Rural Road Safety Course

Roadside Hazard Management

1 What are the Roadside Hazards?

- Any object near the road edge

2 What type of crashes occur?

- Run-off crash
- Single vehicle crash
- Head-on collision

3 How to manage roadside hazards?

- Measures to reduce **likelihood** (or probability) of run-off crash
- Measures to Reduce **severity** of run-off crash
- Speed management
- Clear zone / recovery zone
- Crash barrier

This Session in Two Parts,

- Part-1: Introduction to roadside hazards
  - Types of roadside hazards
  - Important factors in risk assessment
  - Spot speed measurement
  - Importance of speed in safety
  - Star Rating of roads for safety
- Part-2: Roadside hazard management
  - Measure to reduce likelihood of crash
    - Signs and markings
    - Audio Tactile markings or shoulder rumble strips
    - Speed management
  - Measure to reduce severity of crash
    - Clear zone or recovery zone
    - Hazard removal
    - Hazard protection e.g. crash barrier

Part-1: Introduction to roadside hazards

Roadside hazard

- A roadside hazard is any feature or object beside the road that may adversely affect the safety of the roadside area should a vehicle leave the road at that point.
- Any solid object with diameter >10cm can be hazardous to the vehicle and its user in case of a collision – such as poles, trees etc.
- Other objects such as, large rocks or cliff or undrivable side slopes
- Point hazards and Continuous hazards

Point hazards

- Trees
- Poles
- Non-frangible sign-posts
- Unprotected barrier end
- Landscape features such as large flower pots, etc.
- Bridge support piers/columns
- Bridge/Culvert walls
- Any rigid wall or structure/building

Ends of crash barrier

- Unprotected ends of concrete crash barriers are hazardous

Ends of crash barrier

- Ends of crash barriers such as turned down or blunt end are hazardous

Ends of crash barrier

Continuous hazards

- Extend for a considerable length along the road
- Such as rows of point hazards (tree, poles)
- Cliff (on hill roads)
- Rigid walls or buildings
- Solid rock surface
- Longitudinal drains without cover
- Water bodies

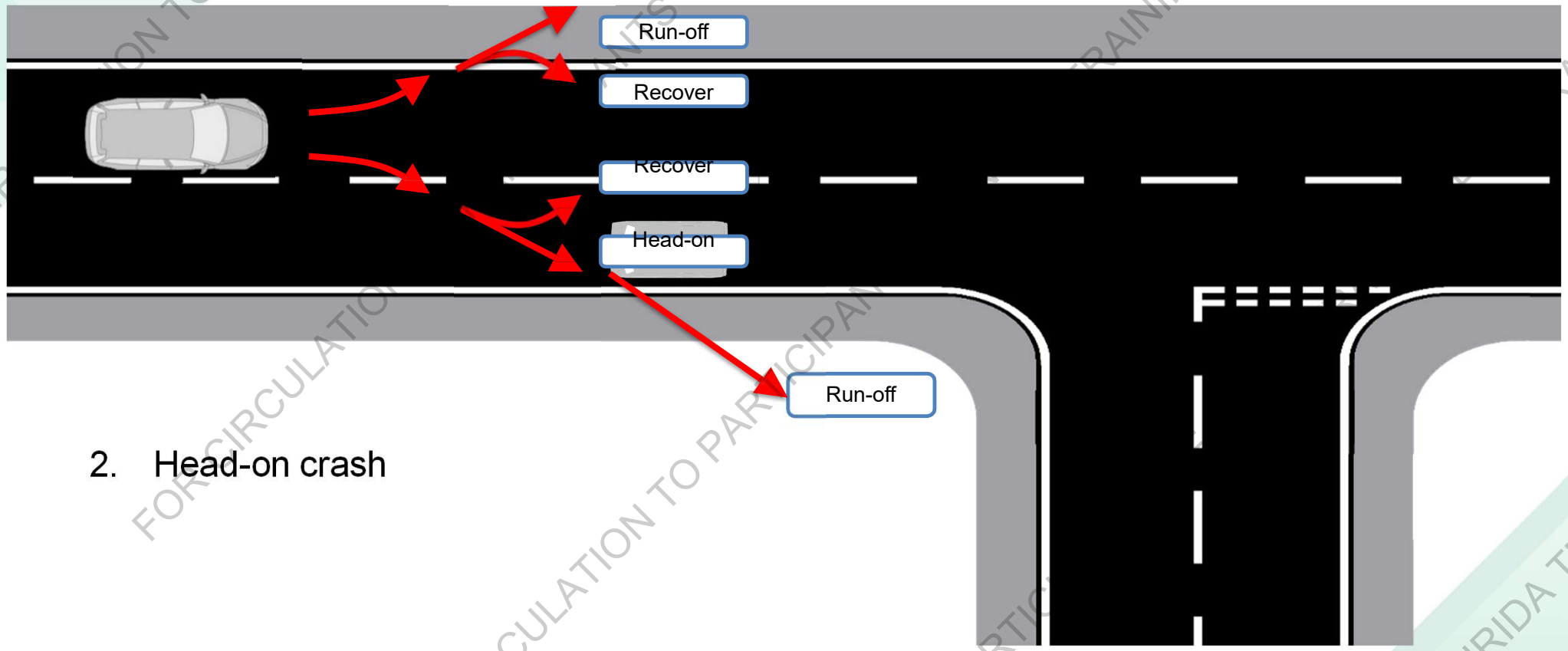
Continuous hazard

Continuous hazard

What type of crashes occur?

Road crashes and Roadside hazards

1. Run-off type crash or single vehicle crash or hit-object type crash



2. Head-on crash

Run-off and Head-on crashes

- Run-off crashes on high-speed highways often occur involving collision with crash barrier ends

Likelihood and Severity of a run-off crash

- Some of the road attributes affect likelihood (or probability) of crash
- And some affect severity (or the outcome) of crash

Likelihood of a run-off crash is governed by,

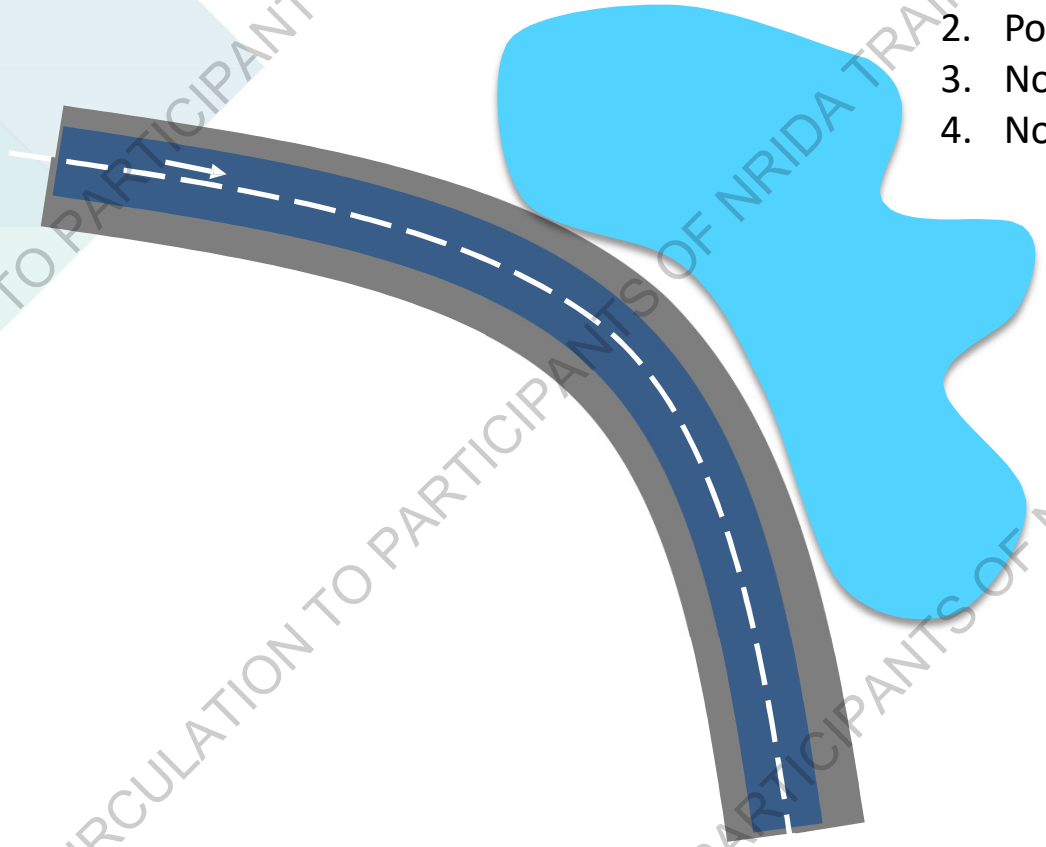
1. Lane width
2. Curvature
3. Quality of curve
4. Delineation (road markings and signages)
5. Shoulder rumble strips
6. Road condition
7. Vertical gradient
8. Skid Resistance

Severity of a run-off crash is governed by,

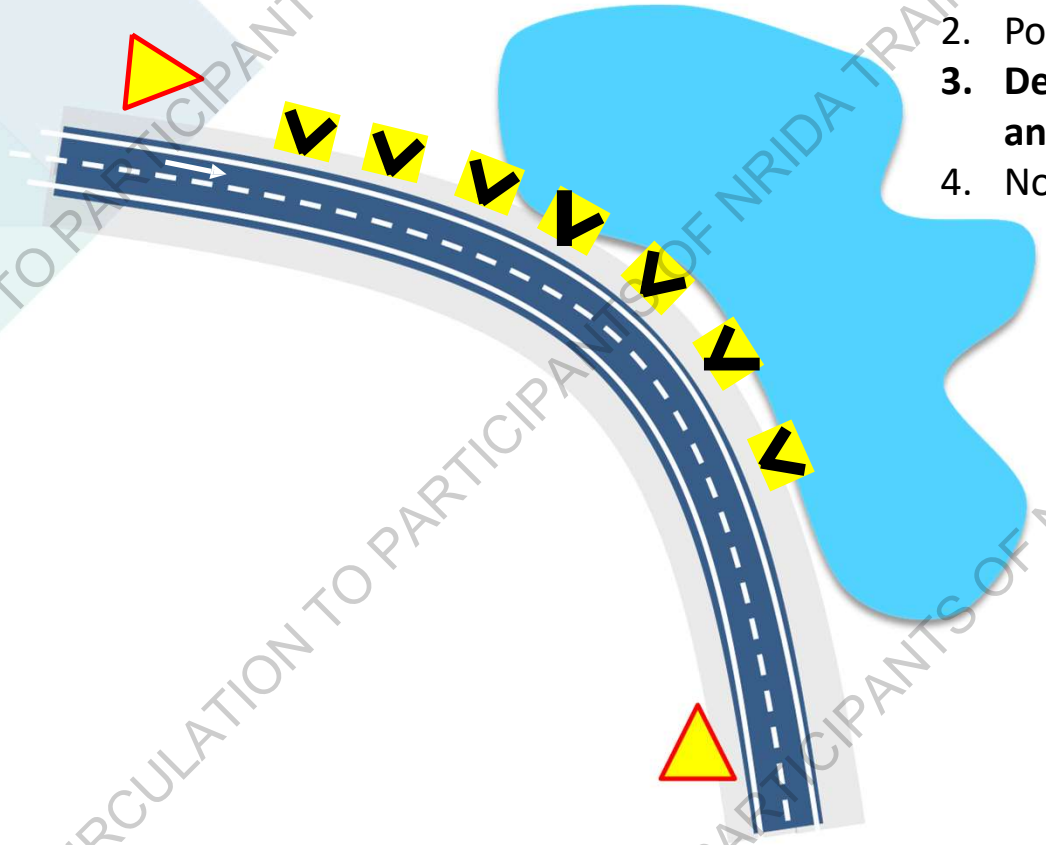
1. Type of roadside object (or hazard)
2. Distance of the object from road edge
3. Width of paved shoulder

Illustration in next slides

1. Sharp curvature on high embankment
2. Pond on outer edge
3. No delineation and signage
4. No edge protection

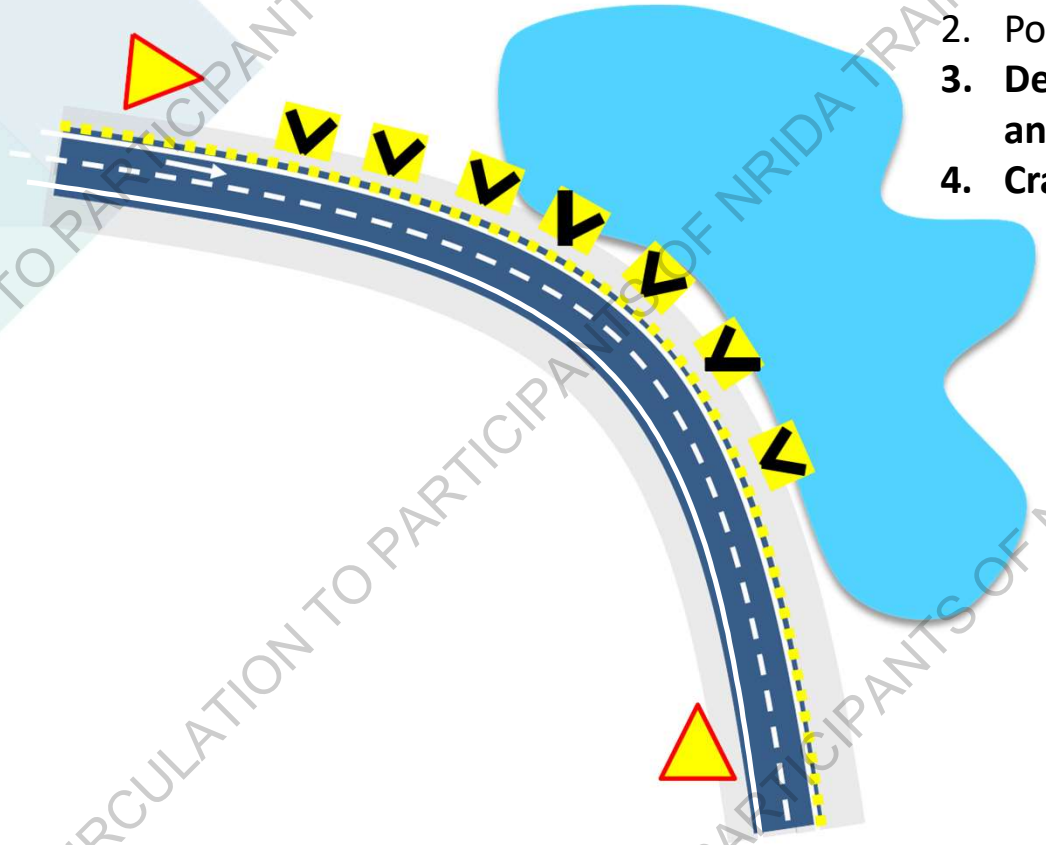


Crash Severity \ Frequency	Low	Medium	High
Minor Injury			
Major Injury			
Fatal			●



1. Sharp curvature on high embankment
2. Pond on outer edge
3. **Delineation (edge lines), warning sign, and chevrons**
4. No edge protection

Crash Severity \ Frequency	Low	Medium	High
Minor Injury			
Major Injury			
Fatal		●	



1. Sharp curvature on high embankment
2. Pond on outer edge
3. **Delineation (edge lines), warning sign, and chevrons**
4. **Crash barrier on the outer edge**

Crash Severity \ Frequency	Low	Medium	High
Minor Injury		●	
Major Injury		●	
Fatal			

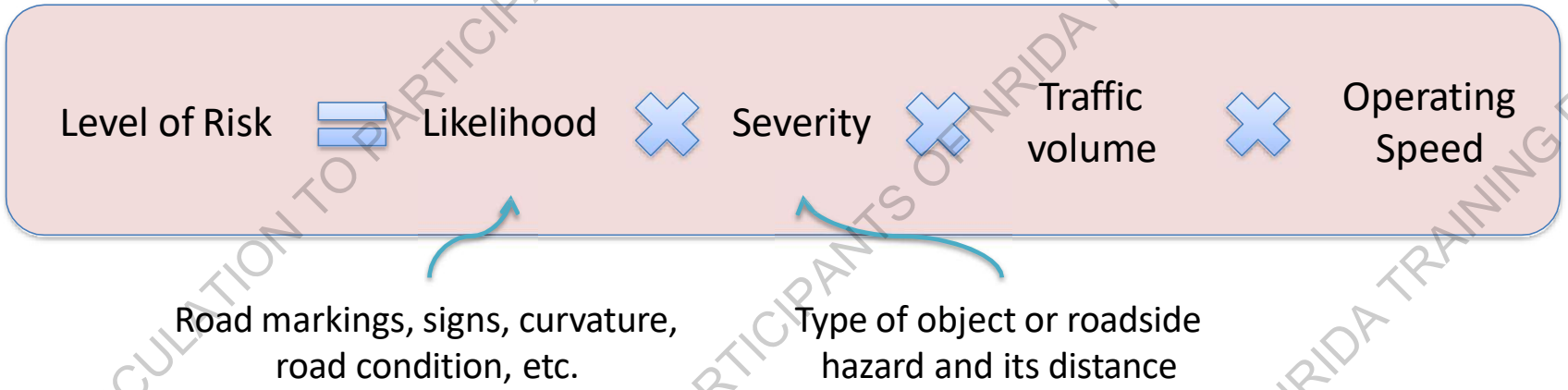
Other important factors in risk assessment

Level of Risk = Likelihood × Severity × ? × ??

