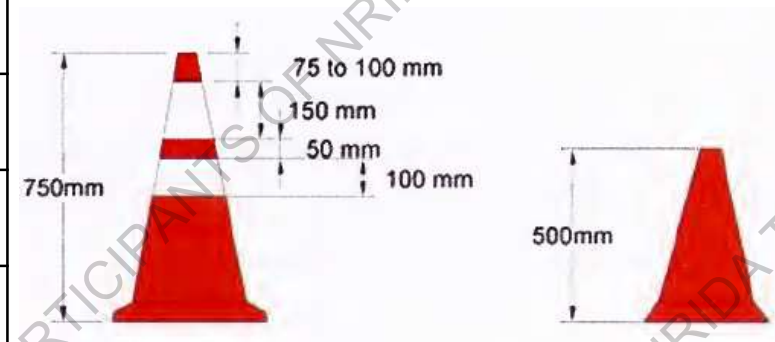
Channelizing Devices – Traffic Cones

- The traffic cones are ideally proposed for temporary works and maintenance activities.
- The traffic cones are easily portable and can be used at places where they are required to be installed and dismantled quite often.
- The application of traffic cones on roadways for various speeds are described in the table below-



Speed	Size	Cones in Transition Area	Cones in Straight Portion
Upto 65 kmph	500 mm	1.5 m	9 m
66- 100 kmph	750mm	1.5 m	9 m
> 100 kmph	1000 mm	1.5 m	9 m

A minimum 300 mm clear distance shall be provided from the traffic edge lane marking to the traffic cones

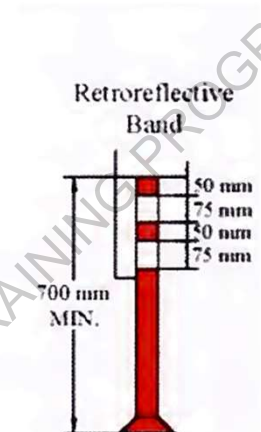
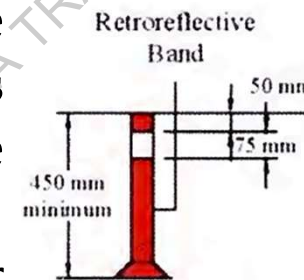


Traffic Control Devices



Channelizing Devices – Tubular Markers

- These 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.
- To delineate the edge of a pavement drop-off where space limitations do not allow the use of larger devices.
- These tubular structures shall be flexible plastic bollards.
- Tubular markers are suitable in urban or in rural sections where pedestrian and cyclist movements are there due to abutting roadside activities.

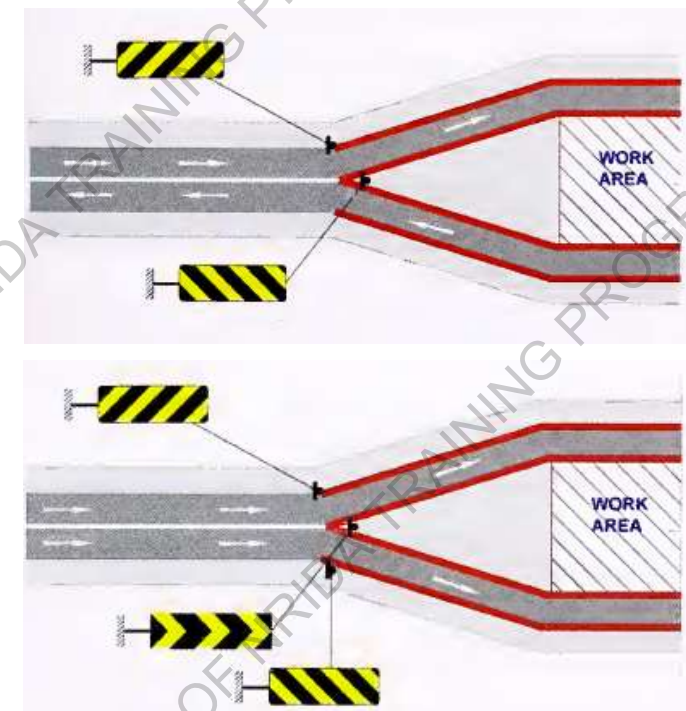


Traffic Control Devices

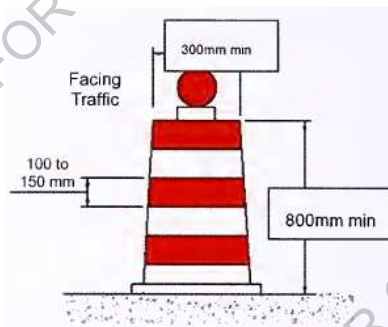


Channelizing Devices – Hazard Markers

- The hazard markers shall be alternating yellow and black retro-reflective stripes, sloping downward at an angle of 45 degrees in the direction of vehicular traffic.
- 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 also at location of diversion.



Channelizing Devices – Drums



- Drums are lightweight with deformable materials.
- The application of drum delineators is permitted in work sites where there is adequate space to install drums with adequate minimum clearance distance.

