



## 4th Regional Road Safety Engineering Workshop

16–17 April 2018 | Istanbul, Turkey

4-й Семинар по инженерному обеспечению безопасности дорожного движения

16–17 апреля 2018 года | Стамбул, Турция

# Treating Hazardous locations with cost-effective countermeasures

*Low cost engineering improvements that can reduce pedestrian collisions or run-off-road crashes.*

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## Objectives of this session:

To encourage CAREC road authorities to use programs of low cost, high benefit engineering improvements at hazardous locations involving pedestrian collisions and run-off-road crashes.



Some crashes occur in clusters.

A road authority can achieve remarkable savings in crash costs by identifying these clusters, and treating them with proven low cost treatments.

Selecting the correct treatment is a skill. It requires knowledge, experience and judgement





# 1. Pedestrian crash locations

CAREC roads are high risk locations for pedestrians

- 7% of fatalities in Afghanistan
- 31% of fatalities in Azerbaijan
- 26% of fatalities in China
- 24% of fatalities in Georgia
- 23% of fatalities in Kazakhstan
- 32% of fatalities in Kyrgyzstan







# 1. Pedestrian crash locations

CAREC roads are high risk locations for pedestrians

- 31% of fatalities in Mongolia
- ?% of fatalities in Pakistan
- 33% of fatalities in Tajikistan
- 23% of fatalities in Turkmenistan
- ?% of fatalities in Uzbekistan





# 1. Pedestrian crash locations

This session is an opportunity for us to open discussion about what your organisation can do/should do to assist pedestrian safety in your country as part of your national Road Safety Action Plan






Why should we be concerned for pedestrian safety?



Why should we be concerned for pedestrian safety?







Why should we be  
concerned for  
pedestrian safety?





About 400,000 pedestrians  
killed worldwide per annum  
(1000 per day!)

- Pedestrians are the largest group of road users
- They need no licence
- Very mobile
- All ages
- Very vulnerable - serious injuries if struck
- Over 30% of road fatalities (depending on city, nation)
- Their trauma costs your country \$\$\$\$

If you and your organisation doesn't provide facilities to assist pedestrian safety - who will?





Pedestrians come  
in all shapes,  
sizes, races,  
and ages





Pedestrians come in all shapes, sizes, races, and ages





Pedestrians come in all shapes, sizes, races, and ages





Pedestrians come in all shapes, sizes, races, and ages

# What can you do to help pedestrians?

- Do not ignore them.
- Appreciate they are legitimate road users.
- Try to facilitate, rather than prohibit, their movements.





# Put yourself in “their” shoes

- Walk the site.
- Ask what would you like to help you to safely cross the road.
- What would you like to provide for your family, friends?



## What facilities do we have to help pedestrians?

DEVICE	CRF (Australia)
Overpass	10%
Subway	10%
Intersection signals	Not known for pedestrians but 45% overall
Mid block push button signals	25%
Zebra Crossing (with flashing signals, without signals)	Not known - estimated 20%
School crossing (or school zone)	Not known - estimated 50%
Refuge	30%

	Overpass	Pedestrian Operated Signals	Pedestrian Crossing (with flashing lights)	Pedestrian Crossing (without flashing lights)	Flagged School Crossing	Pedestrian Refuge
Primary Arterial	○	●	X	X	○ +	○
Secondary Arterial	○	●	○	X	○	○
Collector	X	○	○	○	●	●
Local Road	+	+	○ =	○ =	○	○

● Most likely to be appropriate  
 ○ May be an appropriate treatment  
 X Inappropriate treatment  
 + Pedestrian devices should not be needed  
 \* Flagged school crossings are sometimes used on low volume primary arterials especially in rural areas  
 = Pedestrian crossings (zebra crossings) may be appropriate in a local shopping centre



While we need to think of all groups of pedestrians – crash data tells us there are THREE groups at greatest risk.....





## Three groups of pedestrians most at risk:

- **senior citizens** - 19% of pedestrian fatalities are over 65 years
- **young** - 20% of pedestrian fatalities are aged 4-12 years
- **intoxicated** - 43% of night time pedestrian fatalities  $\geq$  0.15% BAC

.....plus the disabled





**Seniors** – about 20% of pedestrian fatalities are over 65 years of age



**The young**  
20% of pedestrian  
fatalities are aged  
4-12 years





## The intoxicated

43% of adult male pedestrian fatalities  $\geq 0.15\%$  BAC in my State (Victoria).

What % in your country?





How safe are the disabled in your city?

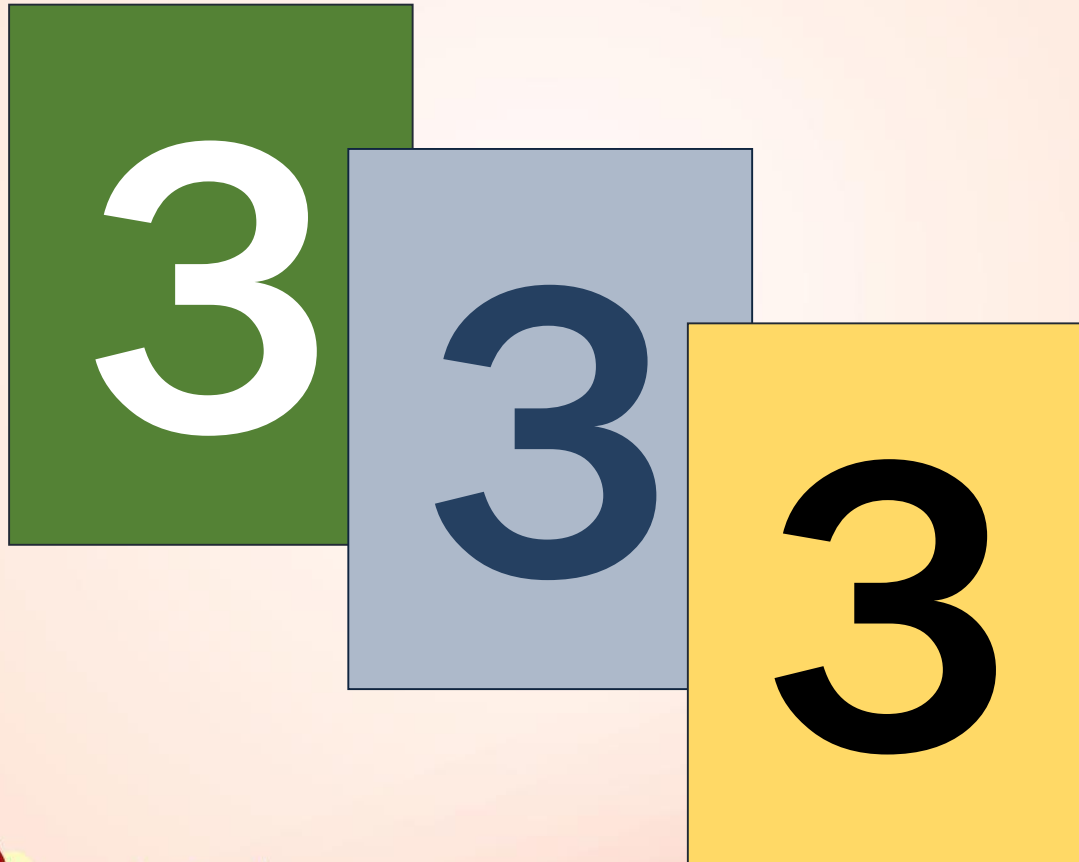




How safe are the disabled in your city?