Road markings, signs, curvature, road condition, etc.

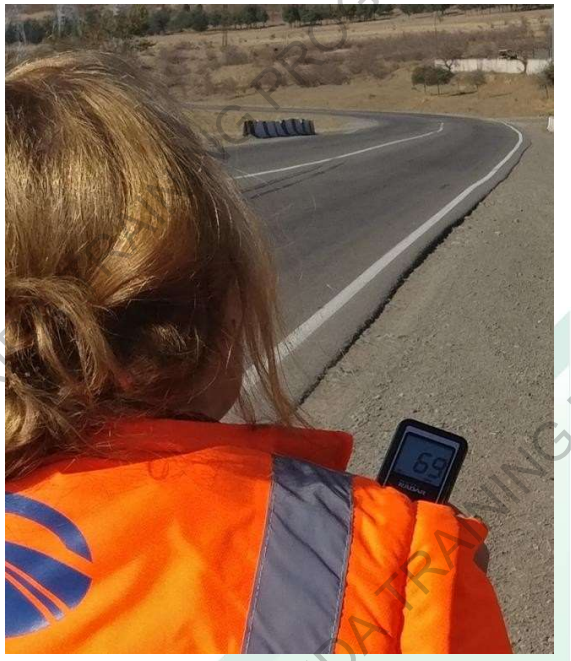
Type of object or roadside hazard and its distance

Other important factors in risk assessment



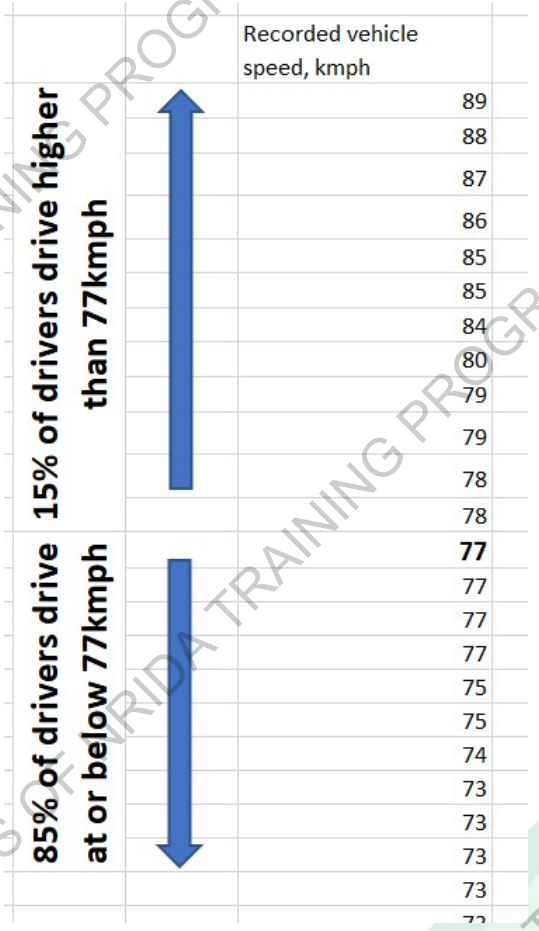
Vehicle operating speeds

- 85th percentile operating speed
  - The speed at or below which 85 percent of all vehicles are observed to travel under free-flowing conditions past a monitored point
- How to measure



Speed Limit and 85th percentile speed

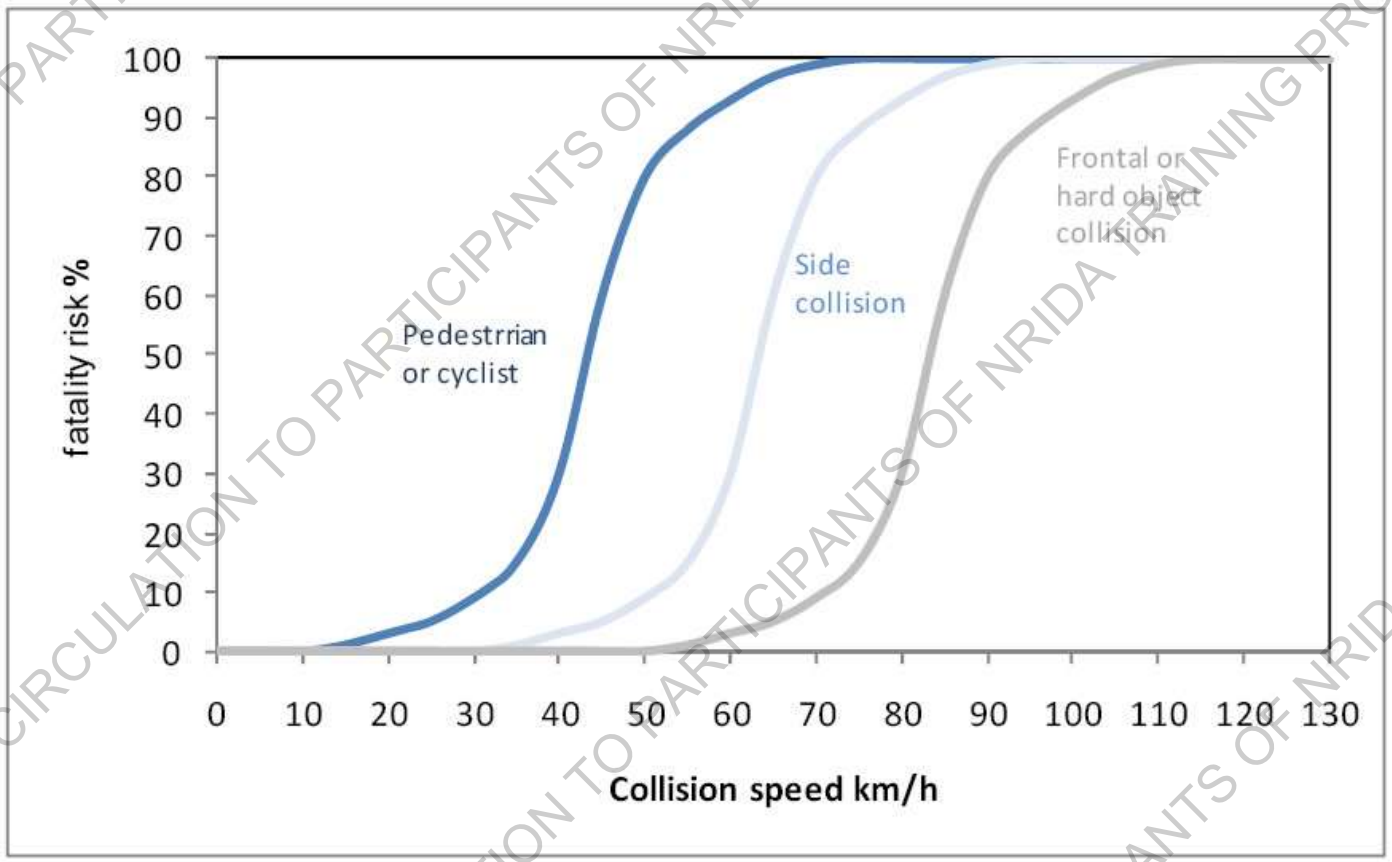
- Drivers do not always comply with the posted speed limits
- 85th percentile speeds generally tends to be higher than posted speed limits
- Example spot speed survey data



85th percentile operating speed = 77kmph

Design Speed | Speed Limit | 85th percentile speed

Speed is Central to Safety



OECD, 2008, *Towards Zero: Ambitious Road Safety Target and the Safe System Approach*

What is Star Rating?

- Star Rating is based on road inspection data
- Simple and objective measure of the level of safety which is ‘built-in’ to the road
- Five-star road segments are the safest while one-star are the least safe
- Star Ratings can be completed worldwide, in urban and rural areas and without reference to detailed crash data, which is often unavailable in low-income and middle-income countries, or is sparse in high-performing high-income countries striving for vision zero outcomes.

iRAP Star Rating

- Proactive assessment of risk for 4 major road users
- 50 road attributes assessed every 100m
- Record features that are known to effect the likelihood and severity of a crash
- Based on road safety research from around the world
- Objective performance scores (Star Ratings)

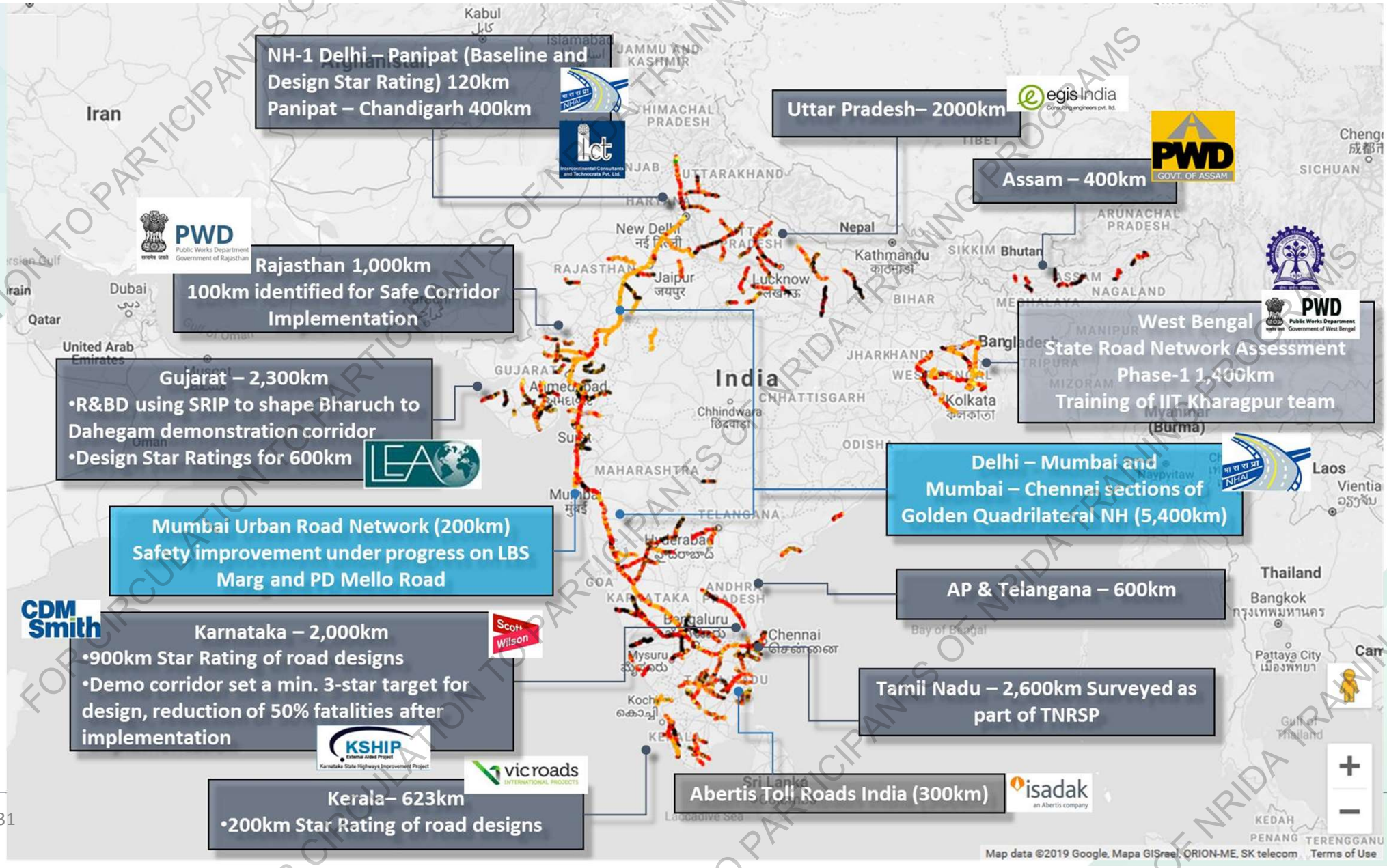
Inspections
We record 50 features that influence serious casualty risk

For more information visit
www.indiarap.org www.irap.org

iRAP Star Rating

- Proactive assessment of risk for 4 major road users
- Recor
- Objec

For more information visit
www.indiarap.org www.irap.org



Roadside hazards in this image

Comparing level of risk with previous image

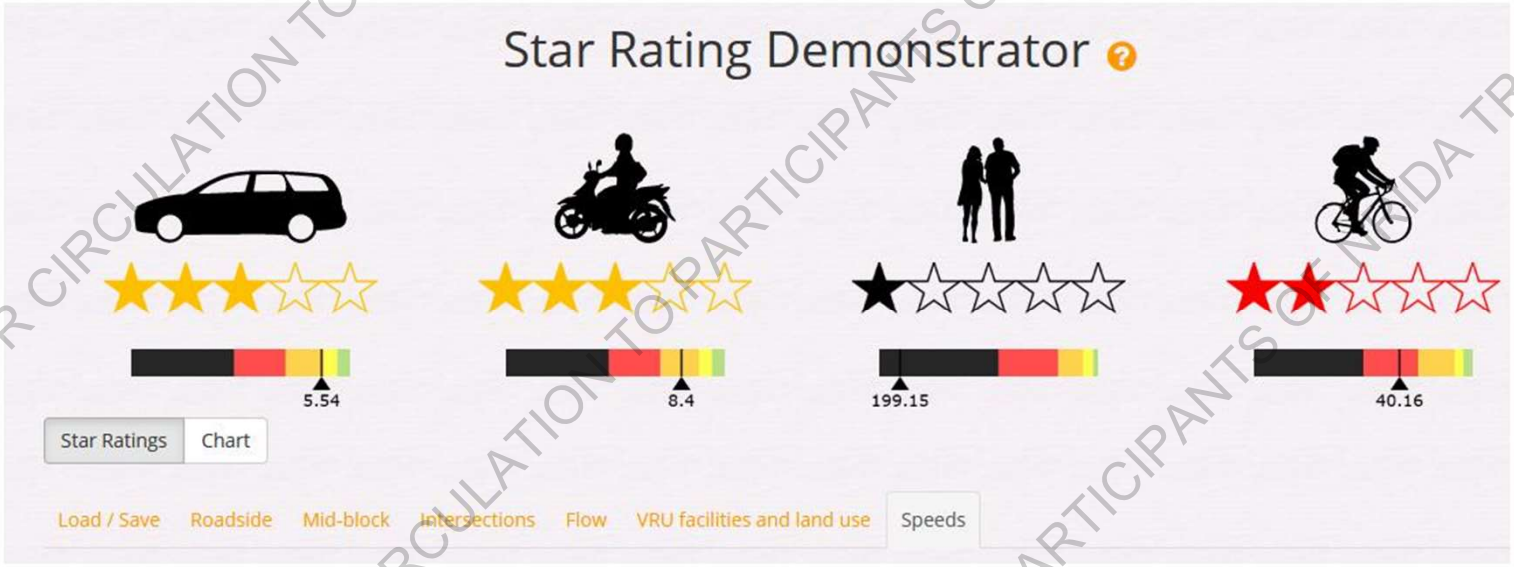
State Highway in Assam

Vehicles: ★ ★

- 60 km/h
- Undivided
- Roadside objects 1-5m
- No Intersection
- Moderate curvature
- Medium lane widths
- No paved shoulder
- Poor delineation
- Adequte pavement condition

Star Rating Demonstrator – iRAP Free Software

- Available on www.vida.irap.org
- Register for free to use the software
- Demonstrator capable of doing Star Rating for a give road section
- Enter all the road attributes such as roadside, intersections, mid-block attributes, facilities for pedestrian and other VRUs, speeds and flow
- Get instant Star Ratings for Vehicle Occupant, Motorcyclist, Pedestrian and Bicyclist