Traffic Control Devices



Channelizing Devices – Barricades

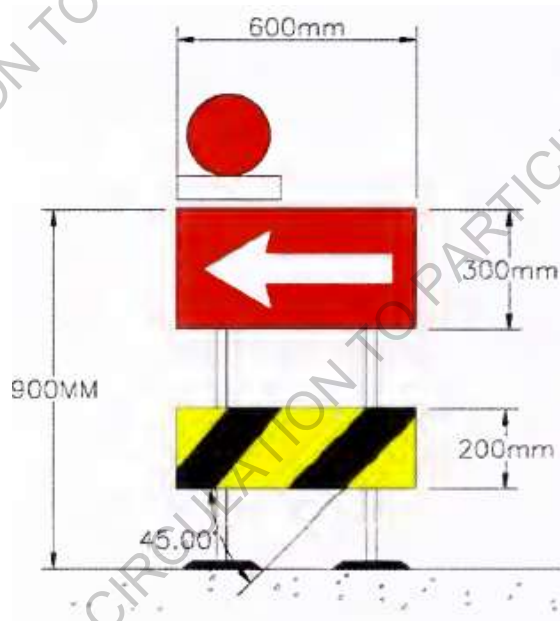
- Barricades are intended to provide containment without significant deflection or deformation under impact and to redirect errant vehicles along the barrier.
- Barricades can be portable or permanent.
- They are designed to be easily relocated and have four specific functions such as to:
 - Prevent traffic to enter work area including excavations or material storage sites;
 - Provide protection and perceived safety to both traffic as well as construction workers;
 - Separate two-way traffic; and
 - Protect construction, such as form work for culverts and other exposed objects, so as to avoid hazard to road users.



Traffic Control Devices



Channelizing Devices – Barricades



Direction Indicator
Barricade



Water-filled
Barricade



New Jersey
Barricade



Traffic Control Devices



Channelizing Devices – Delineators

- Delineators are generally combined with or are used to supplement other traffic control devices.
- 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.
- Delineators are appropriate at location where there is no edge drop at all and should serve as alignment marker so that driver can judge the carriageway edges while passing through the work zone.



Traffic Control Devices



Channelizing Devices – 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 be placed along the entire length of any surfaced detour or temporary roadway prior to the detour or roadway being opened to road users.
- The material used should be hot/cold thermoplastic or ordinary paint. The word messages like 'DO NOT PASS', 'PASS WITH CARE' and 'NO PASSING ZONE' can be written upon the pavement surface.
- The pavement markings shall be reinforced with road studs and the color of the road studs shall be amber.
- Road studs shall be used at acute temporary diversions to reinforce the temporary continuous marking and also where contra-flow situation is required to be adopted as part of work zone traffic management plan.

Traffic Control Devices



Lighting Devices

- Lighting devices are 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 - Floodlights

When construction work is being performed during nighttime, floodlights should be used to illuminate the work area, equipment crossings, and other areas as shown in the image.



Traffic Control Devices



Lighting Devices – Flashing Warning Beacons

- Flashing warning beacons are often used to supplement a traffic control device



Lighting Devices – Flashing Warning Lights

- Flashing warning lights are used to warn road users during both daylight and nighttime hours that they are approaching a potentially hazardous area.



Lighting Devices – Electric Lamps

- These are signaling devices positioned at road intersections, pedestrian crossings and other locations to control conflicting flows of traffic.



Traffic Control Devices



Portable Variable Message Sign

- Portable message signs shall be the devices with the flexibility to display a variety of messages. Each message shall consist of either one or two phrases.
- 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 portable variable message signs should be sited and aligned to provide maximum legibility.
- The primary purpose of portable variable message signs in work zones is to advise the road user of unexpected situations.

Traffic Control Devices



Portable Variable Message Sign

- Applications:
 - ✓ Where the speed of vehicular traffic is expected to drop substantially;
 - ✓ Where significant queuing and delays are expected;
 - ✓ Where adverse environmental conditions are present;
 - ✓ Where there are changes in alignment or surface conditions;
 - ✓ Where advance notice of ramp, lane, or roadway closures is needed;
 - ✓ Where changes in the road user pattern occur.



Traffic Control Devices

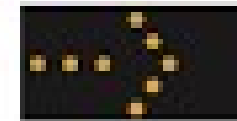


Variable Message Sign – Arrow Boards

- 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 shall have the following three mode selections:
 - A Flashing Arrow, Sequential Arrow, or Sequential Chevron mode;
 - A flashing Double Arrow mode;
 - A flashing Caution



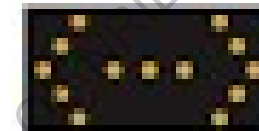
Flashing arrow



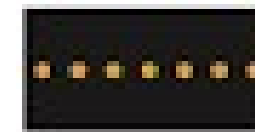
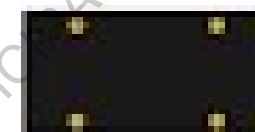
Sequential arrow



Sequential chevron mode



Flashing double arrow mode



Flashing Caution

Traffic Control Devices



Examples from Construction Sites in India



Non Standards Signs

Traffic Control Devices



Examples from Construction Sites in India



Non Reflective Signs

Traffic Management Practice at Work Zone



- To manage the traffic flow through the work zone, a number of practices are available.
- Selecting the appropriate strategy is crucial to planning of WTMP for a safe work zone.
- Common practices are listed below:
 - Alternate One Way Operations
 - Detours
 - Diversions
 - Full Road Closures
 - Intermittent Closures
 - Lane Closures
 - Median Crossovers
 - Use of Shoulder as a Travel Lane
 - Night Construction