# There are three basic pedestrian strategies





## There are three basic pedestrian strategies

Segregation – expressways, malls

Separation – in time or in space

Integration – vehicles & pedestrians “share” the road







Segregation – freeways



Segregation – malls





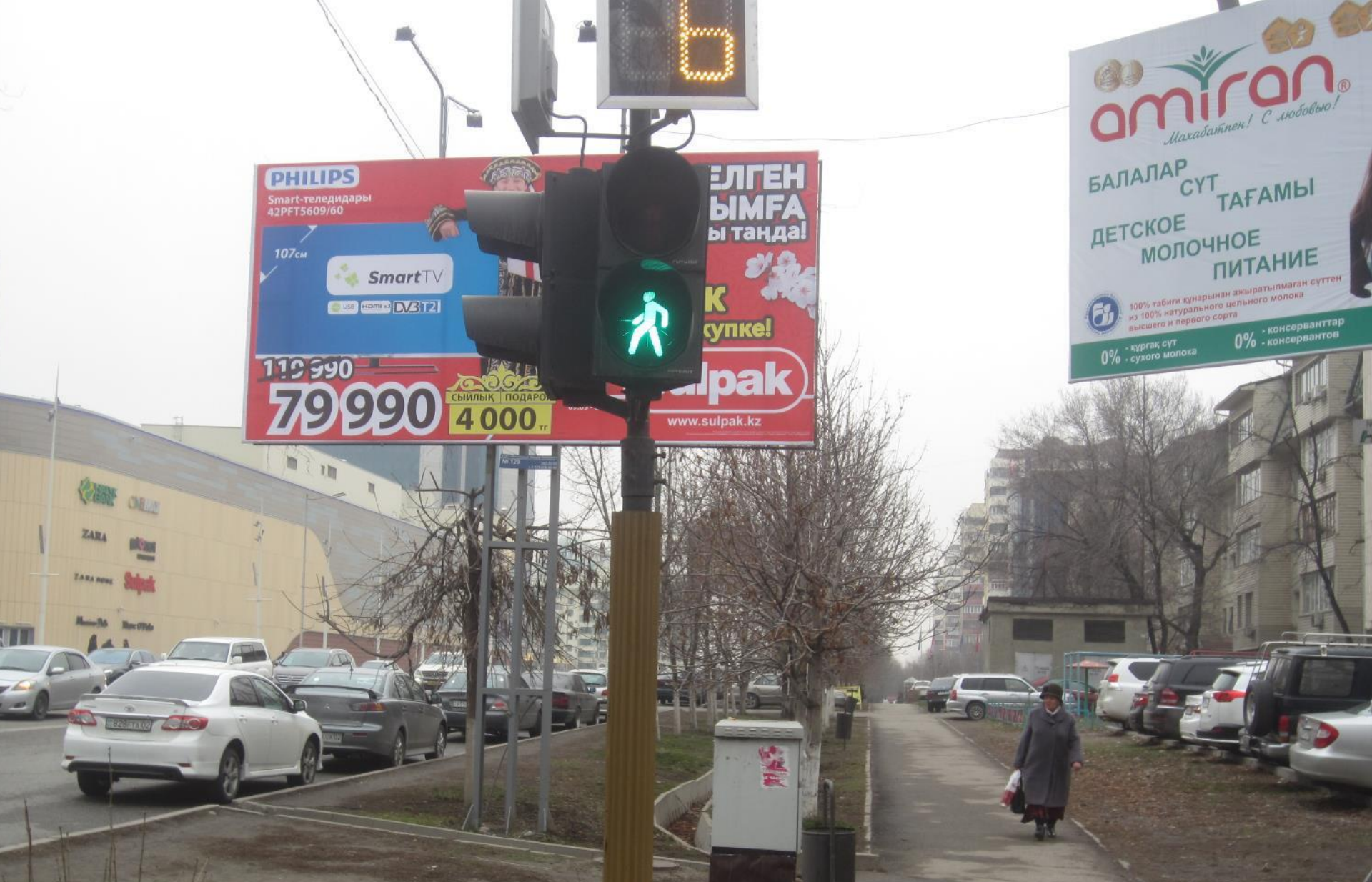
Separation – in time





Separation – in time





All CAREC intersection signals should have pedestrian signals. Clearance times must be adequate for a slow person to clear.

Too many signals in CAREC roads have long WALK times but very short CLEARANCE times. Why?

Allow 1.3m/sec WALK time, and 1.5m/sec CLEARANCE.

Install pedestrian push buttons.

Line marking.







Separation – in time?

Place mid-block crossings on the “desire line”

Install pedestrian push buttons

Adopt a cycle time that does not unduly delay pedestrians

Cut through any median – for elderly, disabled, carts







Separation – in time?

Do NOT use zebra crossings on carriageways more than 2 lanes wide.

Place zebra crossings on the “desire line”

Cut through any median – for elderly, disabled, carts.

Must have advance warning signs PLUS regulatory signs

Must be well maintained, and lit.







Separation – in time?



But please – fewer Zebra Crossings until drivers and pedestrians use them correctly





Separation – in time (something for you to consider)

# Pelican Crossings

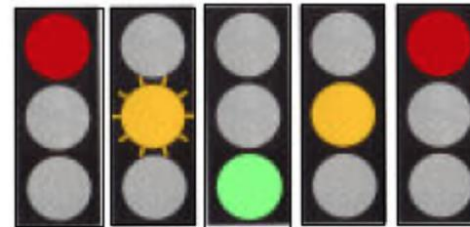
**WHEN  
FLASHING  
GIVE WAY TO  
PEDESTRIANS**



## Pelican Crossing

If the crossing goes straight across the road (even when there is a central refuge) treat it as a single crossing

If the crossing is staggered treat it as two separate crossings.



Flashing Amber Phase







Puffin Crossings (reduce vehicle delays by 40%)



# Toucan Crossings

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Separation – in space





Separation – in space





How can we help pedestrians who walk along a road?

Weigh up the need (more pedestrians = more need).

Try to provide all-weather off-road paths

Pave shoulders – at least 1.5m wide

Tactile edge lines on highways

Paved and indented bus laybys







## Separation in space (grade separation)

- Most pedestrians dislike grade separation
- If grade separation is essential, people usually prefer an overpass.
- If you must have a subway, encourage one that has a straight through view – for personnel safety







Separation – in space





Separation – in space





Why do so many road authorities think that overpasses/subways are the “ultimate” device for pedestrians?

Most pedestrians do not like them, and most do not use them

Disabled/elderly often cannot climb 30+ steps

Subways are often dirty and undesirable.

Look for lower cost and more acceptable facilities





Separation – in space





Separation – in space



Separation – in space







Integration – vehicles and pedestrians “share” the road







Reality! What will you do to reduce pedestrian trauma?  
How will you do it?



# 1. Pedestrian crash locations

This session is an opportunity for us to open discussion about what your organisation can do/should do to assist pedestrian safety in your country as part of your national Road Safety Action Plan





## 2. Single vehicle “run-off-road” crashes

- The roadside hazard management strategy
- The clear zone principal
- The three main groups of safety barriers





## 2. Single vehicle run-off-road crashes

This session is an opportunity for us to open discussion about what your organisation can do/should do to reduce run-off-road crashes in your country as part of your national Road Safety Action Plan





Some crashes occur in clusters.

A road authority can achieve remarkable savings in crash costs by identifying these clusters, and treating them with proven low cost treatments.