Part-2 Roadside hazard management

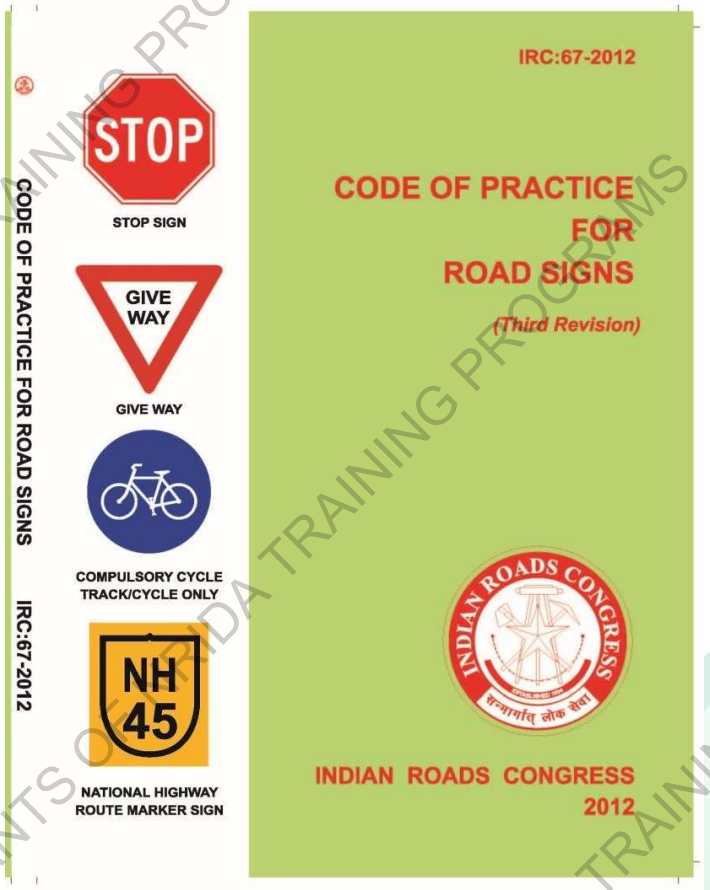
Roadside hazard management

- Measure to reduce likelihood of crash
  - Signs and markings
  - Audio Tactile markings or shoulder rumble strips
  - Speed management
- Measure to reduce severity of crash
  - Hazard removal
  - Hazard protection e.g. crash barrier
  - Clear zone or recovery zone

Measures to reduce likelihood of run-off crash

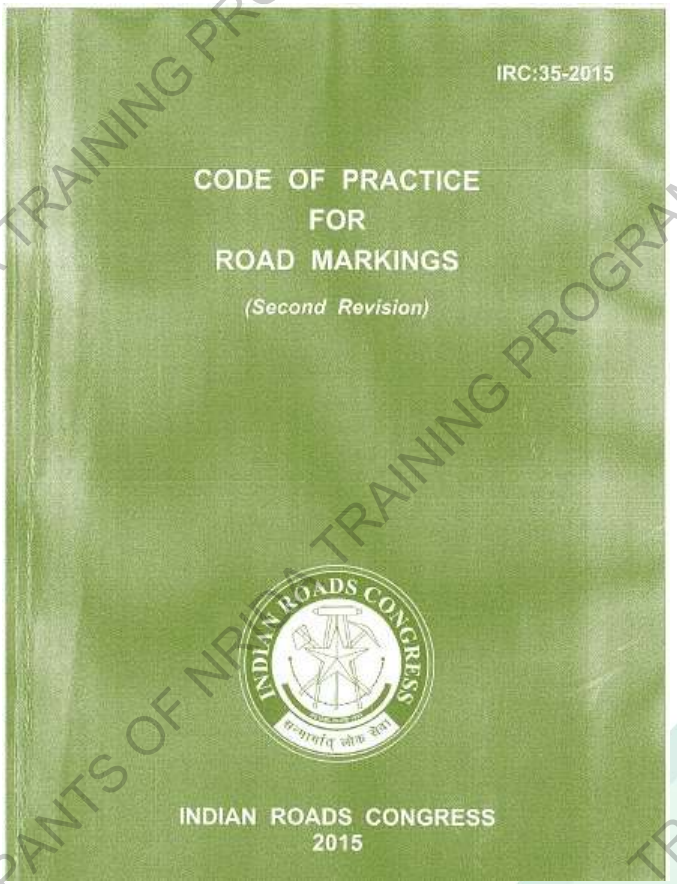
Traffic signs

- Reference document IRC:67-2012
- Key points
  - Design and placement of signs
  - Retro-reflectivity
  - Sheeting material



Road markings

- Reference document IRC:35-2015
- Road markings convey the information which might not be possible using the upright signs
- Clearly define the path to be followed through hazards, and delineate road edges at night
- Keep the vehicle on road
- Types of markings pertaining to roadside hazard management
  - Edge line and center line
  - Hazard markings



Devices helpful to reduce likelihood of run-off crash

- Curve warning and chevron signs
- Fixed object hazard markers
- Delineator posts
- Line-markings and raised pavement markers

Curve warning and chevron signs

- Curve warning sign before approaching the curve
- Chevron signs help to inform the drivers about sharpness of curve
- Installed on outer edge of curve
- Alignment and spacing as per IRC:67-2012

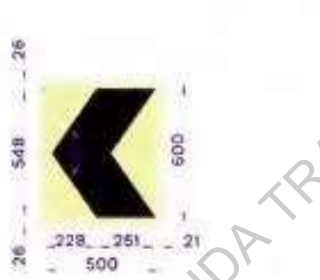


Fig. 15.72 Single Chevron (Normal)

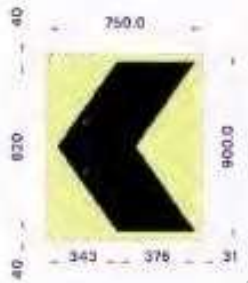


Fig. 15.73 Single Chevron(>100kmph speed)

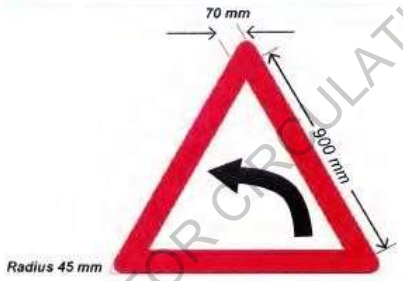


Fig. 15.01 Left Hand Curve

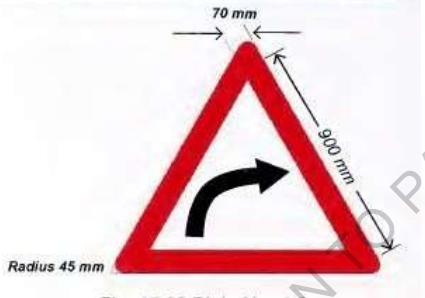


Fig. 15.02 Right Hand Curve

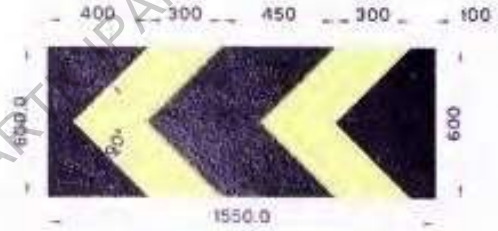


Fig. 15.74 Double Chevron

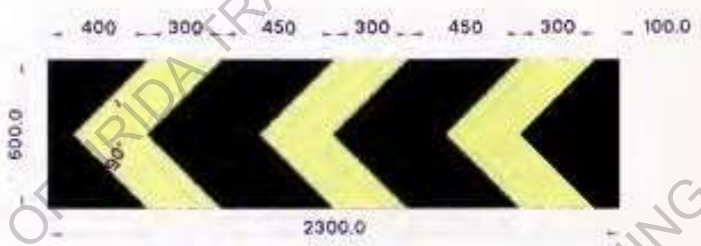


Fig. 15.75 Triple Chevron

IRC:67-2012

Chevron signs example

Road markings: No overtaking

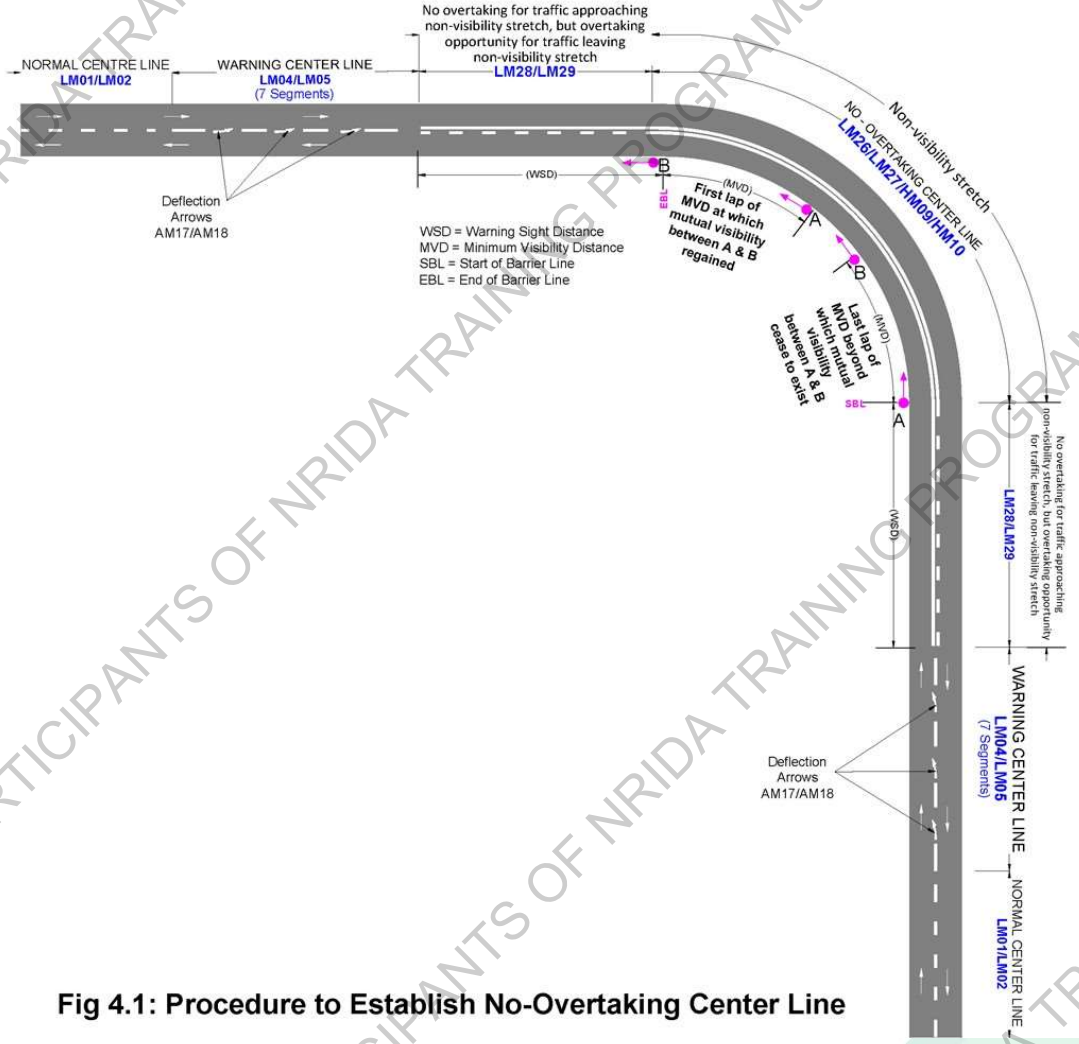


Fig 4.1: Procedure to Establish No-Overtaking Center Line

IRC:35-2015

Road markings: No overtaking with ladder hatching

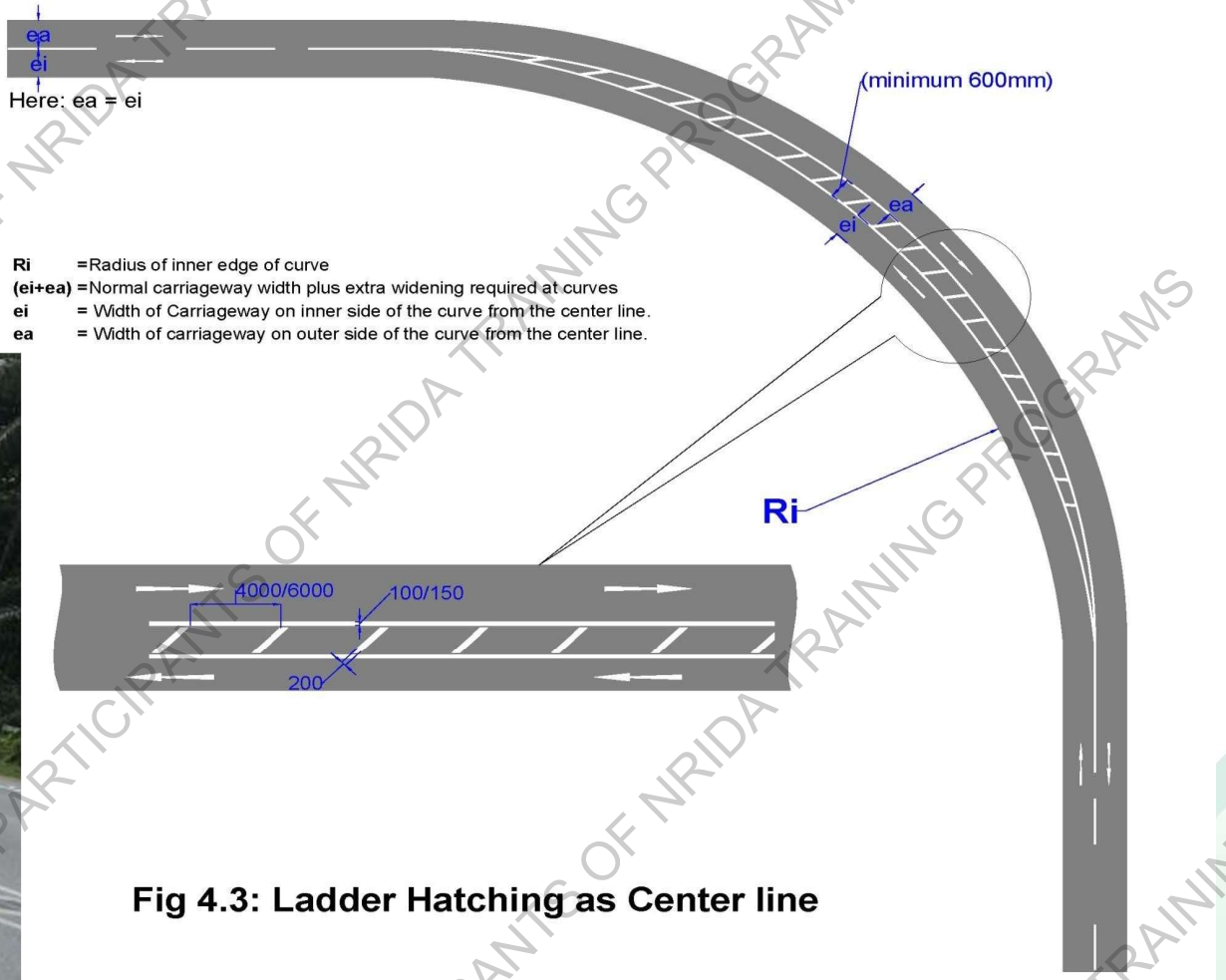


Fig 4.3: Ladder Hatching as Center line

IRC:35-2015

Fixed object hazard marker

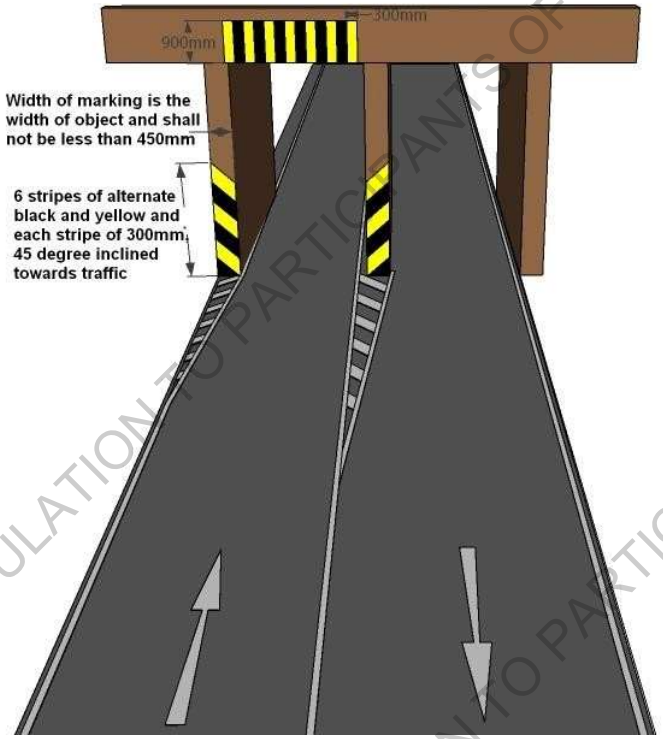
Fig. 15.76 Object Hazard (Left)

Fig. 15.77 Object Hazard (Right)