Traffic Management Practice at Work Zone



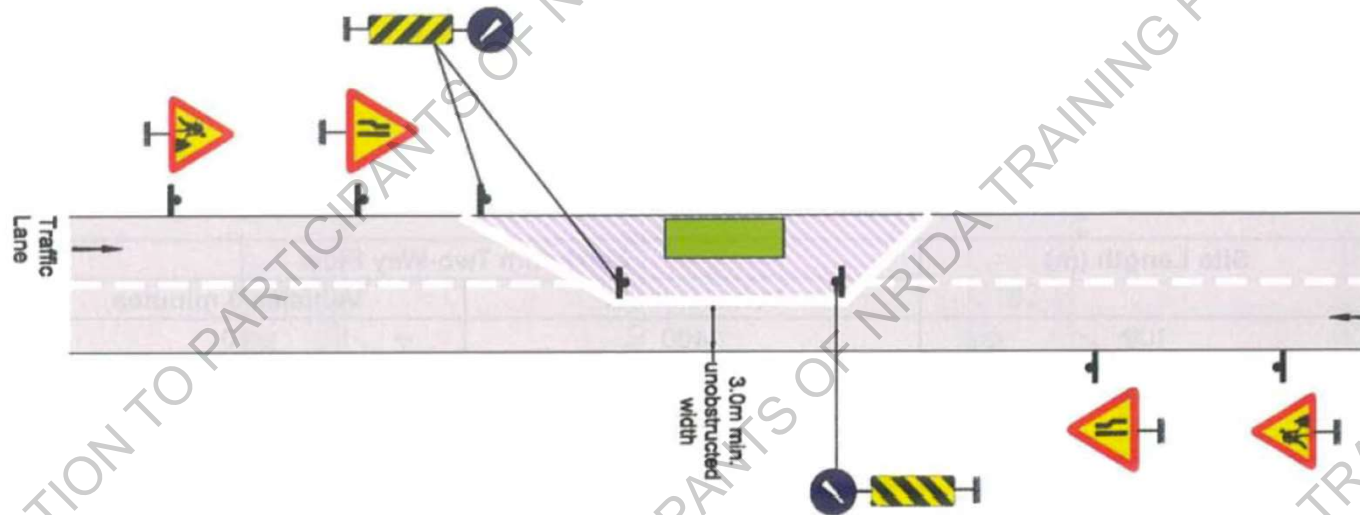
Alternate One Way Operations

- The Alternate One-way operations can be put in place on a two lane bi-directional road.
- 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.

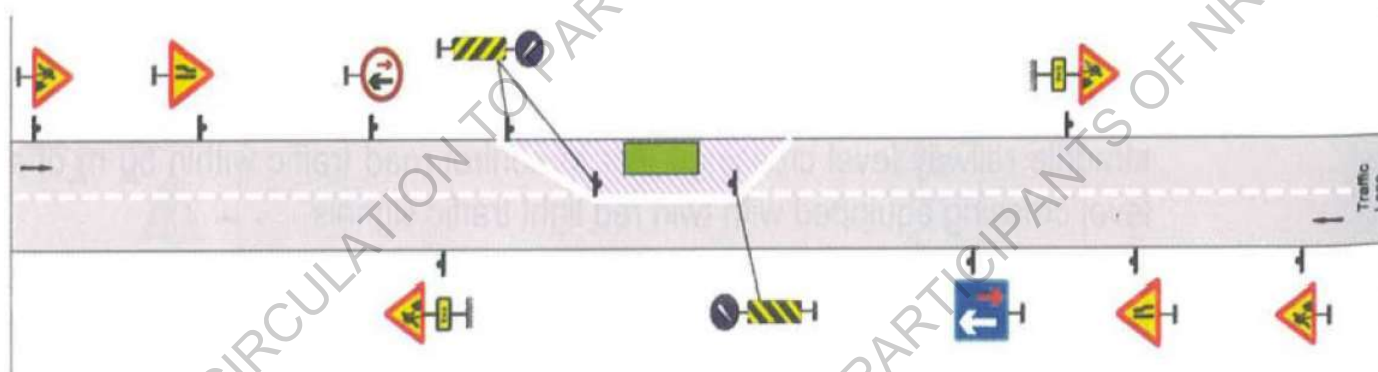
Traffic Management Practice at Work Zone



Alternate One Way Operations



“Give and Take” System

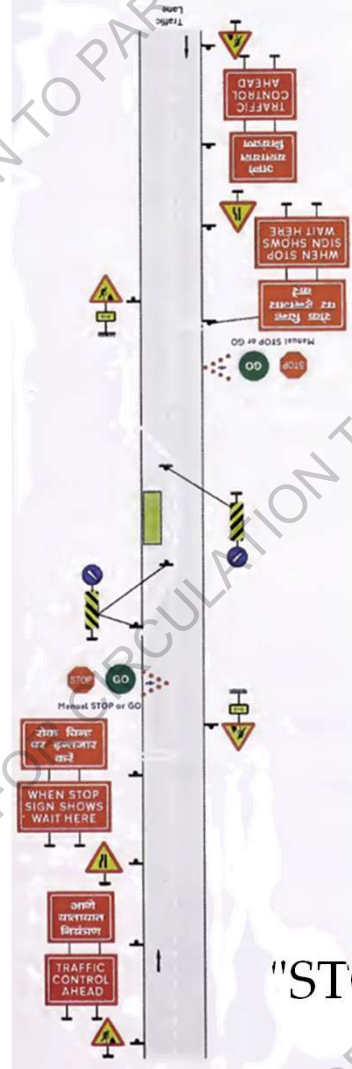


Priority Sign

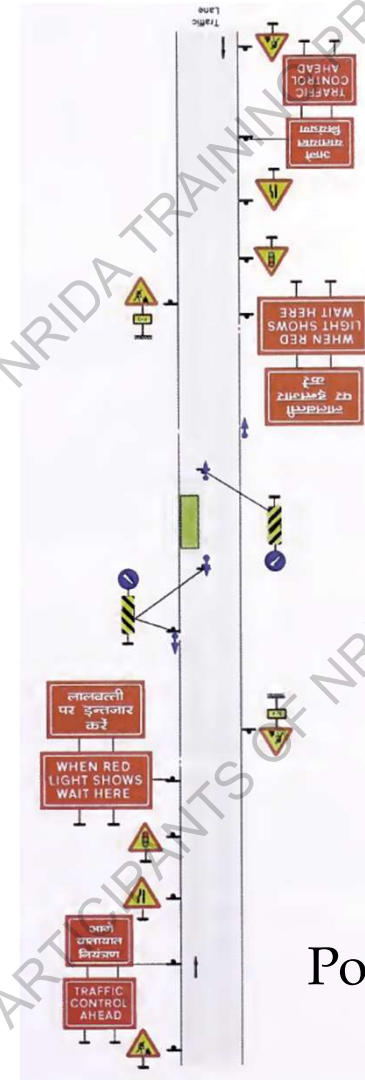
Traffic Management Practice at Work Zone