Selecting the correct treatment is a skill. It requires knowledge, experience and judgement



Your long distance CAREC highways suggest to me that single vehicle run-off-road crashes are a problem in your countries – as they are in mine.

In Australia, 40% of fatalities occur in single vehicle run-off-road crashes.

What is your figure?





To provide a “forgiving” roadside environment, ask:

- What is a hazard?
- How far off the road must a hazard be before we can accept it is “safe”?
- Can one width be used for all roads?

This leads to the important question  
– what is a clear zone?



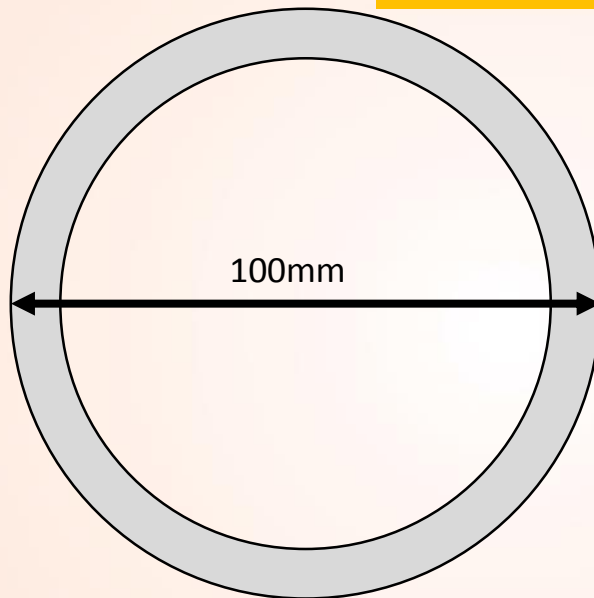


Anything that is “fixed” and has a diameter of 100mm or more, and is on the roadside, within the clear zone.

What is a roadside hazard?



A hazard is any fixed object that is more than 100mm diameter



What distance from the road does a hazard need to be to be considered “safe”.





Roadside hazard





**Roadside hazard**



SEMENT  
M-400

Roadside hazard





**Roadside hazard**



Roadside hazard





Roadside hazard





Roadside hazard





Roadside hazard





**Roadside hazard**

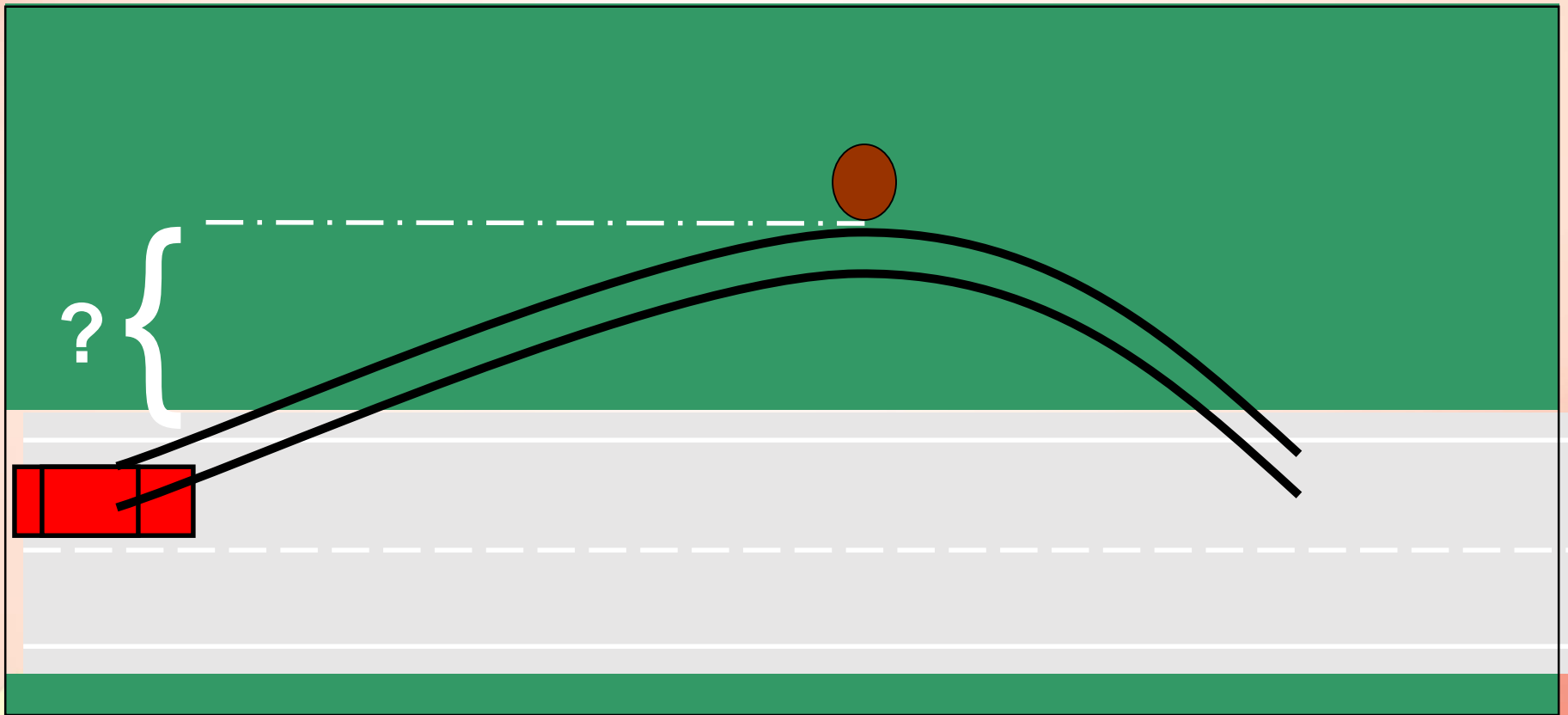


# What is a Clear Zone ?

A driveable roadside area that should be kept clear of hazardous objects in order to minimise the danger of a collision should a vehicle leave the road.