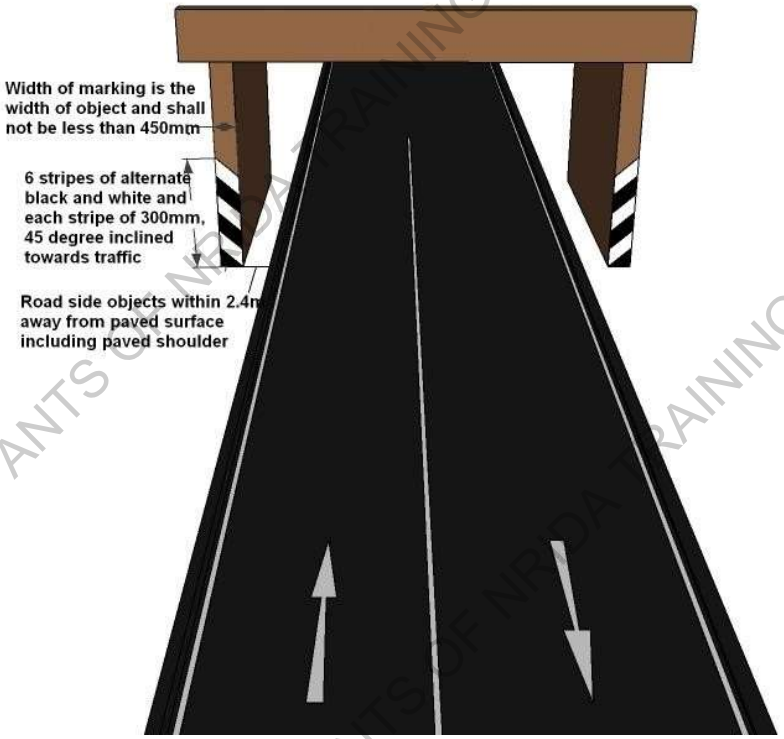
Fig. 15.78 Two Way Hazard Marker

IRC:67-2012

Object hazard markings on bridge columns



Objects within the Carriageway



Objects adjacent to Carriageway

IRC:35-2015

Hatch and Lane change markings

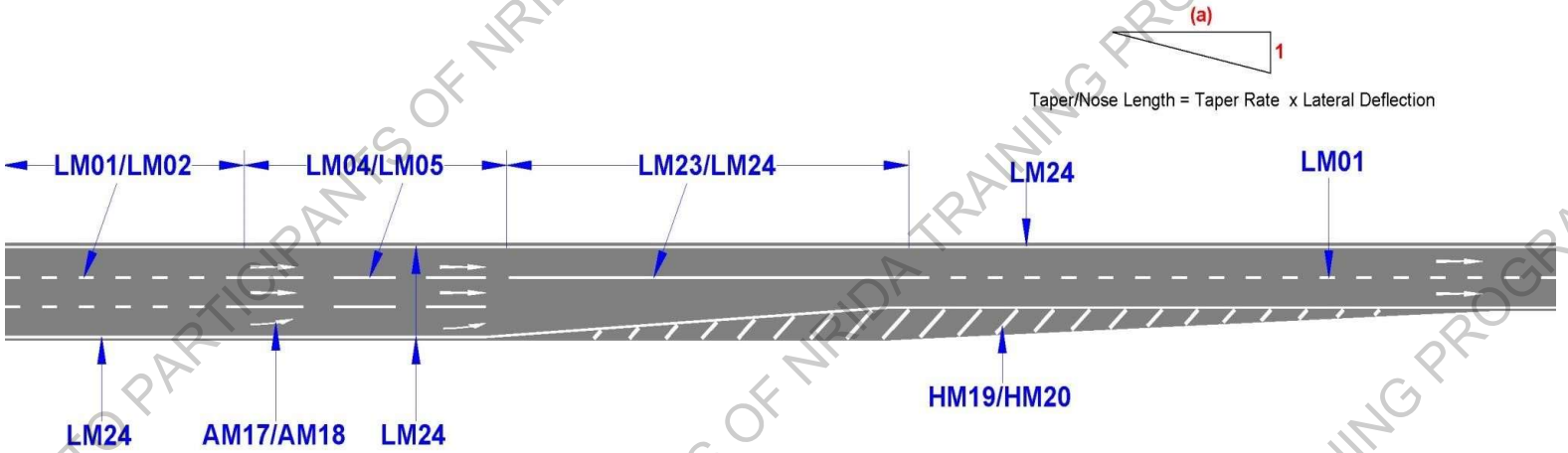


Fig 7.7: Curtailing of One Lane
(For Hazard/Lane Drop)

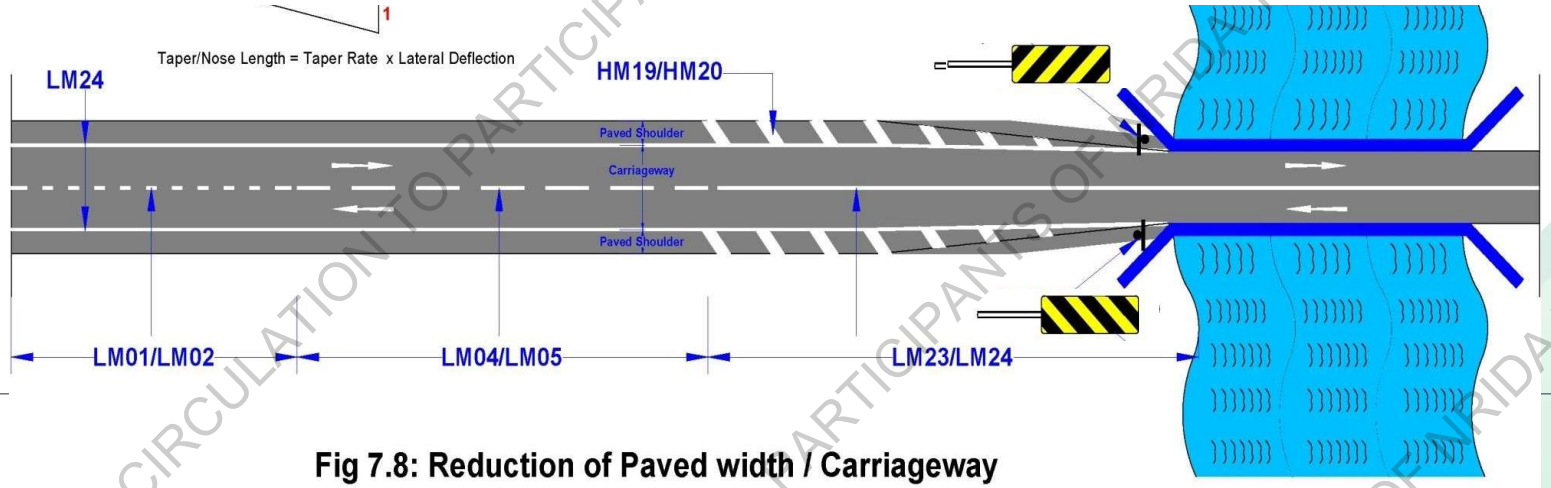
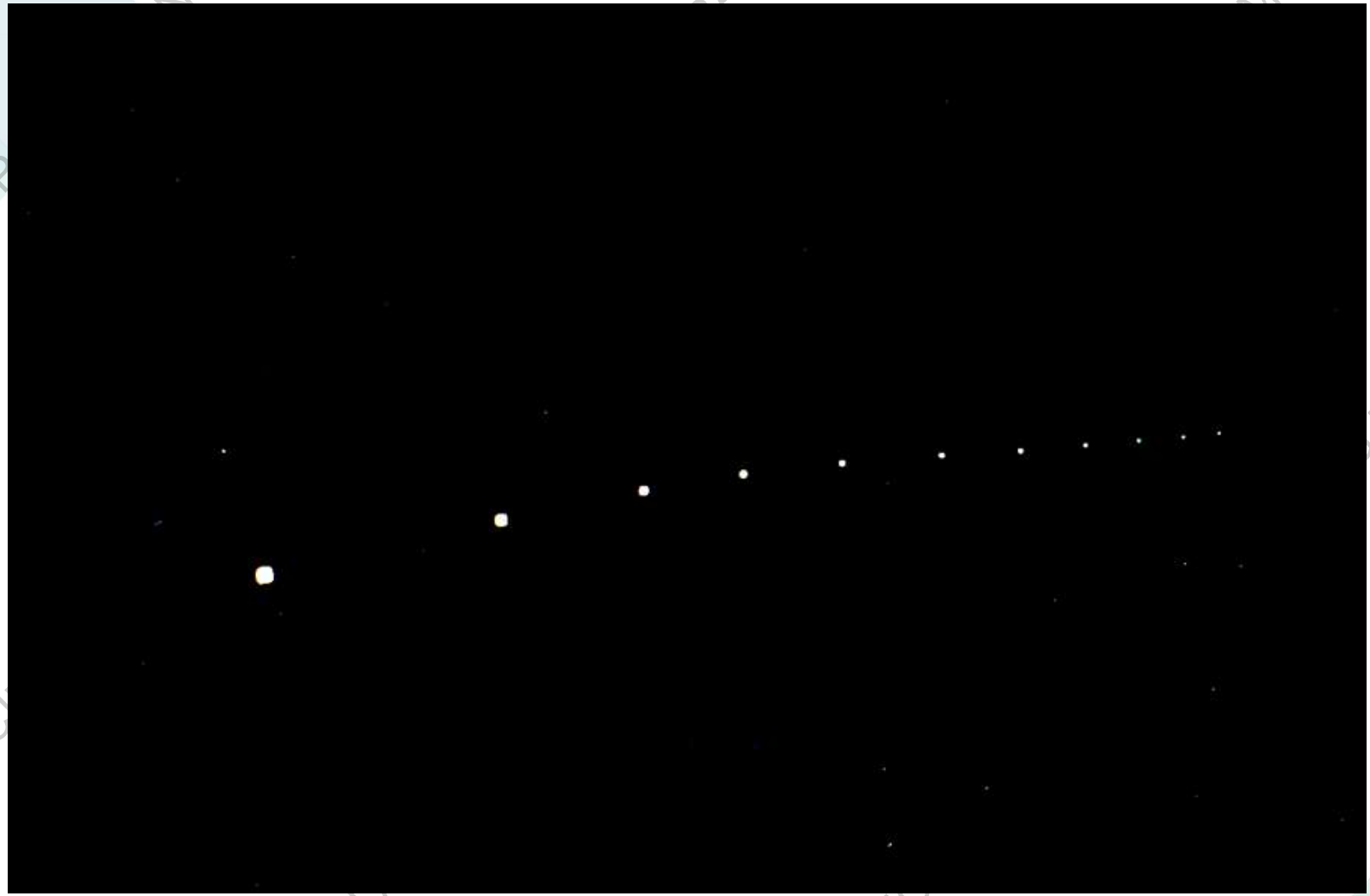


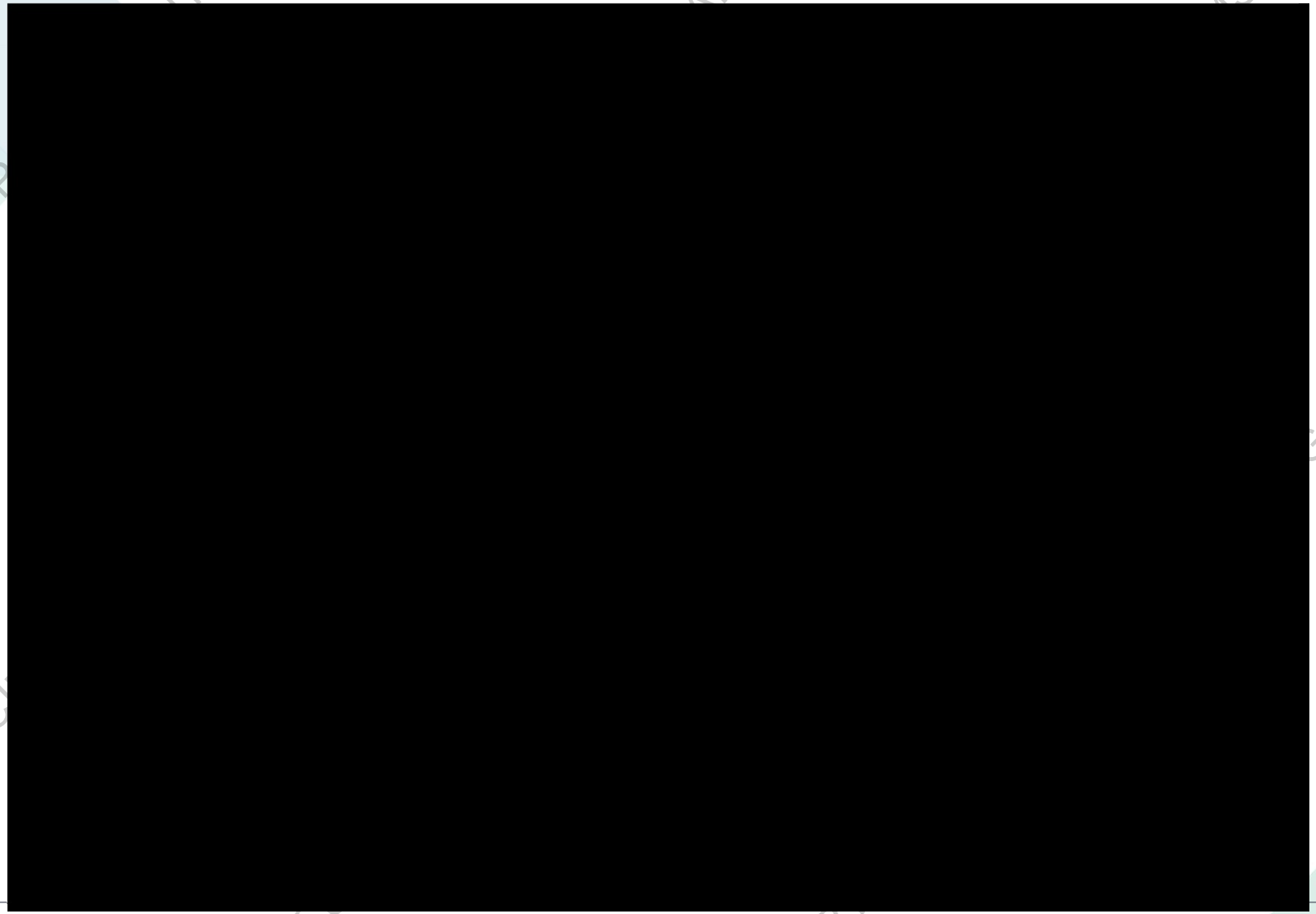
Fig 7.8: Reduction of Paved width / Carriageway

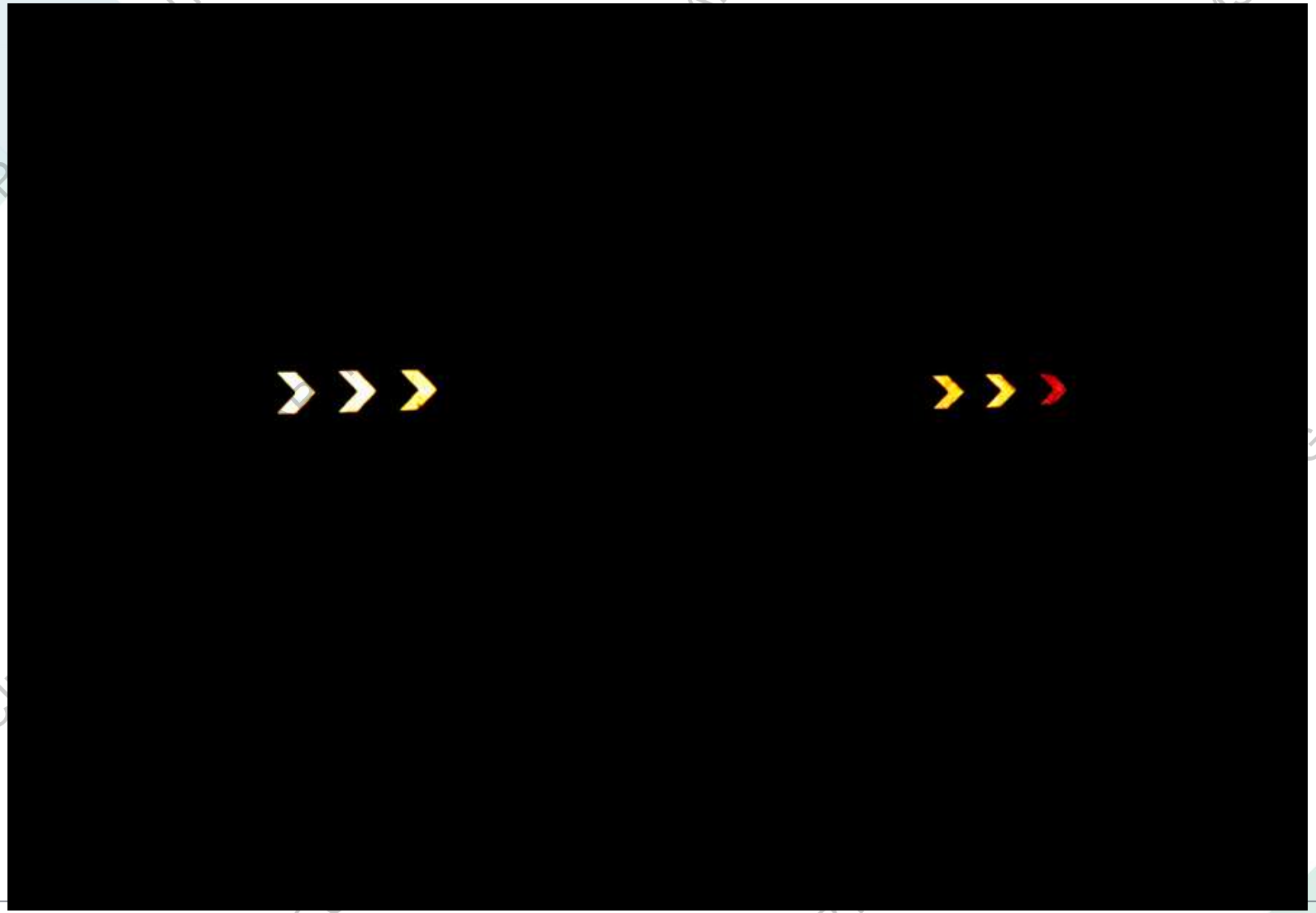
Retro-reflective Raised Pavement Markers (RRPM)