Alternate One Way Operations



"STOP/GO" boards or flags



Portable Traffic Signals

Traffic Management Practice at Work Zone



Alternate One Way Operations

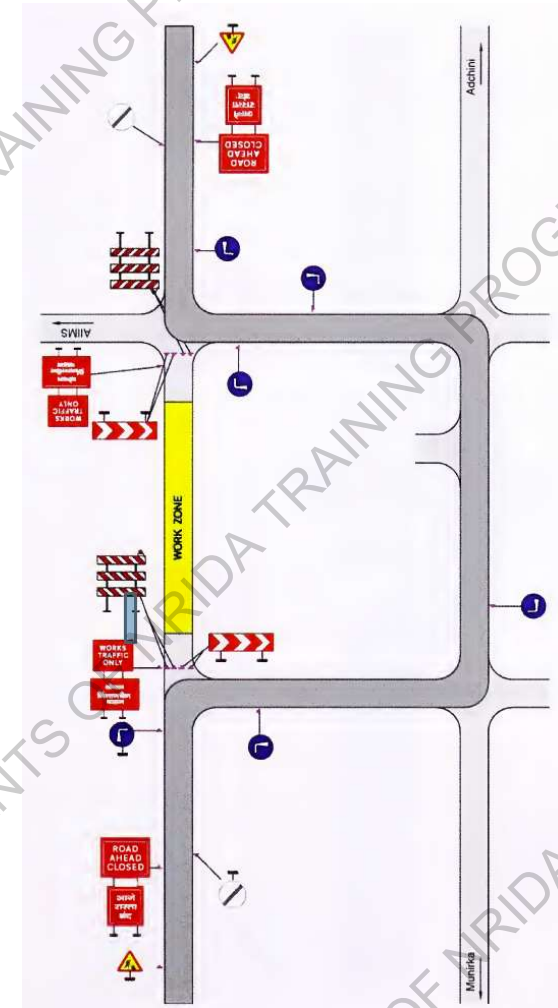
Traffic Control Methods	Maximum Speed Limit (kmph)	Length of Work Zone + Transition Zone (m)	Maximum Two Way Traffic Flow
"Give and take" system	50	50m (max)	<ul style="list-style-type: none"> • 400 veh/hour • 20 commercial veh/hour
Priority sign	60	80m (max)	850 veh/hr
"STOP/GO" boards or Flags	60	100m	1400 veh/hr
		200m	1250 veh/hr
		300m	1050 veh/hr
		400m	950 veh/hr
		500m	850 veh/hr
Portable Traffic Signal	60	300m (max)	No limit

Traffic Management Practice at Work Zone



Detours

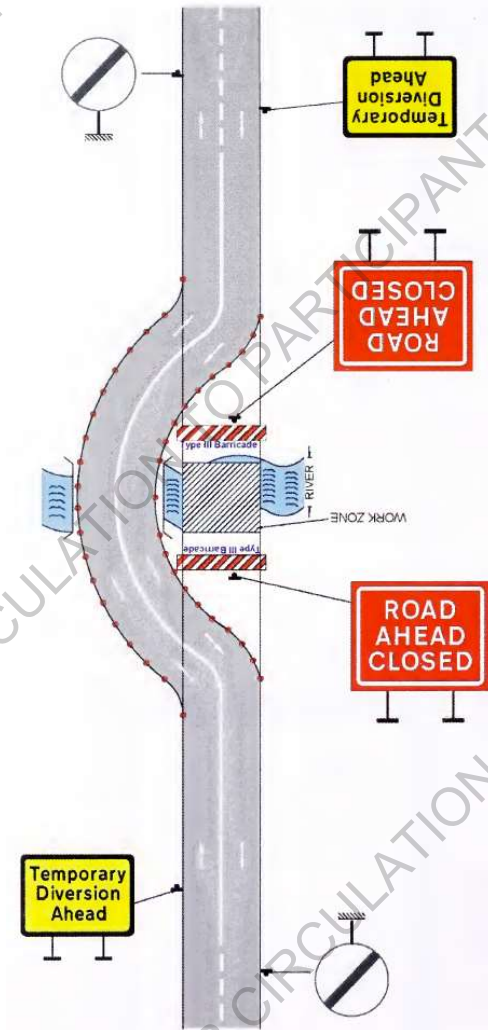
- In this strategy, traffic is rerouted on to an alternate road and the traffic totally avoids the work zone.
- When traffic is directed from a road stretch under construction/improvement, to alternative traffic route, construction operations can proceed rapidly.
- This can improve construction efficiency (i.e., reduce cost) and quality and ensure safety for the workers from passing vehicles.
- 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 detour route goes through areas with large volume of VRUs.