# What is a Clear Zone ?



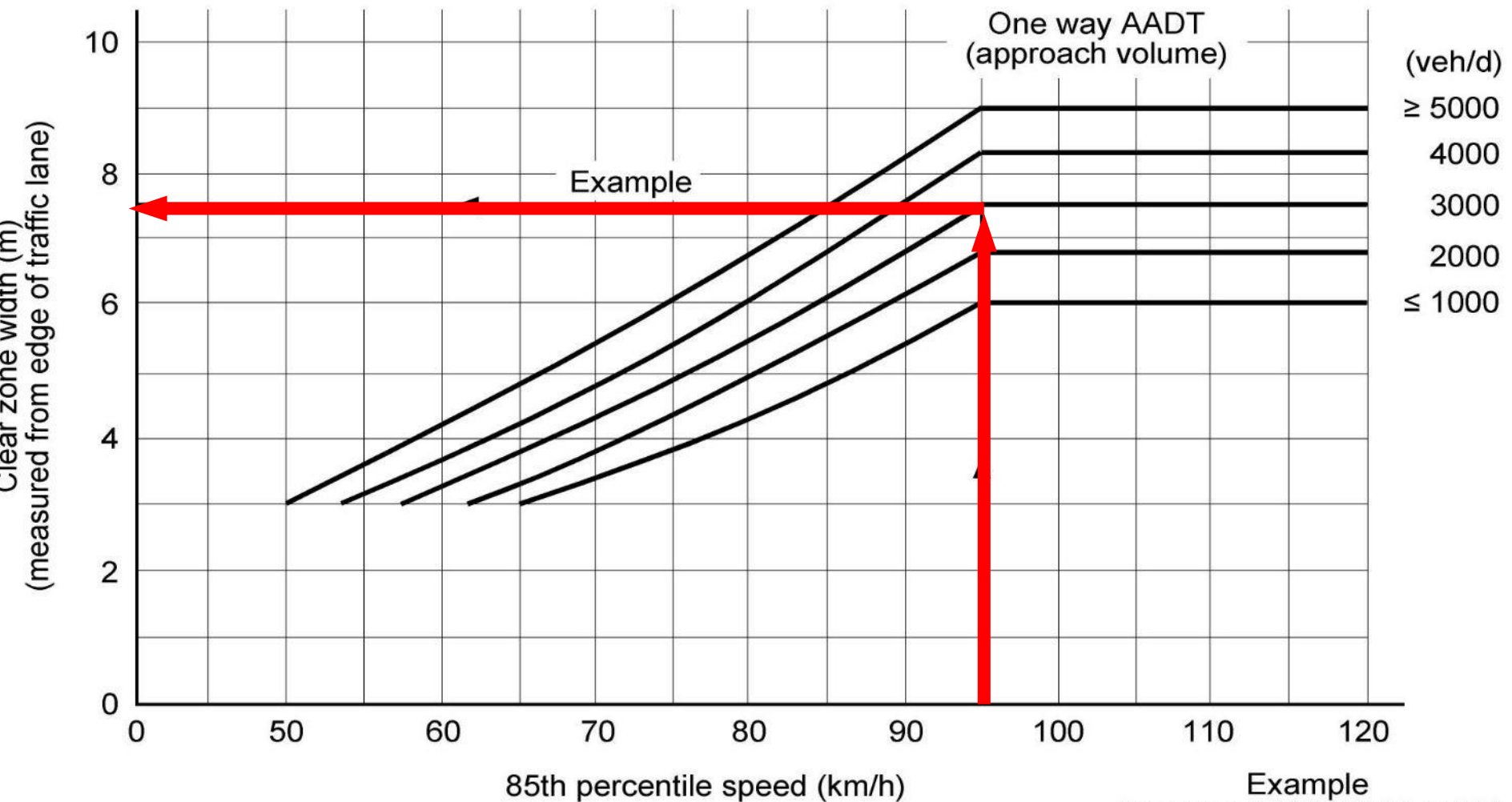


## How do we determine the Clear Zone for a road?

- vehicle speeds
- vehicle volumes
- road curvature
- embankment slope



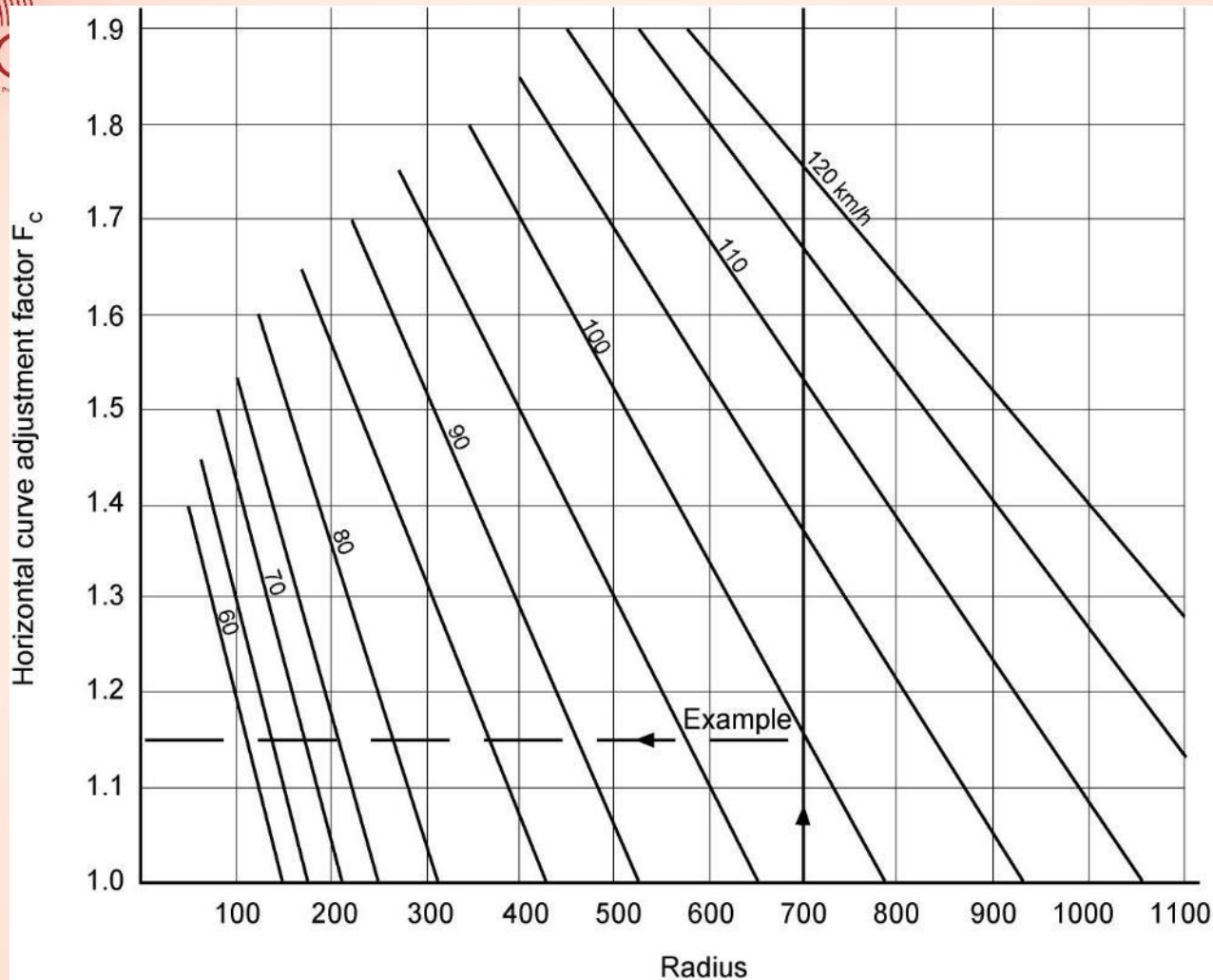
# Determining a clear zone



Example  
 One way AADT 3000 veh/d  
 Operating speed 95 km/h  
 Clear zone width = 7.5 m