Night time delineation with Object hazard markers, RRPMs and Road markings

Curve delineation with Chevrons and guide posts







Audio Tactile Lane Markings

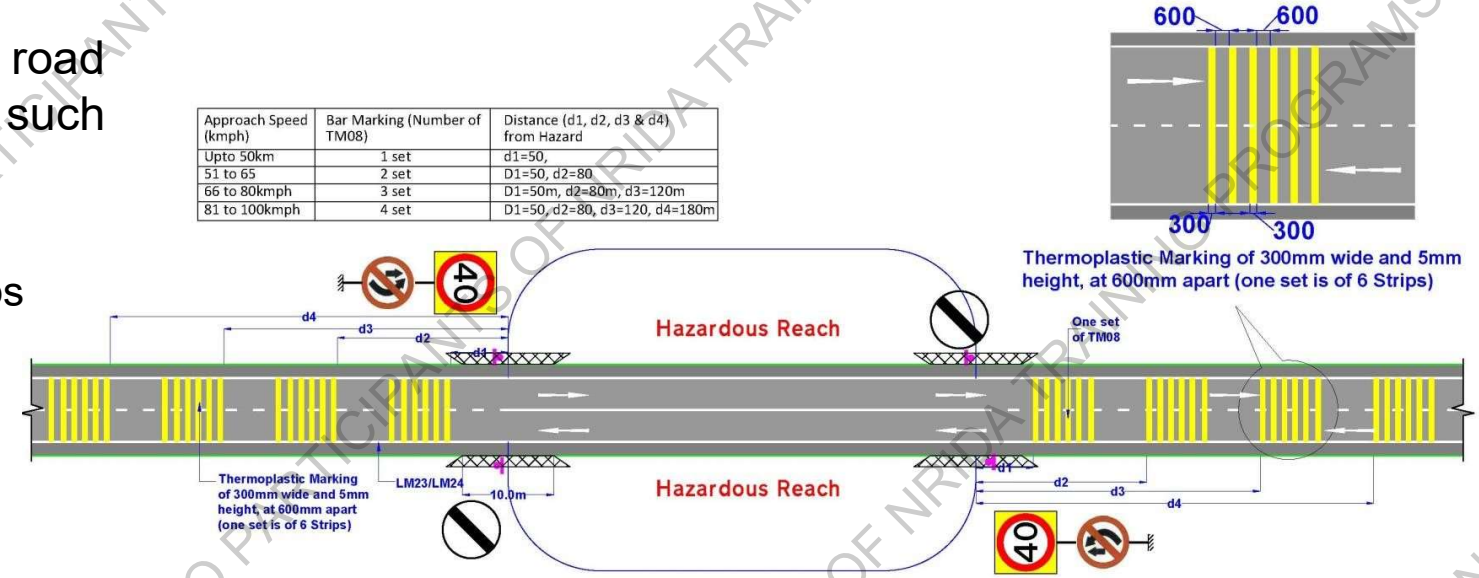
- Also known as ‘shoulder’ or ‘centre line’ rumble strips
- Longitudinal rumble strips (also referred to as raised profile edge lines or audio-tactile edge lines) can be used to delineate the edge of a road where driver fatigue is known to cause crashes.
- Providing visual delineation, longitudinal rumble strips can also be heard and felt by drivers and riders.

Speed Management

- Speed management or Traffic calming is to bring substantial and gradual reduction in speed of traffic approaching a hazardous (or built up) area to improve safety performance

- This can be achieved by road infrastructure measures such as,
  - Signs and markings,
  - Transverse rumble strips
  - Speed humps, speed cushions or platforms

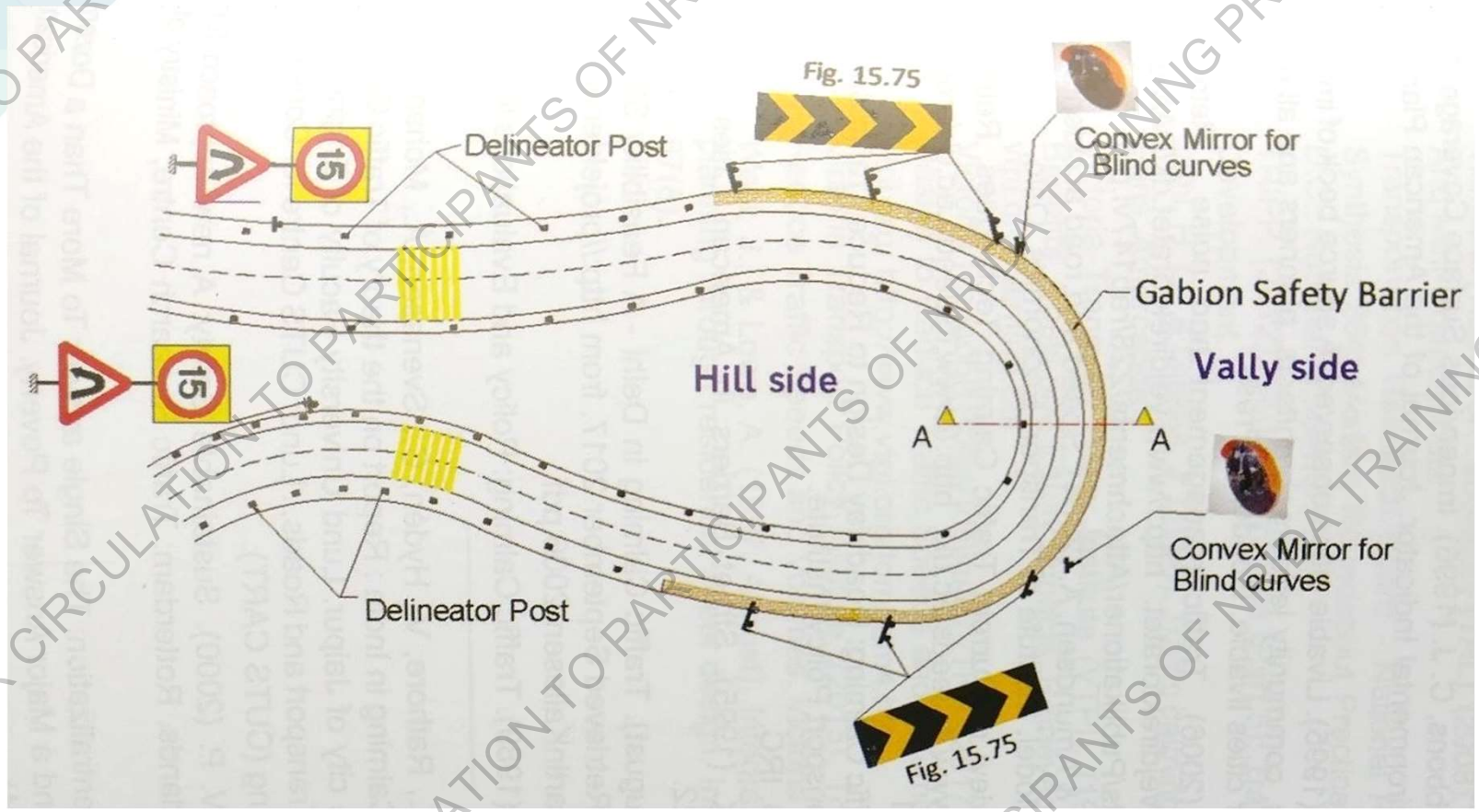
Approach Speed (kmph)	Bar Marking (Number of TM08)	Distance (d1, d2, d3 & d4) from Hazard
Upto 50km	1 set	d1=50,
51 to 65	2 set	D1=50, d2=80
66 to 80kmph	3 set	D1=50m, d2=80m, d3=120m
81 to 100kmph	4 set	D1=50, d2=80, d3=120, d4=180m



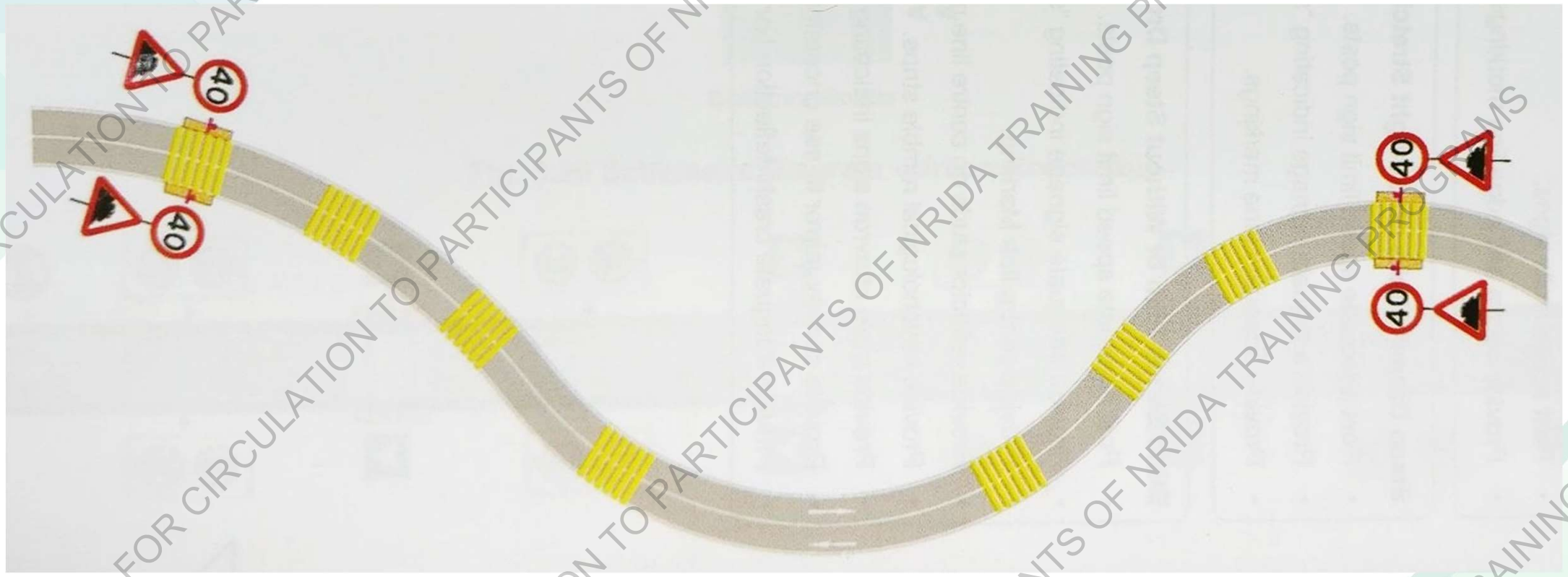
Note:-
1) Figure, abbreviations, and details mentioned shall be read in conjunction with IRC 67 2012 (Road Signs) and IRC 35 2015 (Pavement Markings), unless otherwise mentioned.
2) Location where speed has to be curtailed with soft treatment ie. Rumble Strip.

Applicable to,
Urban area with high pedestrian flow
Rural road sections with high risk of run-off, head-on or intersection crash

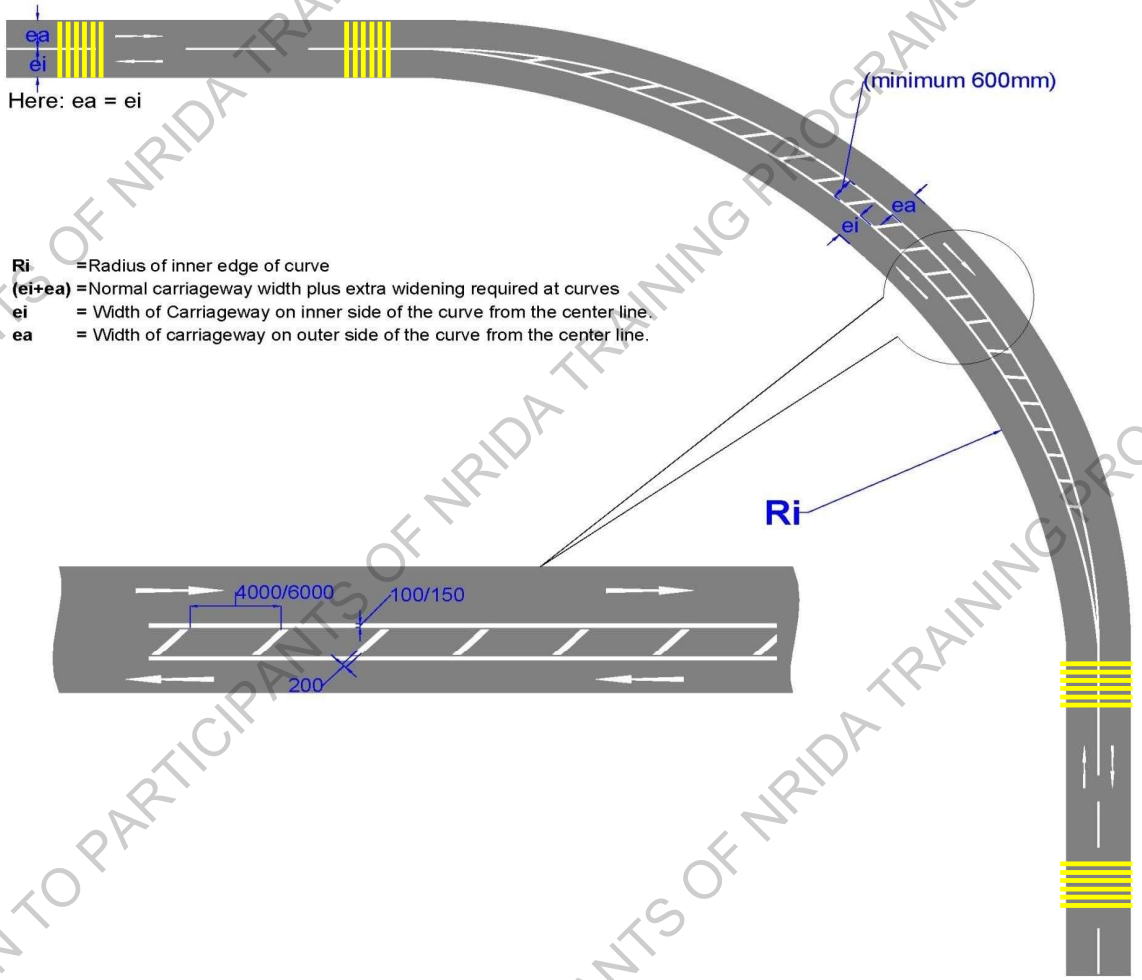
Traffic calming for hair-pin bend



Traffic calming for sharp curvature



Combination of signs, markings and traffic calming measures



Ri =Radius of inner edge of curve
(ei+ea) =Normal carriageway width plus extra widening required at curves
ei = Width of Carriageway on inner side of the curve from the center line.
ea = Width of carriageway on outer side of the curve from the center line.