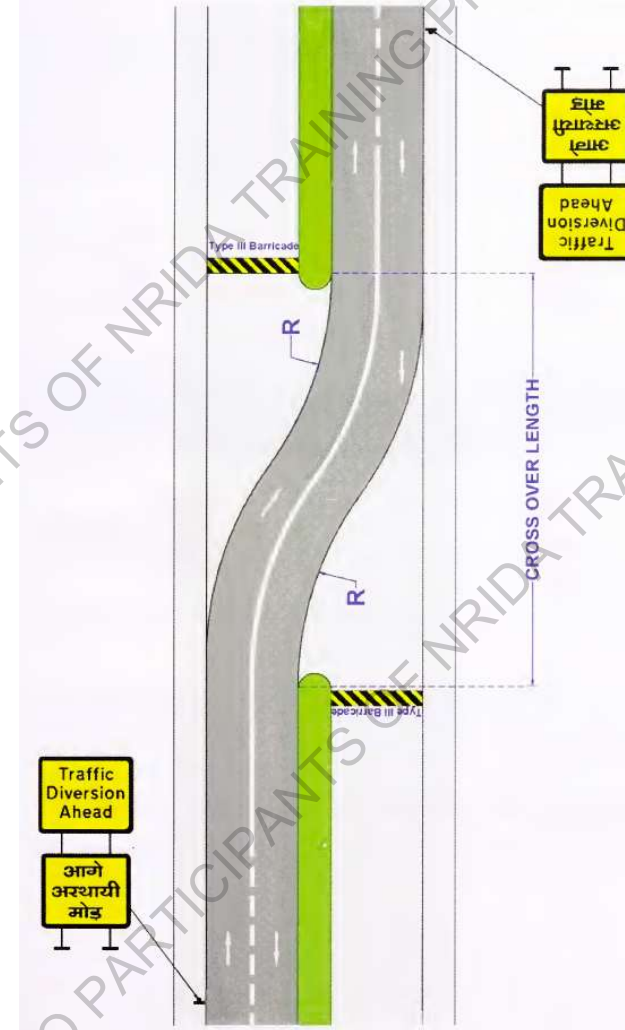
Traffic Management Practice at Work Zone



Diversions



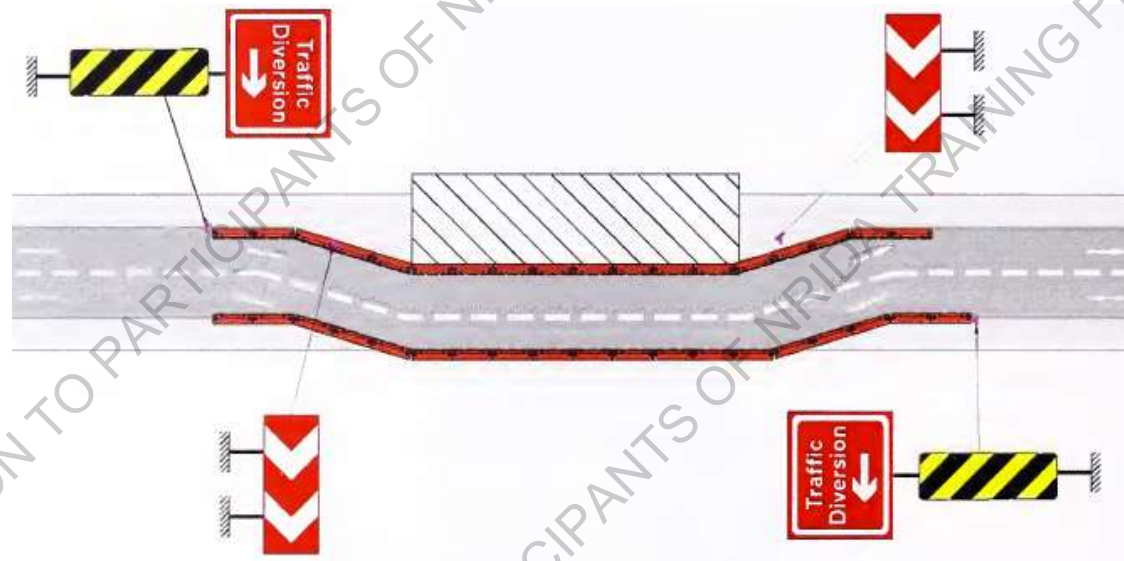
Median Crossovers



Traffic Management Practice at Work Zone



Use of Shoulder as a travel lane



Night Construction

- Night construction may be preferred in many cases 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.
- The major drawback is that the agency cost is escalated and social pattern of workers is disrupted.

Traffic Management Practice at Work Zone

Sr.	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 night time hours.	Lower traffic volume or lower traffic impacts.	Higher agency cost; disruption of social pattern of workers; Noise pollution.

Vulnerable Road Users



- Vulnerable Road Users (VRUs) in India are generally considered to be the road users in the form of pedestrians, cyclists and two-wheeler riders and other non motorized vehicles, who are more exposed and susceptible to road traffic hazards.