# EFFECT OF HORIZONTAL CURVES ON CLEAR ZONE

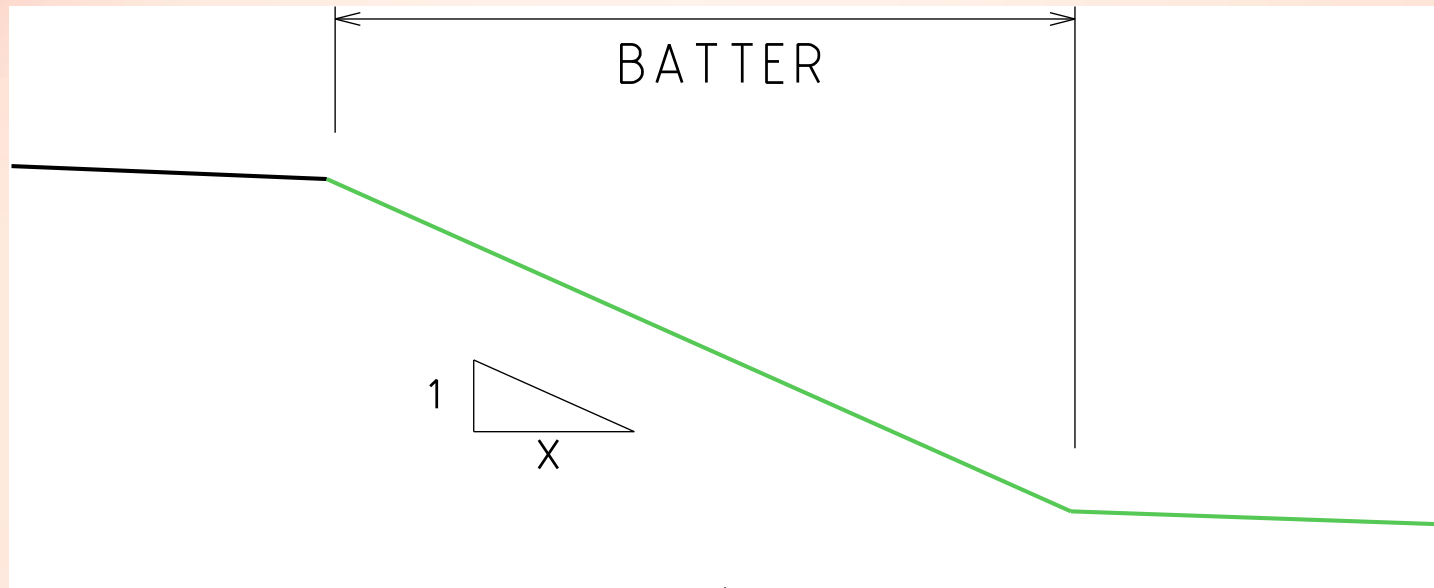


**Note:** For Radii > 1000 metres use  $F_c = 1.0$

**Example:**  
On curves, a 700 metre radius curve at an Operating Speed of 100 km/h suggests an  $F_c$  of 1.15



# Side Slopes



- **6:1** Driveable Limit for Trucks
- **4:1** Driveable Limit for Cars
- **3:1** Limit for Mowing
- **2:1** Generally Requires Planting Out
- **1.5:1** Often Requires Beaching



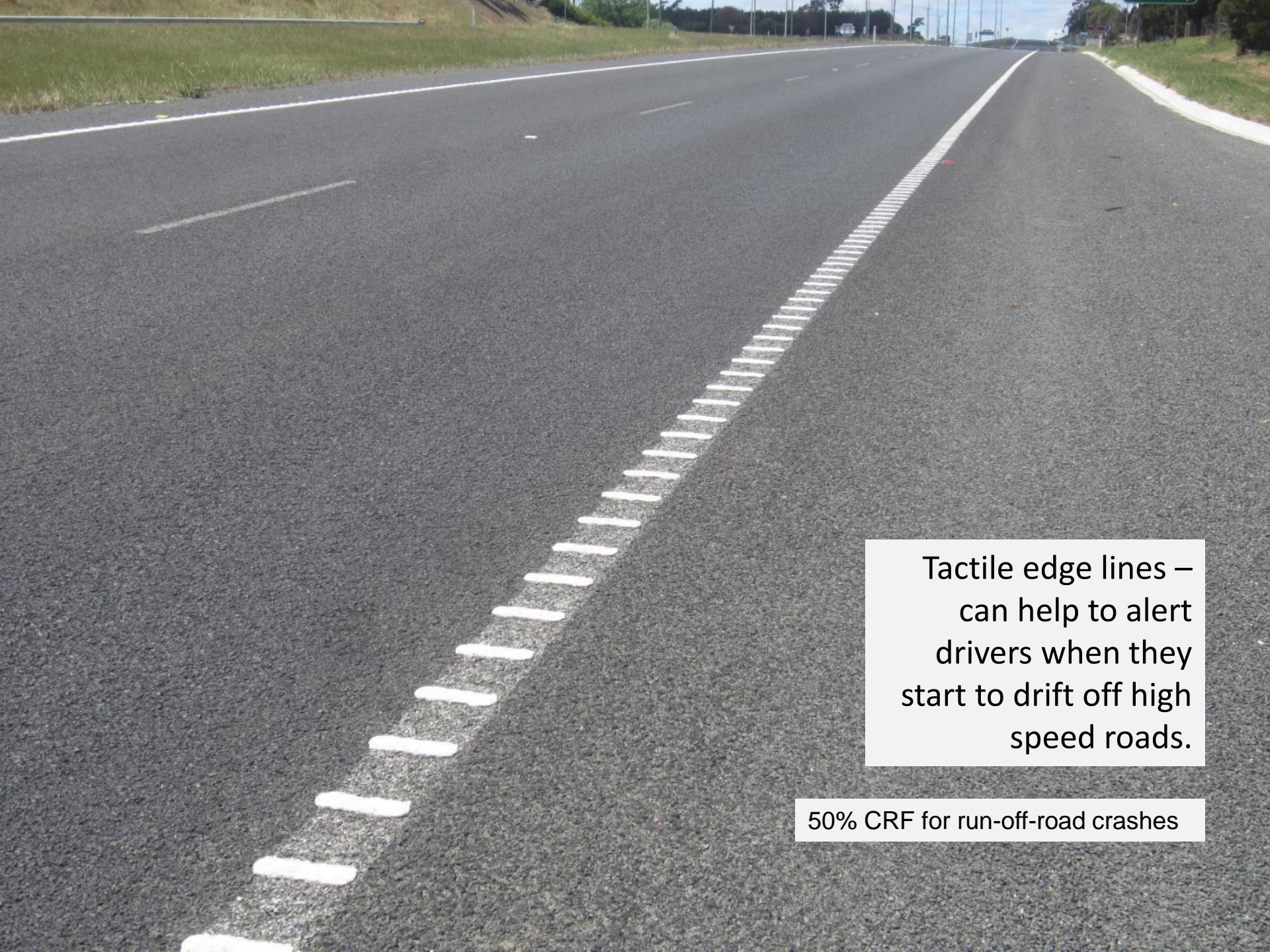


# A strategy for Roadside Hazard Management

- 1. Keep vehicles on the road**
- 2. Provide a forgiving roadside**

- i. remove the hazard**
- ii. relocate the hazard**
- iii. alter to reduce severity**
- iv. shield using barriers/attenuators**





Tactile edge lines –  
can help to alert  
drivers when they  
start to drift off high  
speed roads.