Measures to reduce severity of run-off crash

Measures to reduce severity of run-off crash

Hazard Removal

- Relocation of hazard such as tree or pole to distance such as >10m
- Convenient when a single object (point hazard)
- If not possible to remove or relocate the hazard, provide crash barrier

Clear zone or Recovery Zone (next slides)

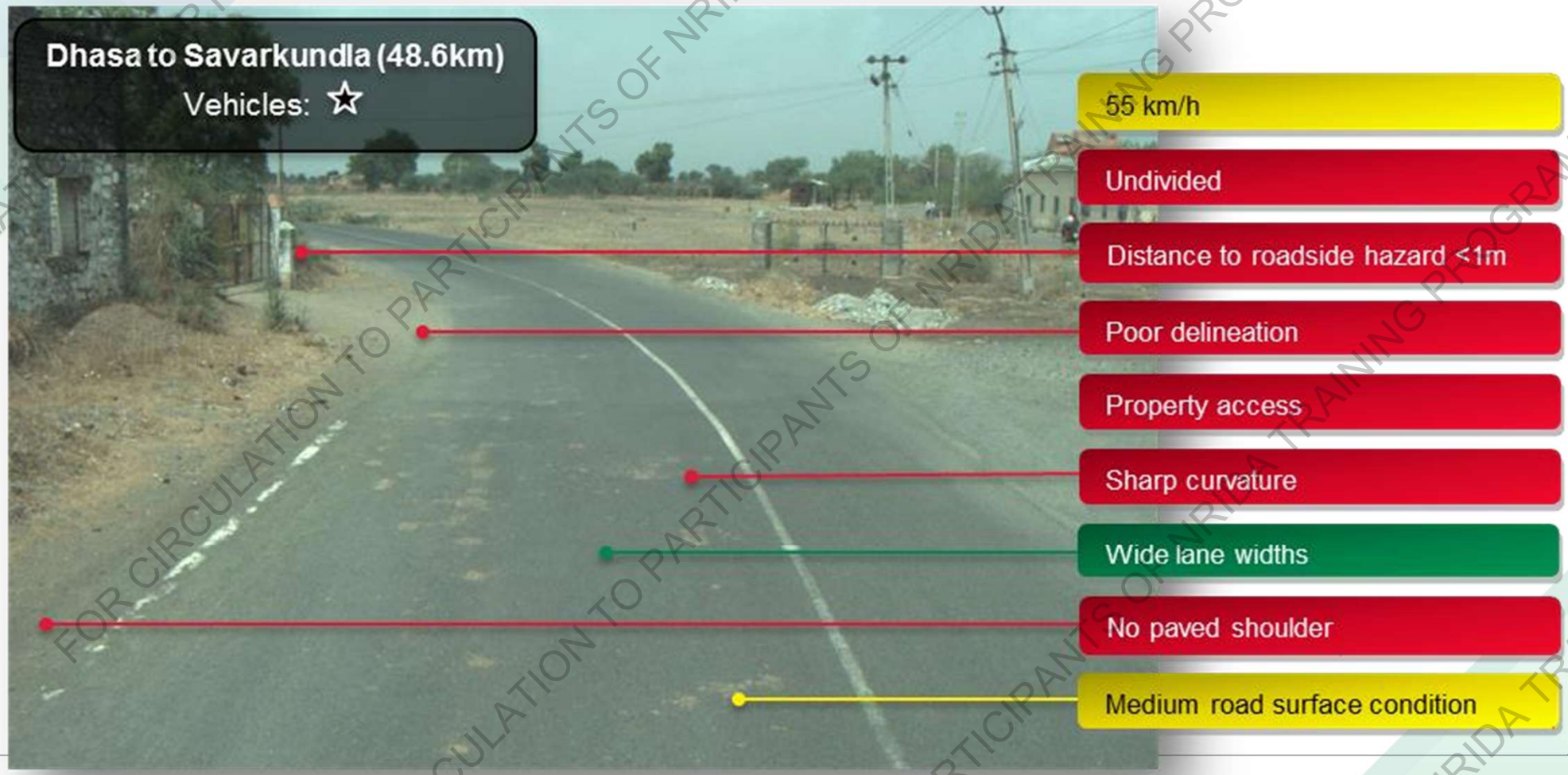
Provision of Crash Barrier (next session)

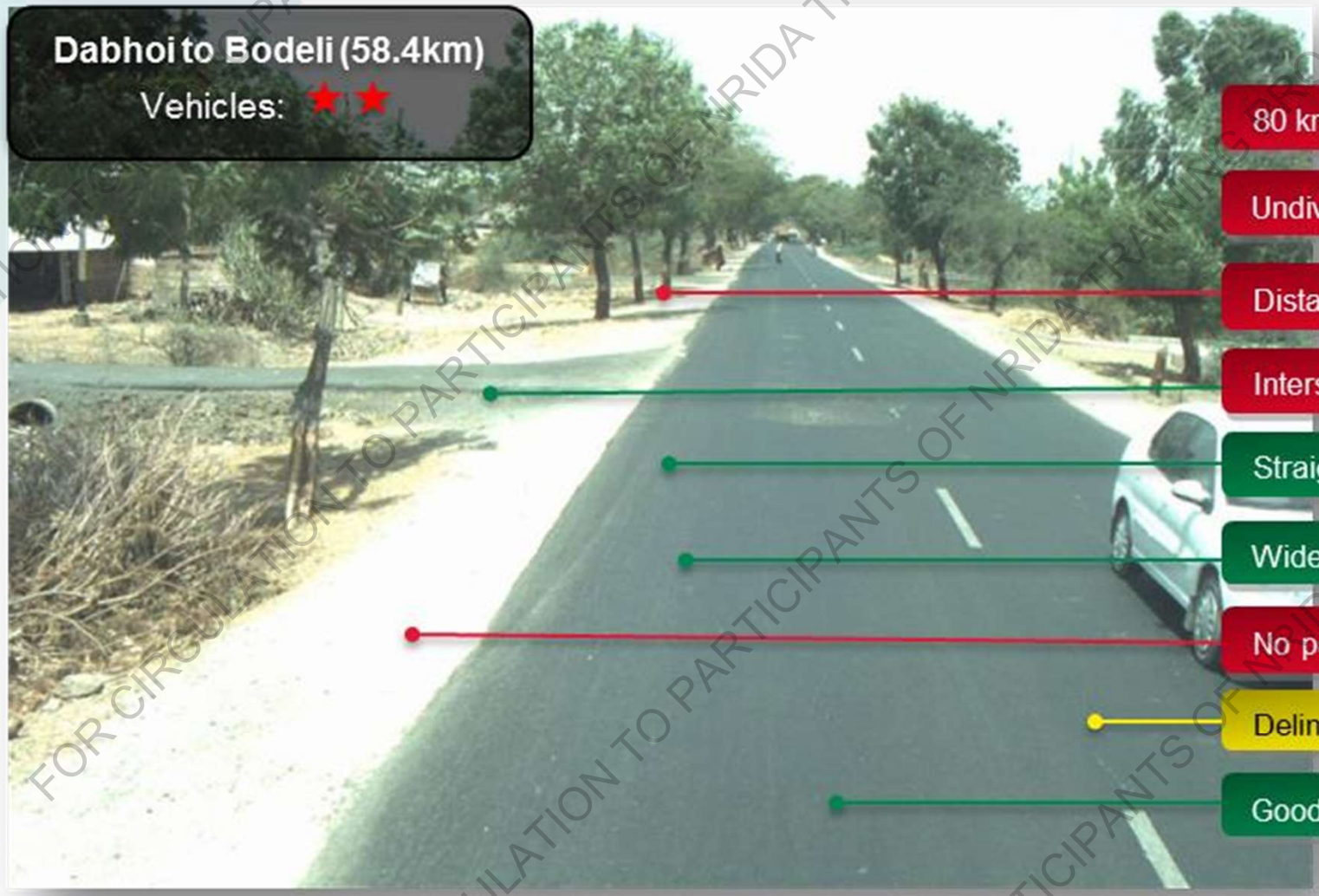
Clear zone or recovery zone

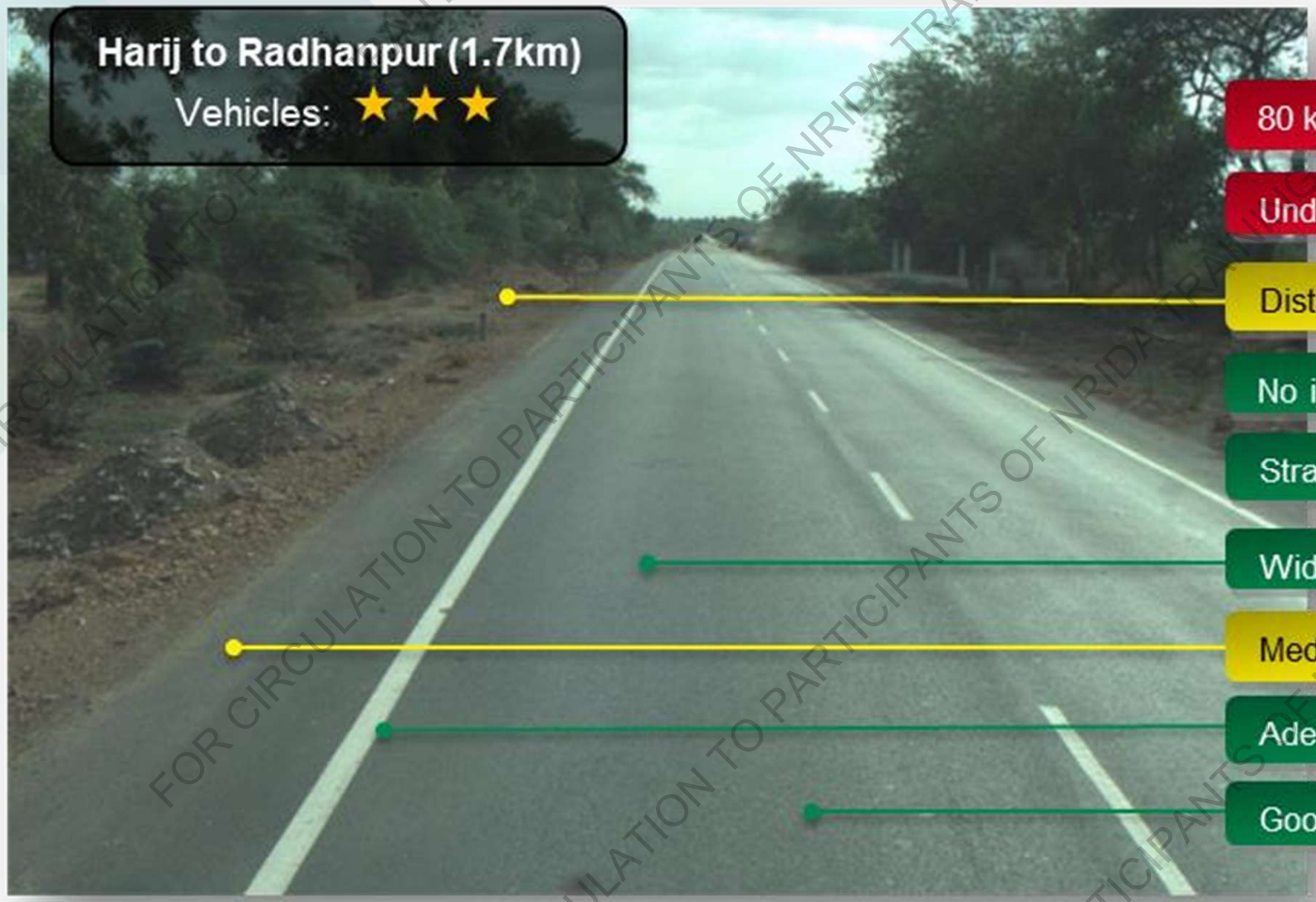
Clear Zone or Recovery Zone

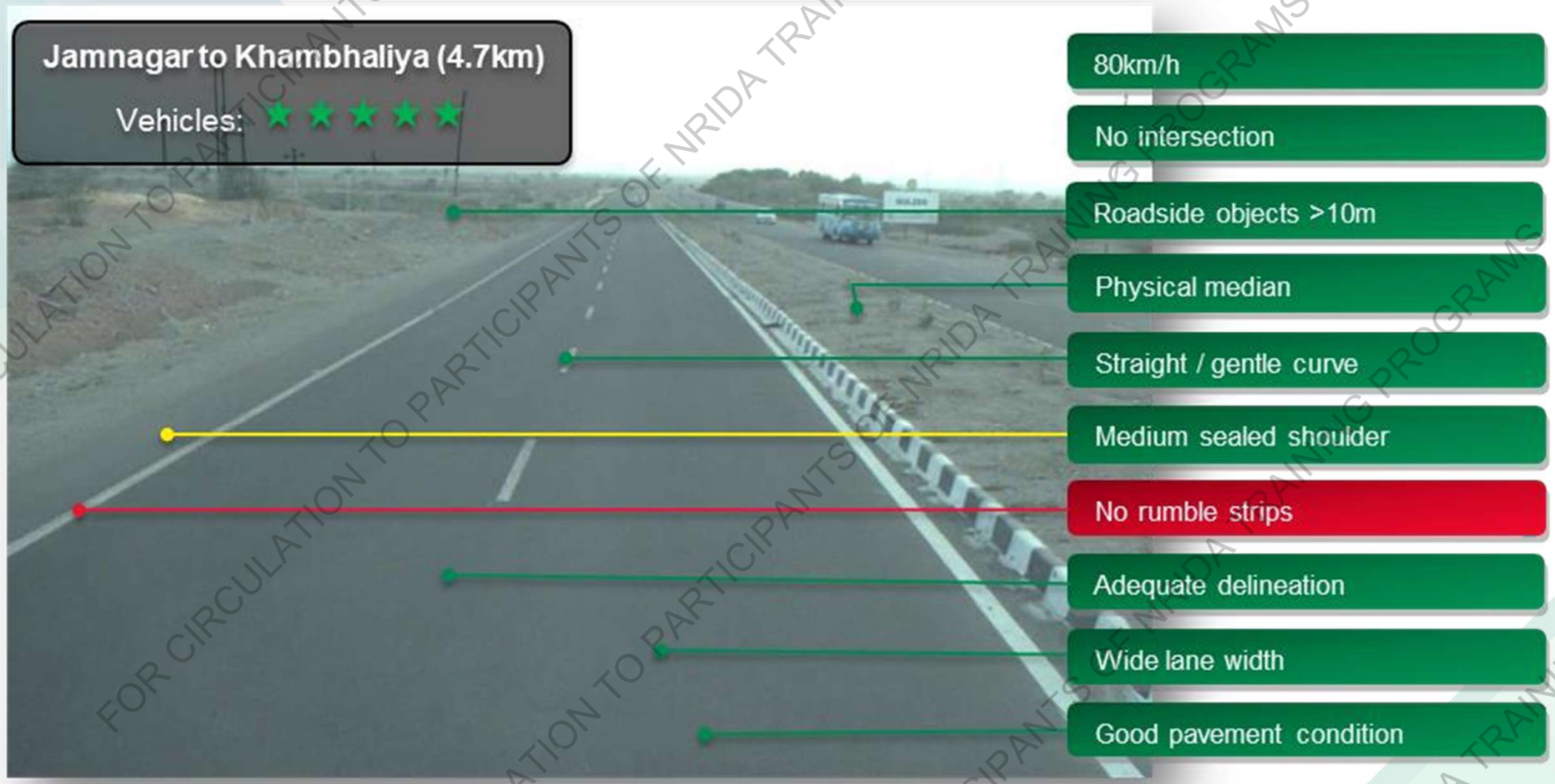
- Clear/open area (free from any objects or steep slope) on the roadside where vehicles can slow down without hitting a fixed object
- This also allows the driver to regain control of vehicle
- Even if vehicle hits the object, the impact occurs at low speed
- How large do we need to make this clear area beside the road? 2m? 5m? 10m?
- Challenges when the road reservation is very constrained

Examples

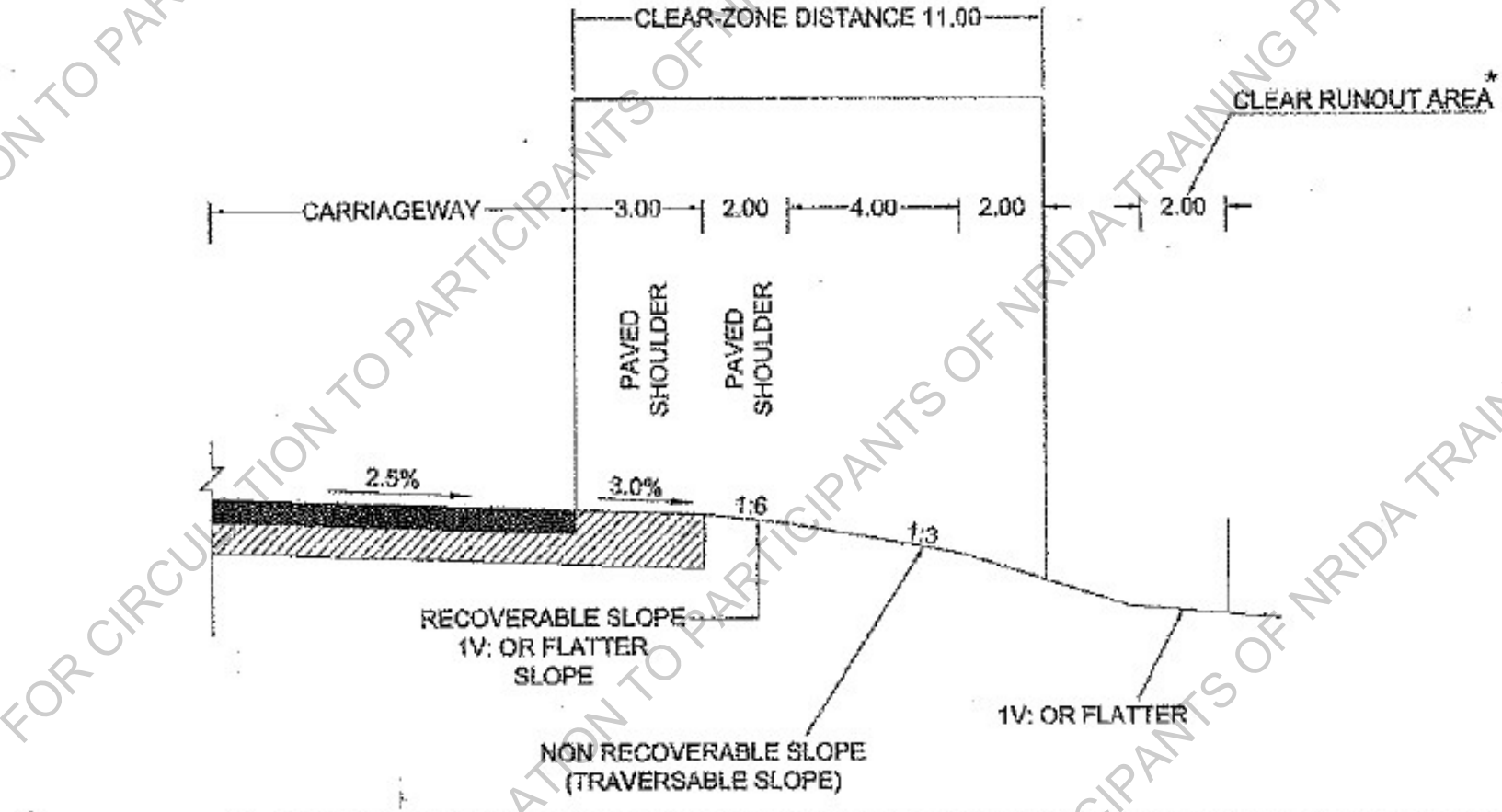








Clear Zone width as per IRC:119-2015



*THE CLEAR RUNOUT AREA IS ADDITIONAL CLEAR-ZONE SPACE THAT IS NEEDED BECAUSE A PORTION OF THE SUGGESTED CLEAR-ZONE (SHADED AREA) FALLS ON A NON-RECOVERABLE SLOPE