Protected Pedestrian Path



Mesh Barrier



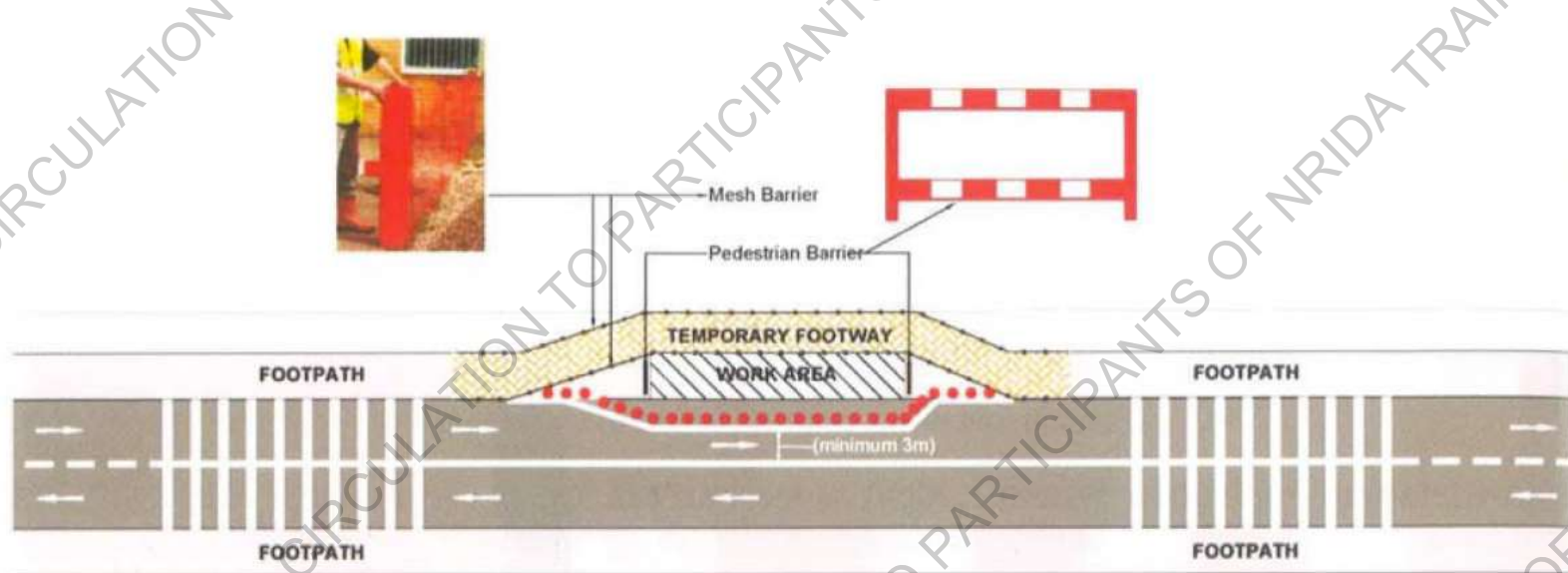
Pedestrian Barrier

Vulnerable Road Users



Alternate Way for Pedestrians

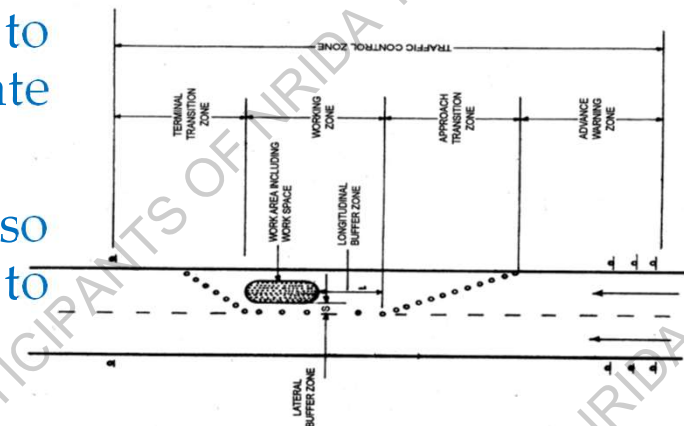
- An alternative safe route for pedestrians must be provided if it is necessary to close a footpath or part of a footpath as shown.
- Pedestrian access to property must always be ensured.
- Temporary pedestrian ways should never be less than 1 m wide and, wherever possible, they should be 1.5 m or more in width.
- It must be ensured that pedestrians are not diverted onto an unguarded carriageway.



Road Safety Audit: Case Study



- Absence / Inconsistency of planned traffic control zone for the work area
- Hardly any planned traffic control zone for the construction going along the road.
- All the construction zones are required to have elements, as per IRC guidelines provided by IRC-SP55:2014.
- Take appropriate steps to inform and guide the road users safely into the work zone.
- To provide a safe movement to traffic and to give adequate safety to workers an adequate buffer zone should be provided.
- Use of proper barricading should be made. Also adequate delineation and lighting be installed to provide safety during night conditions.



Road Safety Audit: Case Study



- Absence of Barricading to segregate construction and traffic movement areas on highway sections
- Barricades are intended to provide containment without significant deflection or deformation under impact and redirect errant vehicles along barrier.
- All barricades shall be conspicuously seen in the dark/night time by the road users so that no vehicle hits the barricade.
- Conspicuity shall be ensured by affixing retro-reflective stripes of required size and shape at appropriate angle at the bottom and middle portion.
- Minimum one red light or red light blinker be placed at the top of each barricade.



Road Safety Audit: Case Study



Absence of Barricading to segregate the construction and traffic movement areas on highway sections



Road Safety Audit: Case Study



- Absence of Barricading and other work zone safety measures at Construction Sites for structures like culverts and superstructures
- Safety issues near structures like culverts and flyovers and bridges increase manifold because of depths or heights involved and the protruding steel reinforcements and temporary scaffoldings etc.
- The barricading required for such situations was found to be missing or below standard. Similarly advance information about diversions was missing.
- Follow all safety requirements of safety for steel and RCC structures for the highway.
- Proper conspicuity of such sites at nights by proper measures for night time visibility.



Road Safety Audit: Case Study



- Work on Both Sides without provision of work zone safety measures
- Work is in progress on both sides of existing road without any proper barricading or delineation.
- This reduces the available carriage way because of loss of shoulders and big edge drops created.
- Such situation deters motorists to go towards edge because of kerb shyness and the soft ground of limited shoulders.
- The hazards multiply in dark hours.
- Need to plan activities in such a way that the available carriageway is not drastically reduced.
- In case it is necessary to carry out activities on both sides, proper traffic management plans should be prepared and implemented.



Road Safety Audit: Case Study



- Non-provision of safe buffer zone between road traffic and heavy construction equipment and machinery in work zone



Speed restriction (kmp/h)	Minimum longitudinal Buffer zone (L) (m)	Minimum Lateral buffer zone (S) (m)
50 or less	50 or less	0.5
60	60	0.5
80	80	1.2
100	100	1.2
120	120	1

Road Safety Audit: Case Study



- Roadside Short-Duration activities without any safety measures
- Careful consideration of traffic and roadway conditions must be given to each work zone prior to selecting the traffic control set-up
- Shoulder work and low-speed, low-volume traffic conditions may require only the work vehicle hazard beacon and personal protective equipment.
- High-speed, high-volume lane work may require a full lane closure set-up, even though the work duration may be 60 minutes or less.