50% CRF for run-off-road crashes



# Remove the Hazard

- Remove trees
- Use underground power line
- Cover drains
- Demolish structures





Cover drains





Cover drains

# Relocate the Hazard

- ideally to a location outside the clear zone
- relocation to a less vulnerable position can reduce risk





# Alter the Hazard to Reduce Impact Severity

- frangible lighting poles
  - slip base
  - impact absorbing
- frangible sign posts
- grade steep slopes (4:1 or flatter)
- driveable culverts



# Slip Base Pole



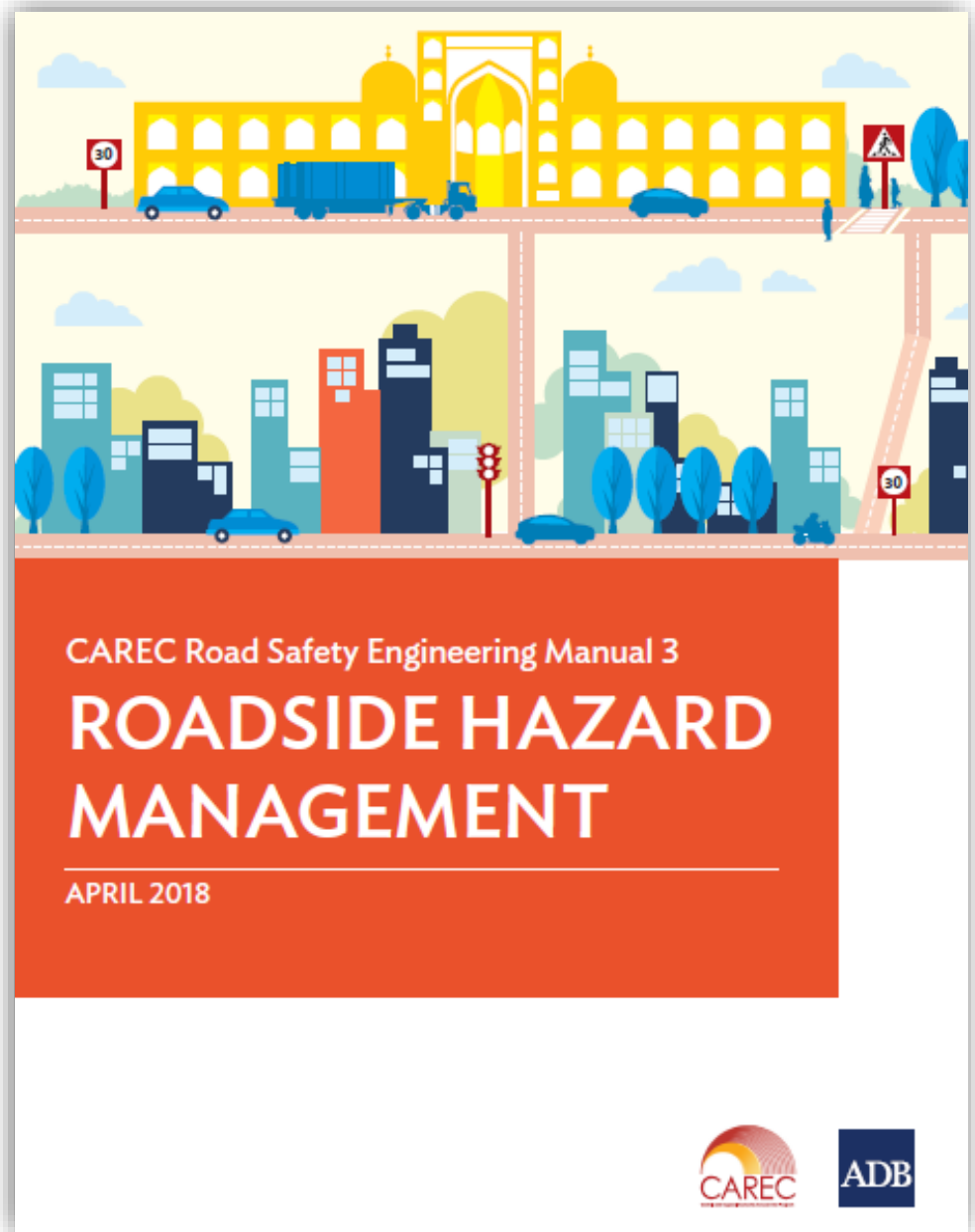




# Impact Absorbing Poles



CAREC now  
has a manual  
dealing with  
Roadside  
Hazard  
Management





The background image shows a road scene. On the left, a silver car is parked near a concrete structure. In the background, a tall, multi-story building is visible. On the right, a road curves, and a red and white directional sign is visible. A white van is parked on a grassy area in the distance.

# **THE THREE “I’S”**

**- IDENTIFY**

**- INVESTIGATE**

**- IMPLEMENT**

# A strategy for Roadside Hazard Management

- 1. Keep vehicles on the road**
- 2. Provide a forgiving roadside**

- i. remove the hazard**
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# Safety barriers

Remember that safety barriers are roadside hazards – try to design the new road to avoid having to use them