Clear Zone width as per IRC:119

- For 80kmph design speed and standard side slope of 1:6 the width is about 6m
- For steeper side slope the clear zone width shall be more
- Governing factors are Speed, Traffic Volume, Curvature and side slope

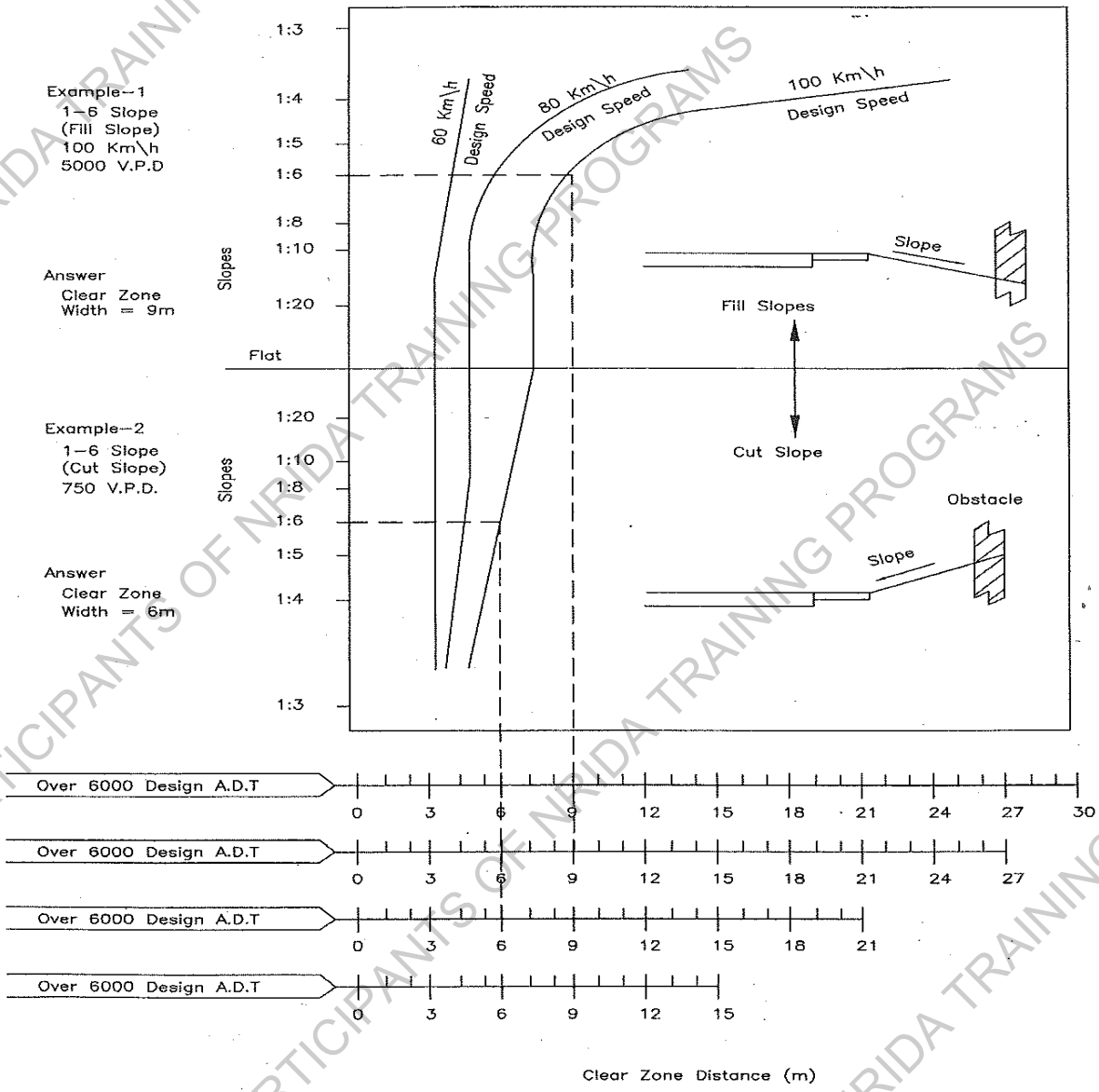


Fig. 6 Clear Zone Distance Curves
(Source: Ref. 1)

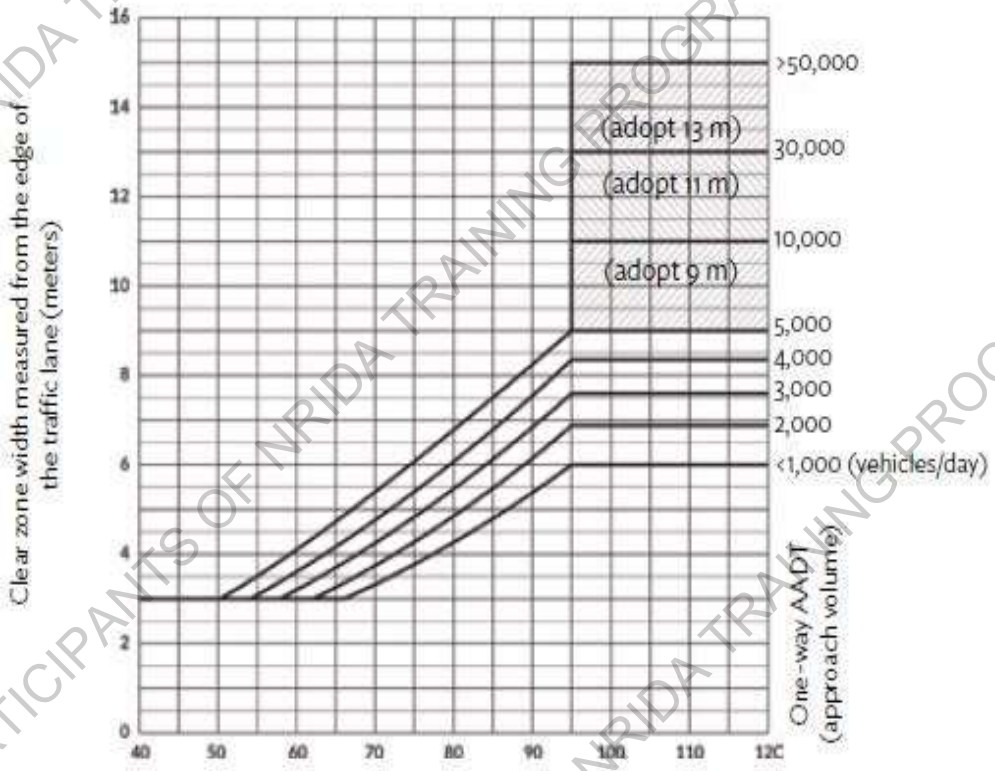
Clear Zone width

- Australian road design guide based on AASHTO standards
- For operating speed of 80kmph and low AADT, the width is 6m
- For high speed of 100kmph and high AADT, the clear zone width is 11m

Adjustment factors (charts) applicable on the above for Curves, and Side slope

Source: Roadside Hazard Management, CAREC Road Safety Engineering Manual v3, ADB

Figure 1: Clear Zone for Straight Roads



Example 1: If the operating speed is 80 km/h and the one-way AADT is 4,000 vehicles/day, the clear zone width is 6 m.

Example 2: If the operating speed is 100km/h and the one-way AADT is 20,000 vehicles/day, the clear zone width is 11 m (adopt range 10,000–30,000 vehicles/day)

AADT = annual average daily traffic, km/h = kilometer per hour, m = meter.

Source: VicRoads. 2011. *Supplement to Austroads Guide to Road Design – Part 6 (Roadside Design, Safety and Barriers)*. Sydney, Australia.

Crash Barriers

Crash Barriers

- Prevent vehicles from crashing into the roadside hazard or crossing over from one carriageway to the other
- Absorb part of energy from the impact caused by the vehicle
- Redirect the vehicle to its normal movement lane

- Types
  - Rigid barriers
  - Semi-flexible barriers
  - Flexible barriers
- End treatment
- Transition from one type to another, e.g. metal barrier to concrete barrier

IRC:119-2015

Types of barrier

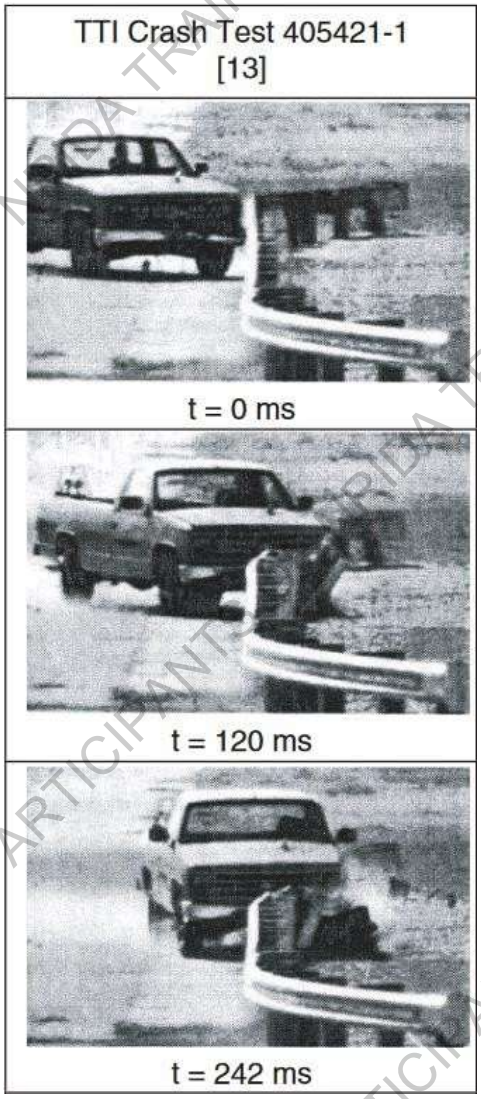
Concrete barrier

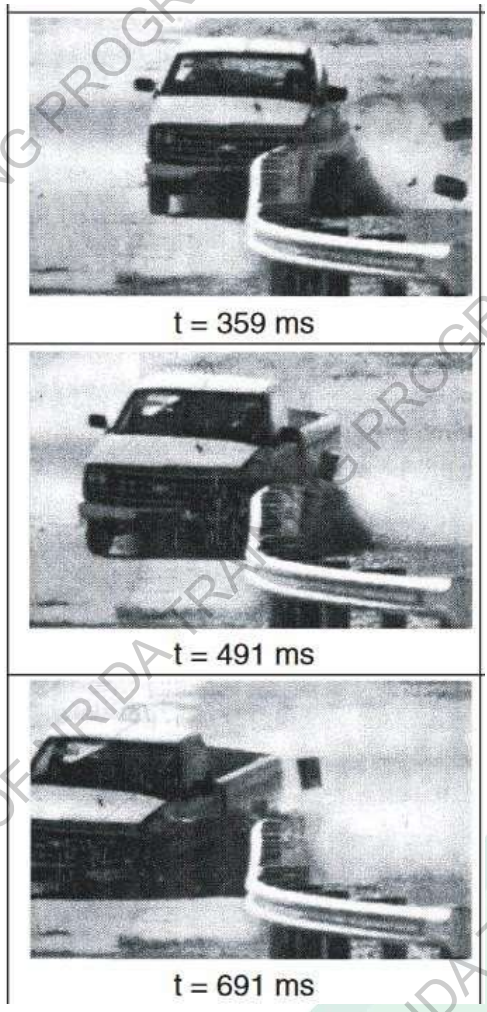
Metal beam barrier

Wire rope barrier

3 basic requirements of crash barriers

- Prevent
- Absorb energy
- Redirect vehicle





Comparison of 3 types

Barrier type	Containment	Deflection	Impact Severity
Rigid	High	Low	High
Semi rigid	Normal to high	Medium	Medium
Flexible	Normal to high	High	Low

Important points for crash barrier

- Space available behind the barrier must be adequate to permit the full deflection of the barrier
- It must contain and redirect the vehicle, without penetrating over the barrier
- Vehicle should remain upright during and after the impact

The crash barrier in this image may not be able to satisfy one of the above requirements

IRC:119-2015

Warrants for provision of roadside crash barrier

- For road embankments
  - For embankment slope 3:1 or milder no barrier required
  - For steeper slopes barrier required with respect to height of embankment as in the chart
- If hazardous roadside object is present within the clear zone, barrier is required

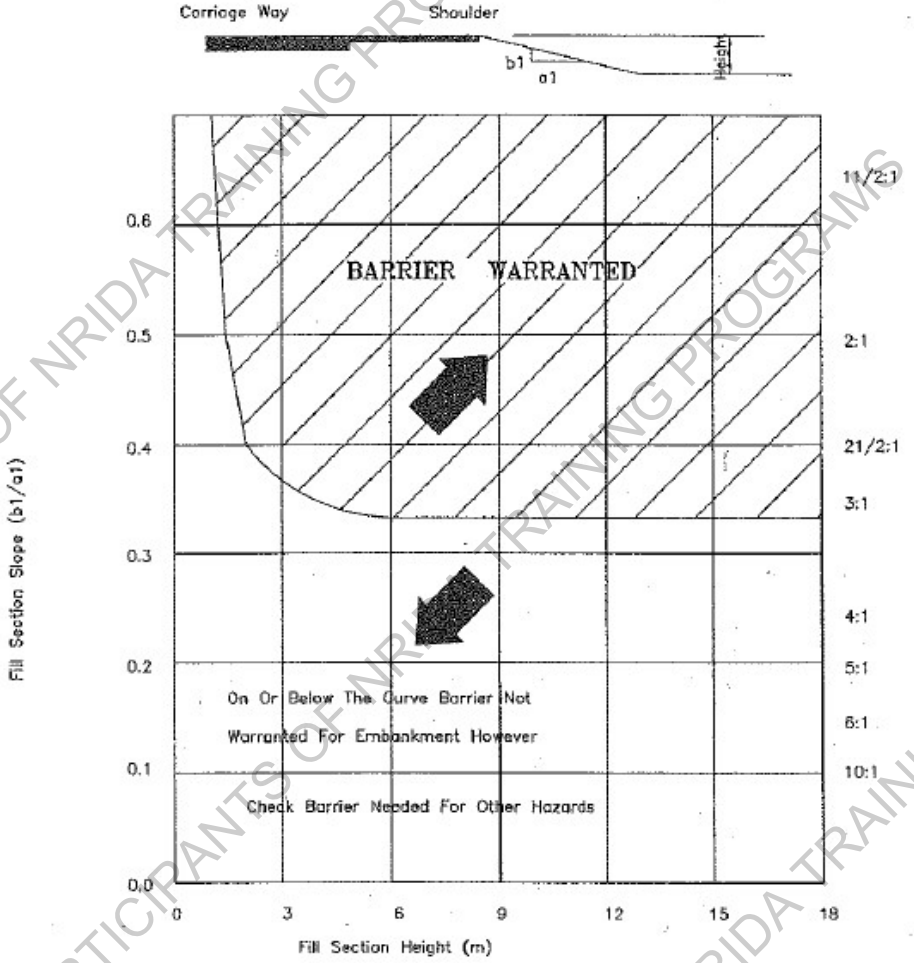


Fig. 4 Warrants for Fill Section Embankments

Warrants for provision of roadside crash barrier

- For shielding roadside objects
  - Rough rock cuts or large boulder
  - Streams or permanent water bodies >0.6m depth
  - Shoulder drop-off with slope 1:1 or steeper and height >0.6m
  - Concrete base >15cm height
  - Bridge piers or abutments of underpass
  - Retaining walls and culverts
  - Trees, etc.