Road Safety Audit: Case Study



- Workers Health, Safety and Environment Aspects
- Working at heights can be hazardous without use of proper PPEs
- There are areas or activities where fall protection is needed.
- These include, but are not limited to, ramps, runways, and other walkways; excavations; hoist areas; holes; formwork and reinforcing steel; leading edge work; unprotected sides and edges; pre-cast concrete erection; and other walking/working surfaces.



Work Zone Examples from India



Unprotected foundation trench in work zone



Unprotected vertical cut close to traffic

Work Zone Examples from India



Unsafe operations in work zone



Absence of demarcation and buffer zones in work zone

Work Zone Examples from India



Truck colliding with median barrier of vehicular underpass



Sharp diversion with no speed reduction in work zone

Work Zone Examples from India



Unprotected operations & workers in work zone

Pre Opening Stage Audit

This audit involves a detailed inspection of the new road project immediately prior to its opening. This stage will examine features such as

- Although most road projects are constructed “under traffic” there is a time just before the Contractor hands over the project when the project is almost complete and when a preopening stage audit is undertaken
- The new road should be driven, ridden and walked (as appropriate) by the audit team to ensure that the safety needs of all road users are provided for.
- A night-time inspection is particularly important at this stage to check installation and visibility of signs, markings, delineation, lighting and any other night time/low light related issues.

Safety Audit of Existing Road

- The audit of existing road aims to ensure that the safety features of a road are compatible with the functional classification of the road
- It also aims to identify any feature that may develop over time into a safety issue (such as a tree blocking sight lines at an intersection)
- Safety Audit with/without crash data

Audit Team

As per IRC SP 88

- ★ Senior Road Safety Auditor
- ★ Road Safety Auditor
- ★ Road Safety Assistance/Apprentice

As per NHAI and Site Requirements

- ★ Senior Road Safety Auditor cum Team Leader
- ★ Traffic Engineer/ Transport Planner
- ★ Bridge Construction Engineer
- ★ Mechanical Engineer

Senior Road Safety Auditor

- Graduate in civil engineering with more than 10 years' experience in design, construction and maintenance of roads
- Completed an approved road safety audit training program of at least two weeks duration
- Minimum 3 years practical experience in road safety, and
- Completed at least five road safety audits. At least three of the five audits must be at a design stage

Road Safety Auditor

- Graduate in civil engineering with more than 7 years' experience in design, construction and maintenance of roads
- Completed an approved road safety audit training program of at least two weeks duration
- Minimum 2 years practical experience in road safety, and
- Completed at least three road safety audits

Road Safety Assistance/Apprentice

- Graduate in civil engineering with more than 2 years' experience in design, construction and maintenance of roads
- Completed an approved road safety audit training program of at least two weeks duration

Why Audit Checklists

- ★ Checklists to reduce the risk that important safety concerns not overlooked during an audit
- ★ Checklists remind audit teams to always consider the safety needs all road users i.e. vulnerable road users (pedestrians, bicyclists, rickshaw pullers and three wheelers) and motorised road users (car, truck and bus users).

Types of Audit Checklists

- ★ Checklist for Planning/Feasibility Stage
- ★ Checklist for Detailed Design Stage
- ★ Checklist for Construction Stage
- ★ Checklist for Pre-opening Stage
- ★ Checklist for Audit of Existing Roads
- ★ Checklist for rural roads with low design speeds and low volumes of traffic

Audit Thought Process

- ★ Is the proposed cross section suitably safe for the road classification?
- ★ Do the horizontal and vertical alignments commensurate with design speed ?
- ★ Will the new road be easily understood by the road users (motorised and non motorised)?
- ★ Do any parts of the design present direct risk to any group of users?
- ★ Are any roadside hazards obvious?
- ★ If adequate provisions made to ensure safety of vulnerable road users – moving along as well as across the new road?
- ★ Will weather conditions present any safety issues?
- ★ Will the new road be safe at night?
- ★ If any of these trigger a potential safety concern, suggest /propose alternative in the design now in a positive manner to improve safety?

Audit Thought Process

- ★ **Warnings** to Road Users can be given by signs, pavement markings or rumble strips
- ★ **Information** to Road Users is best provided in small amounts, and drivers are not overloaded. Direction signs and lane direction arrows are examples of providing necessary information to drivers/riders
- ★ **Guide** Road users such as where their route changes direction unexpectedly. This occurs often at road work diversions and at sharp curves on hill roads
- ★ **Control** on traffic movement on intersections is a necessary part of a safe road network
- ★ **Forgiving Roads** to reduce the risk to the occupants of vehicles that leave the road. Has the roadside hazard management strategy been applied? Barrier should be your last option.

IRC Reference Codes for Audit

- ★ IRC 73 Geometric Design Standards for Rural (Non Urban Highways)
- ★ IRC 86 Geometric Design Standards for Urban Roads
- ★ IRC 35 Code of Practice for Road Marking
- ★ IRC:38: Guidelines for Design of Horizontal Curves for Highways and Design Tables
- ★ IRC 65 Guidelines For Planning & Design of Roundabouts
- ★ IRC 67 Code of Practice for Road Signs
- ★ IRC: 80 Type Design for Pick-up Bus Stops on Rural (Non Urban) Highways
- ★ IRC 99 Guidelines for Traffic Calming Measures in Urban & Rural Areas
- ★ IRC 103 Guidelines for Pedestrian Facilities
- ★ IRC 119 Guidelines for Traffic Safety Barriers
- ★ IRC SP 73 Manual of Specifications & Standards for 2-Laning of Highway
- ★ IRC SP 84 Manual of Specifications & Standards for 4-Laning of Highway
- ★ IRC SP 87 Manual of Specifications & Standards for 6-Laning of Highway
- ★ IRC SP 23 Vertical Curves for Highways
- ★ IRC SP 41 Guidelines for Design of At Grade Intersections in Rural and Urban Areas
- ★ IRC SP 55 Guidelines for Traffic Management for Work zones
- ★ IRC SP 85 Guidelines VMS
- ★ IRC SP 88 Manual for Road Safety Audit