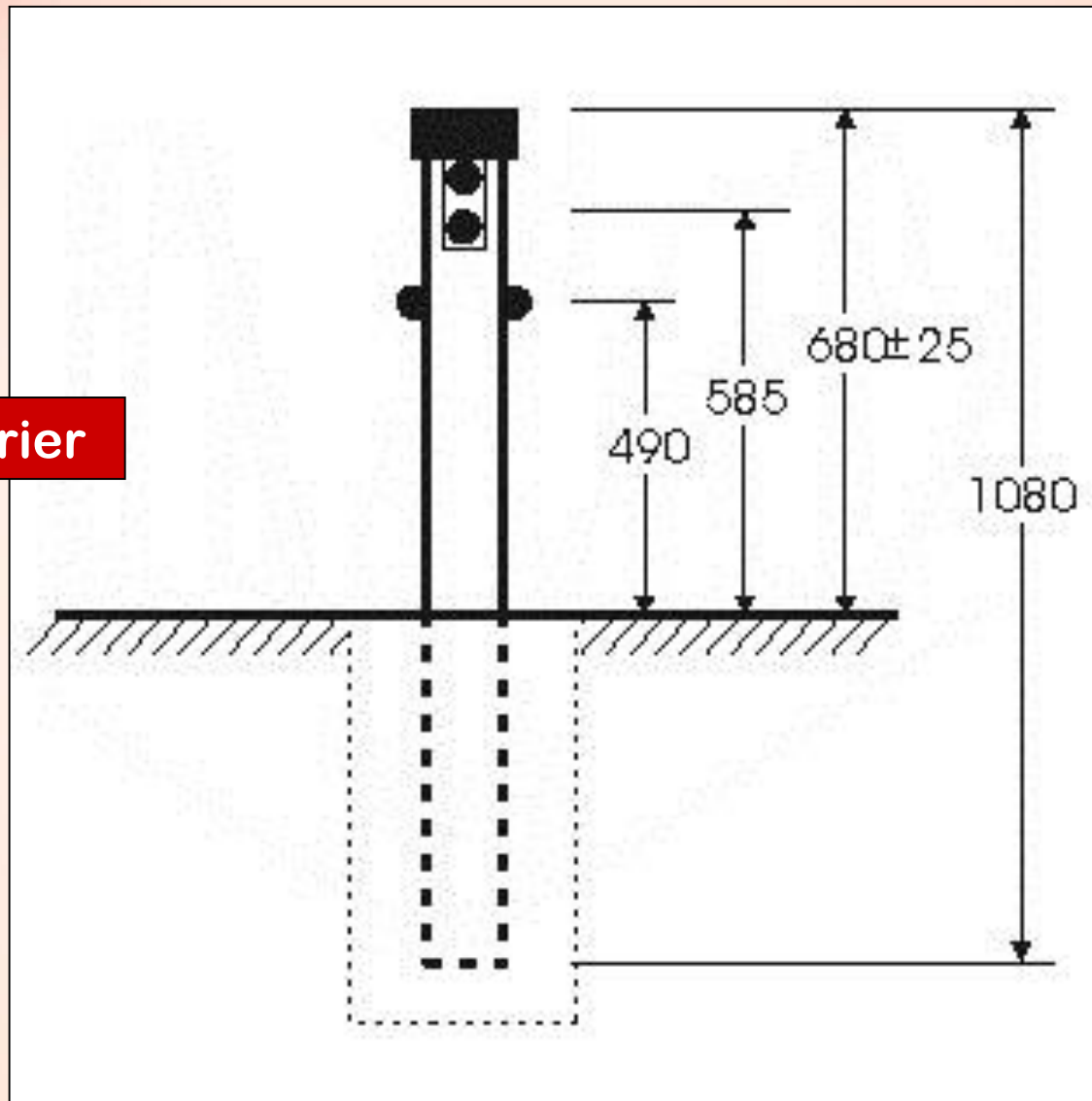
# Three groups of barriers

- Flexible barriers
- Semi-rigid barriers
- Rigid barriers





## Flexible barrier



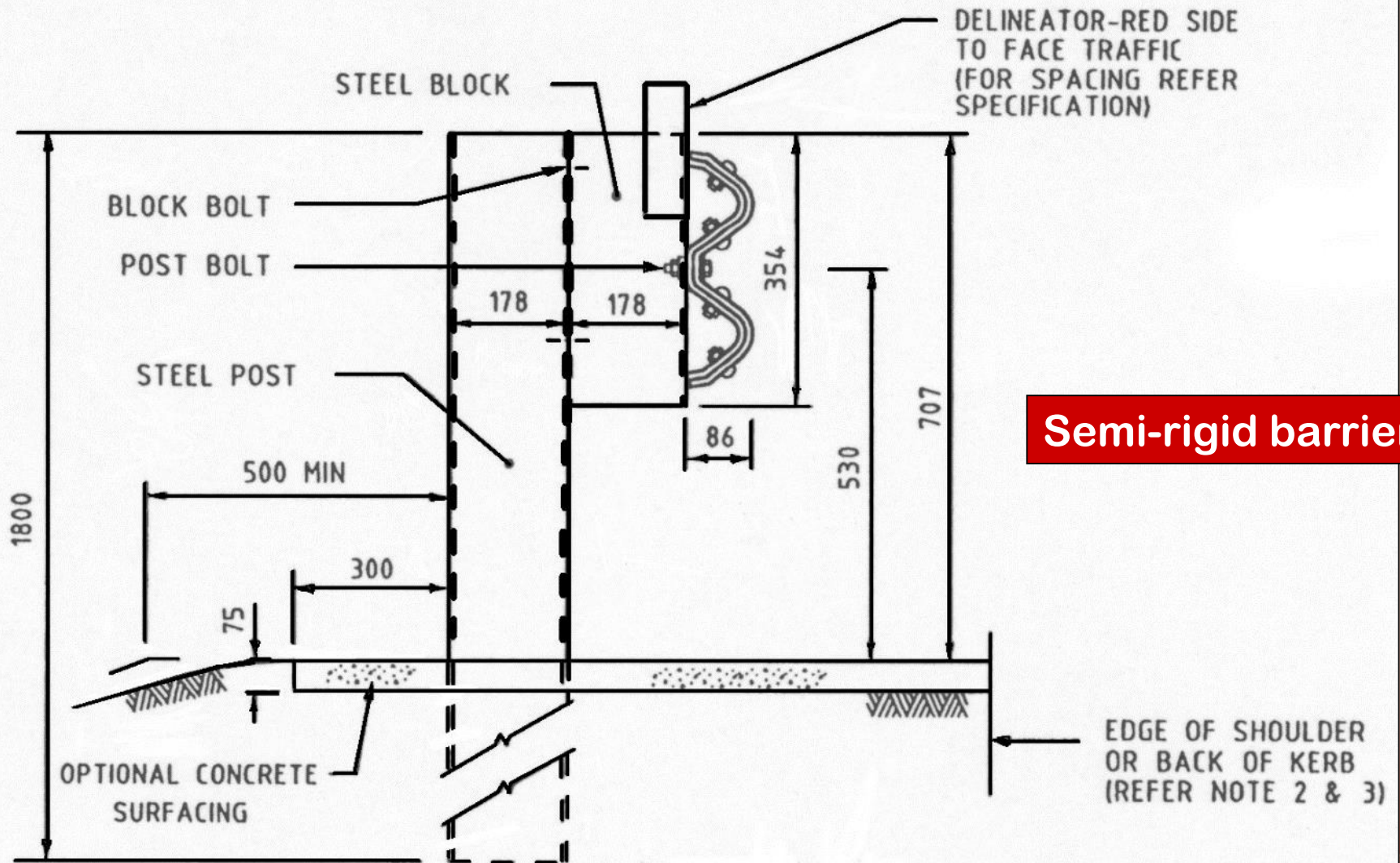
## Brifen Wire Rope Safety Barrier





**Brifen Wire Rope Safety Barrier**





**Semi-rigid