IRC:119-2015 Guidelines for Traffic Safety Barriers

End treatment of safety barrier

Blunt End

Fishtail or Spoon type Ends

Turned Down Ends

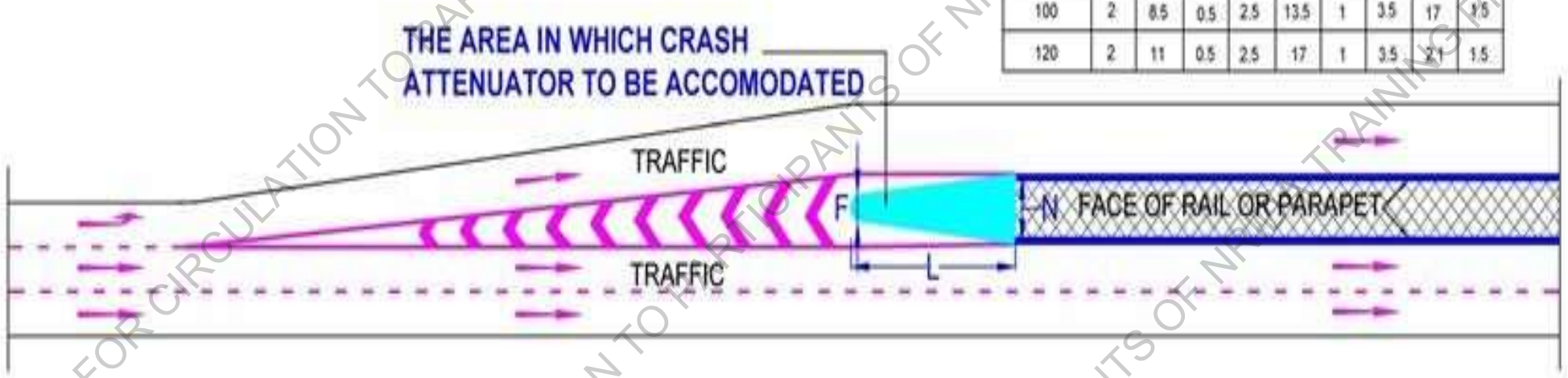
Unprotected barrier ends are dangerous

Delhi – Gurgaon Expressway, high speed (100kmph), high traffic volume

Delhi ring road, high speed (60kmph), high traffic volume

Energy absorbing end terminal

MINIMUM SPACE REQUIRED FOR CRASH ATTENUATORS. i.e. RESERVE AREA (In meter)									
SPEED OF MAIN HIGHWAY (kmph)	MINIMUM SPACE						PREFERRED SPACE		
	RESTRICTED CONDITIONS			UNRESTRICTED CONDITIONS					
	N	L	F	N	L	F	N	L	F
60	2	2.5	0.5	2.5	3.5	1	3.5	5	1.5
80	2	5	0.5	2.5	7.5	1	3.5	10	1.5
100	2	8.5	0.5	2.5	13.5	1	3.5	17	1.5
120	2	11	0.5	2.5	17	1	3.5	21	1.5



- TIA provided at hazardous locations and gorge arrears to act as energy absorbers

Energy absorbing end terminal

Transition from rigid to semi-rigid barrier

Transition from rigid to semi-rigid barrier

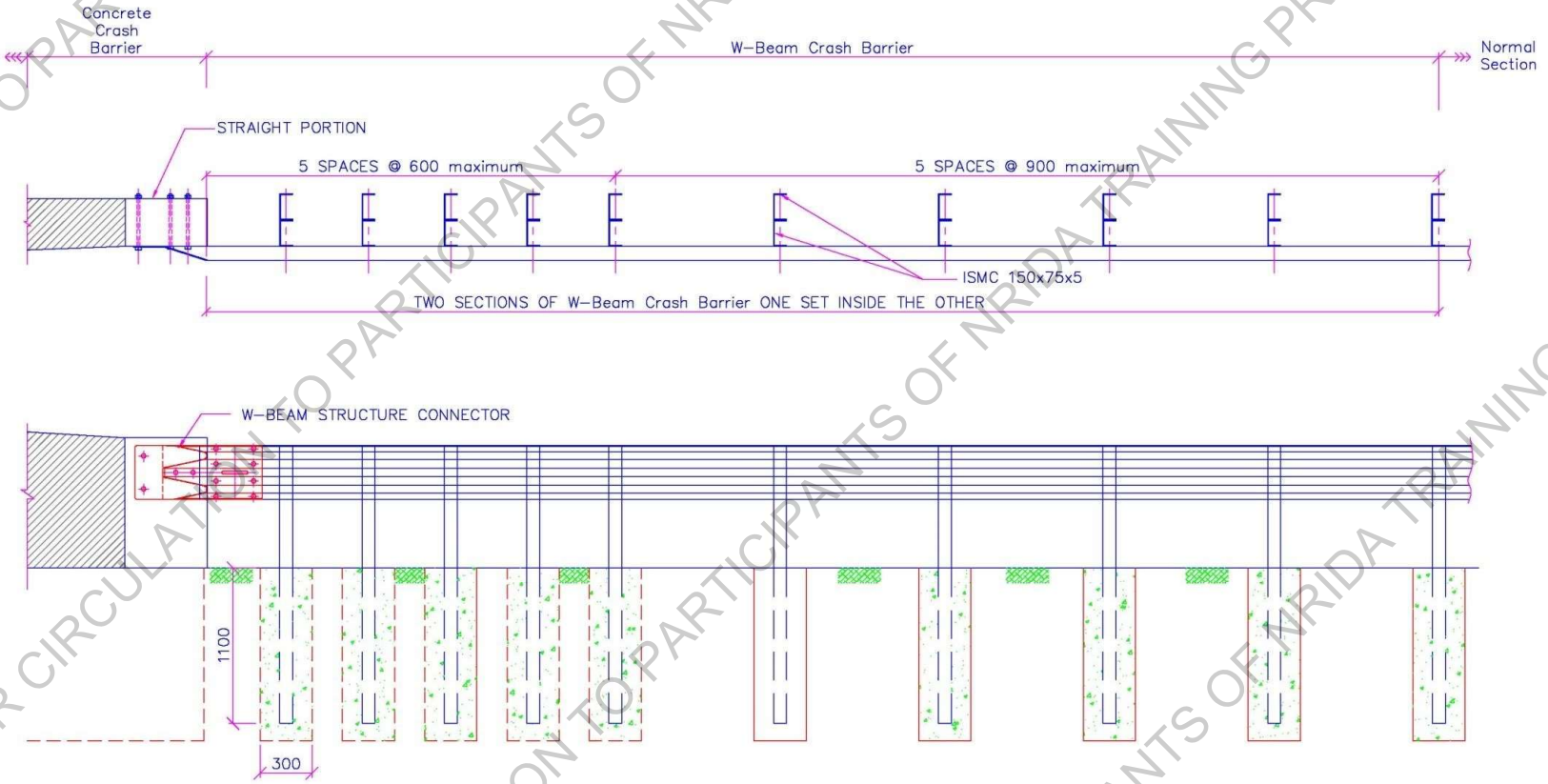
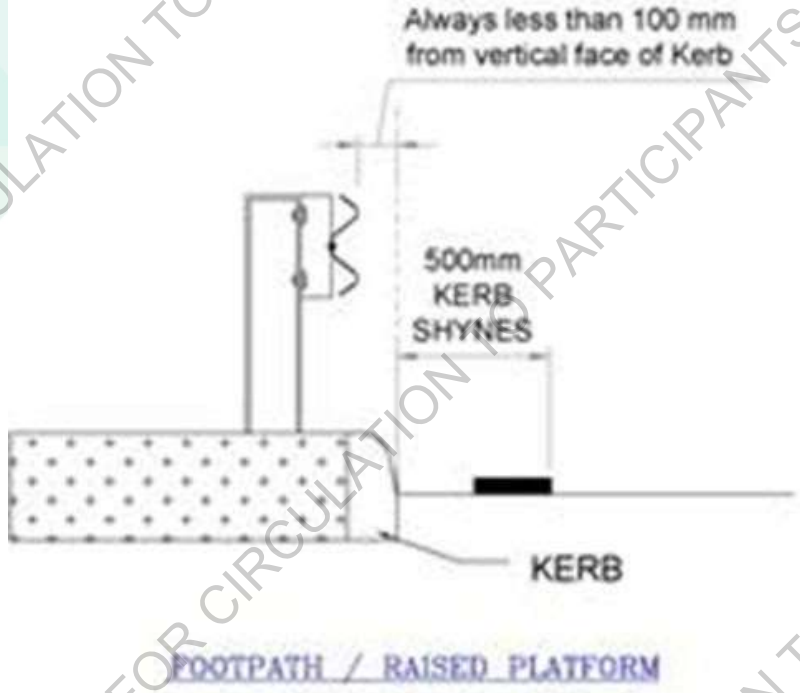


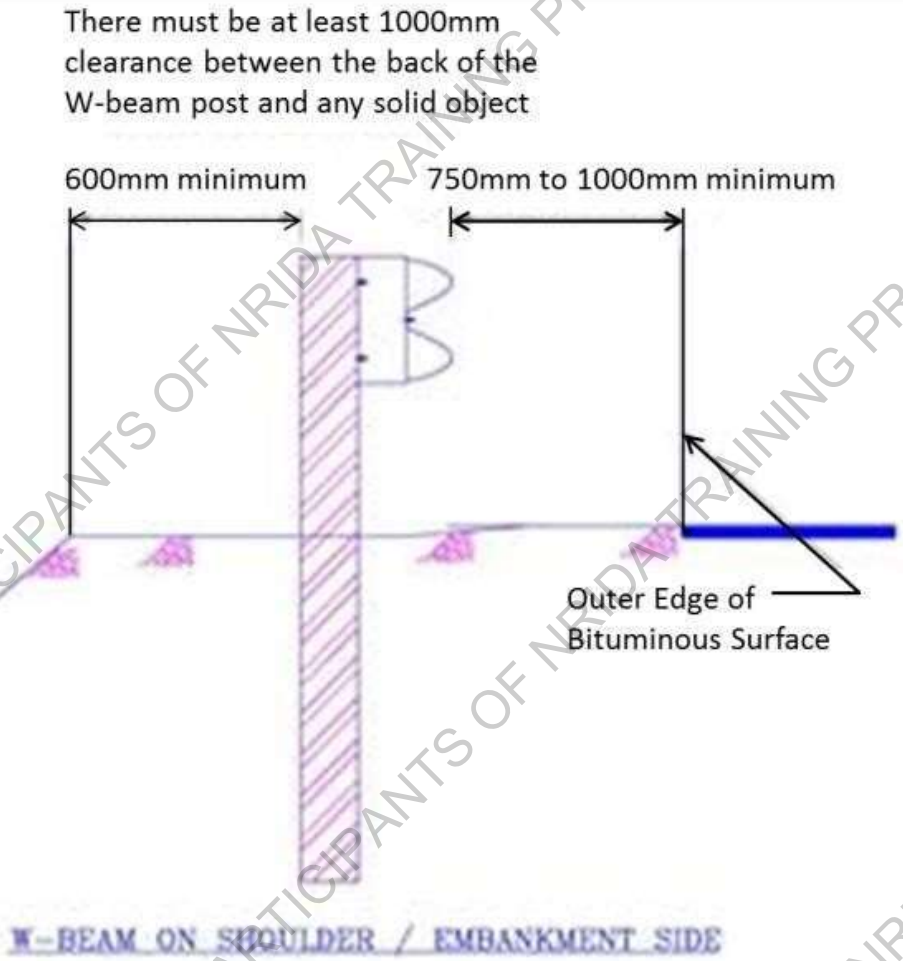
Fig 9.15: W Beam to Concrete Connection Details

Transition from rigid to semi-rigid barrier

Important design parameter



FOOTPATH / RAISED PLATFORM



W-BEAM ON SHOULDER / EMBANKMENT SIDE

Do you see any road hazard in this image?

Go to www.menti.com and use the code 57 76 26 8

What risk you identify in the image? (choose any 3)

Mentimeter

Median Barriers

- To stop the vehicles crossing over the median
- It stops the run-off crash to result into a head-on collision
- Also shields objects such as trees or poles in the median

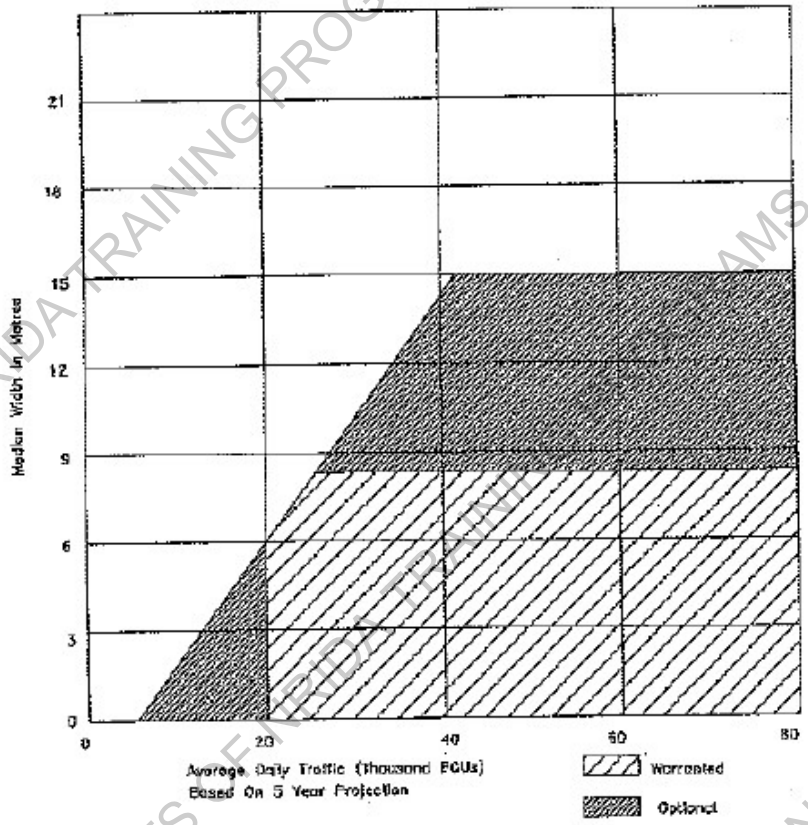


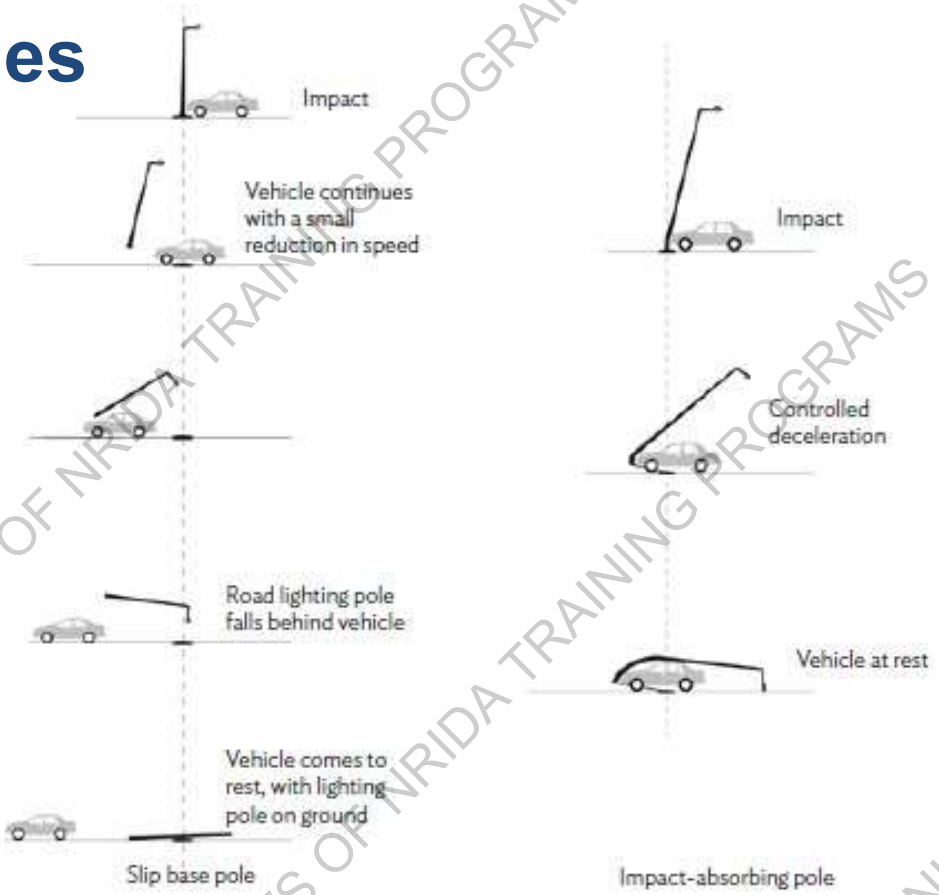
Fig. 22 Warrants for Median Barriers
(Source : Ref. 1)

Frangible v/s non-frangible poles

- Frangible or slip base lighting column suitable for speeds higher than 80kmph and in areas with minimal pedestrian and vehicle parking
- Impact absorbing lighting columns suitable in low speed (below 80kmph) and in areas where some pedestrian and vehicle parking is present

Slip base column

Impact absorbing column



Source: Roadside hazard management, CAREC Road Safety Engineering Manual 3, ADB

Reference Documents

- IRC:119-2015 Guidelines for Traffic Safety Barriers
- IRC:35-2015 Code of Practice for Road Markings (Second Revision)
- IRC:67-2012 Code of Practice for Road Signs (Third Revision)
- CAREC Road Safety Engineering Manual 3 – Roadside Hazard Management
- Guide to Road Design Part-9 Roadside Hazard Management, Austroads

THANK YOU