List of Safety Drawings to be Audited

- Plan & Profile of Project Highway with HAR & VAR Report for main highway and Service Road
- Typical Layout and Details of Median Opening Locations
- Typical Cross Sections with their applicability chainage wise
- Detailed Layout Drawings of Intersections/Interchanges
- GADs of all Major & Minor Bridges; Flyovers/VUP/PUP/ROB
- Typical Layout Plan and details of Toll Plaza showing Traffic Aid Post, Medical Aid Post, Weigh Batcher, Public Toilet facilities, etc; Truck Lay bye; Bus Bays & Bus Shelter, Rest Areas
- Road Furniture Plan showing details of traffic signage and pavement Markings
- Details of Highway Drainage, Slope Protection Works,
- Details of Protection Works- Fencing/Metal Crash Barrier/Rigid Barrier, etc
- Details of Highway Lighting and their location specific positions
- Advanced Traffic Management (ATMS)

Safety Audit Report

Safety Audit Reporting

Audit findings are presented in a standard format chainage wise in each km

- ★ Name of Project
- ★ Audit Stage
- ★ Audit Duration
- ★ Audit Team
- ★ Project Background or Project Introduction
- ★ Salient Features of Project
- ★ Audit Findings : Describe with the site photographs
- ★ Safety Concerns due to
- ★ Risk : Very High/ High / Medium
- ★ Recommendations
- ★ Priority : Essential / Highly Desirable / Desirable
- ★ Report Signed by Team Leader / Concessionaire/
- ★ Client Response: MoRTH/ NHAI /NHIDCL /PWD
Contractor/ IF/PMC



Safety Audit Reporting

Risk : Very High/ High / Medium	Priority Level for Recommendations
Very High : Multiple deaths are likely due to High speed or multi-vehicle crashes	Essential : Recommendations shall be implemented “at any cost”.
High: A death and/or serious injuries are likely due to High/medium speed vehicle/vehicle collisions. High/medium speed collisions with a fixed roadside object. Pedestrian crashes on rural highways	Highly Desirable: Recommendations shall be implemented unless cost of remedial treatment is prohibitive and risk can be reduced by an alternative measure
Medium: Minor injuries only are likely due to Low speed collisions	Desirable: Recommendation shall be implemented to reduced risk further.


Safety Audit Reporting

Mitigation Measures	Examples
Short Term	Non Urban Roads: Road Signs, Speed limits/ Speed Breakers, pavement Markings, Delineators, Pedestrian Railings, Crash Barriers, Studs/ Cats eye, etc Urban Roads: Restriction of certain types of vehicles by time/by lanes, One way street, Reversible lanes, Bus Lane, etc.
Medium Term	Extra widening on curves, Improvement of Horizontal and Vertical geometry, Street lightings, Crash Barrier, Junction Improvements, Footpath Provisions, Sight distance Improvements, Signalization, Removing of obstructions, etc.
Long Term	Provision of Bypass, Provision of service roads, Provision of grade separated interchanges, provision of vehicular & pedestrian underpasses, provision of FoB, etc.

Audit Report

No	Safety Concerns & Audit Findings		Recommendations		Client Response
	Description (with images if any)	Risk	Description (with figures if any)	Priority	
2	Typical cross sections				
2.1	<p>The drawings show a 1.5m wide unpaved shoulder along both sides of the highway. Unpaved shoulders discourage vulnerable road users from walking/riding on them as shown in picture (especially during the monsoon period). They become damaged when heavy vehicles drive on them. This can lead to deep drop-offs from the pavement which in turn becomes a hazard for small vehicles. There are many pedestrians, bicyclists and motorcyclists using this highway. They need the protection of a paved shoulder.</p> 	High	<p>Review the proposed cross section to provide a paved 1.5m wide shoulder along both sides of the highway for the entire project highway</p> <p>If paved shoulder cannot be provided for entire project highway, provide at least for the section where pedestrians and bicyclists are predominately present like villages and settlements</p> <p>For sections of road with predominant pedestrian and bicyclist, provide gateway measures to reduce speed with road humps, speed limit signs, and road markings as given in IRC 99</p> 	Desirable	
				Highly Desirable	
				Essential	

Audit Report

No	Safety Concerns & Audit Findings		Recommendations		Client Response
	Description (with images if any)	Risk	Description (with figures if any)	Priority	
8	Roadside Hazards				
8.1	<p>There are steep undrivable roadsides in the hill section between km 130 – 134 (approx.). These are within the clear zone for this highway and they are roadside hazards. The drawings are silent about any safety improvements along this area. The slopes cannot be "softened" due to the topography.</p> 	Very High	<p>Provide delineation of the section between km 130 – 134 using Chevron signs, delineator posts as well as centre lines, edge lines and advanced warning signs</p> <p>Provide paved shoulders through this section, ensuring the outer shoulder matches the super elevation of the curve.</p> <p>Install suitable safety barrier in those locations where the side slope begins within the 5m clear zone (measured from the edge line).</p>	<p>Essential</p> <p>Highly Desirable</p> <p>Essential</p>	

Audit Report

No	Safety Concerns & Audit Findings		Recommendations		Client Response
	Description (with images if any)	Risk	Description (with figures if any)	Priority	
3	Signs, signals, pavement marking and delineation				
3.1	<p>Many of the road signs were not standard. Many were made of old material such as corrugated iron.</p> 	Very High	<p>Provide standard diversion boards as given in IRC SP 55</p> <p>Traffic control devices should be placed in such way that an approaching driver could see clearly and can take appropriate action.</p>	<p>Highly Desirable</p> <p>Highly Desirable</p>	



Thanks!