barrier**



**W Beam Safety Barrier**

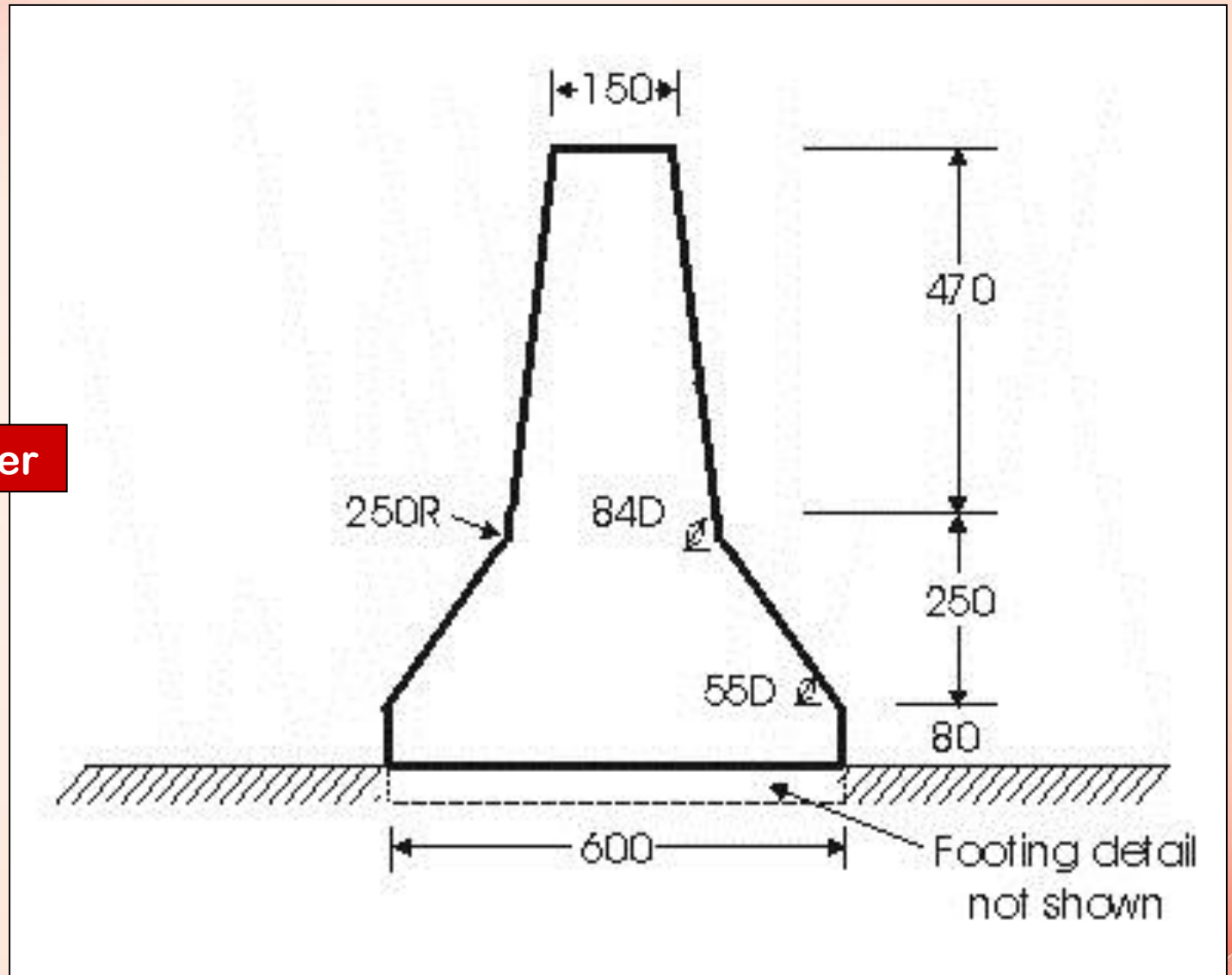


W Beam Safety Barrier





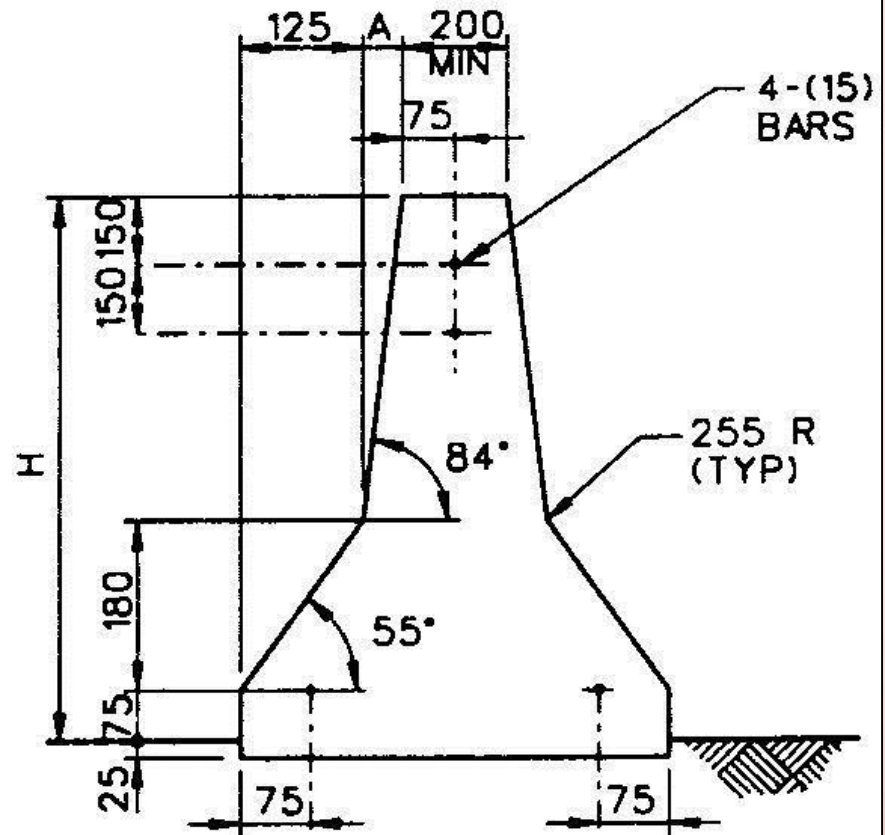
## Rigid barrier



New Jersey Barrier



## Rigid barrier

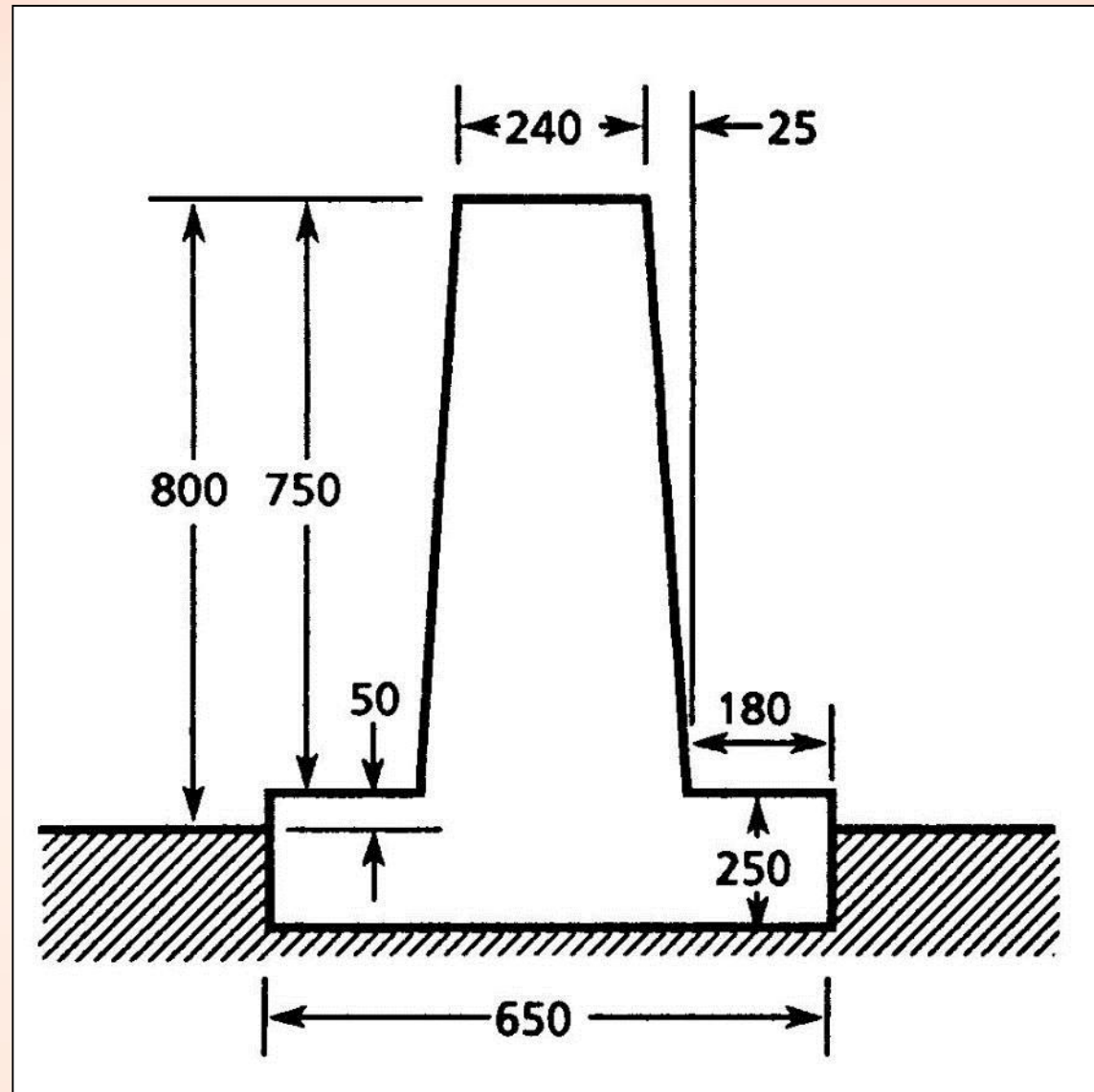


## F Profile Barrier





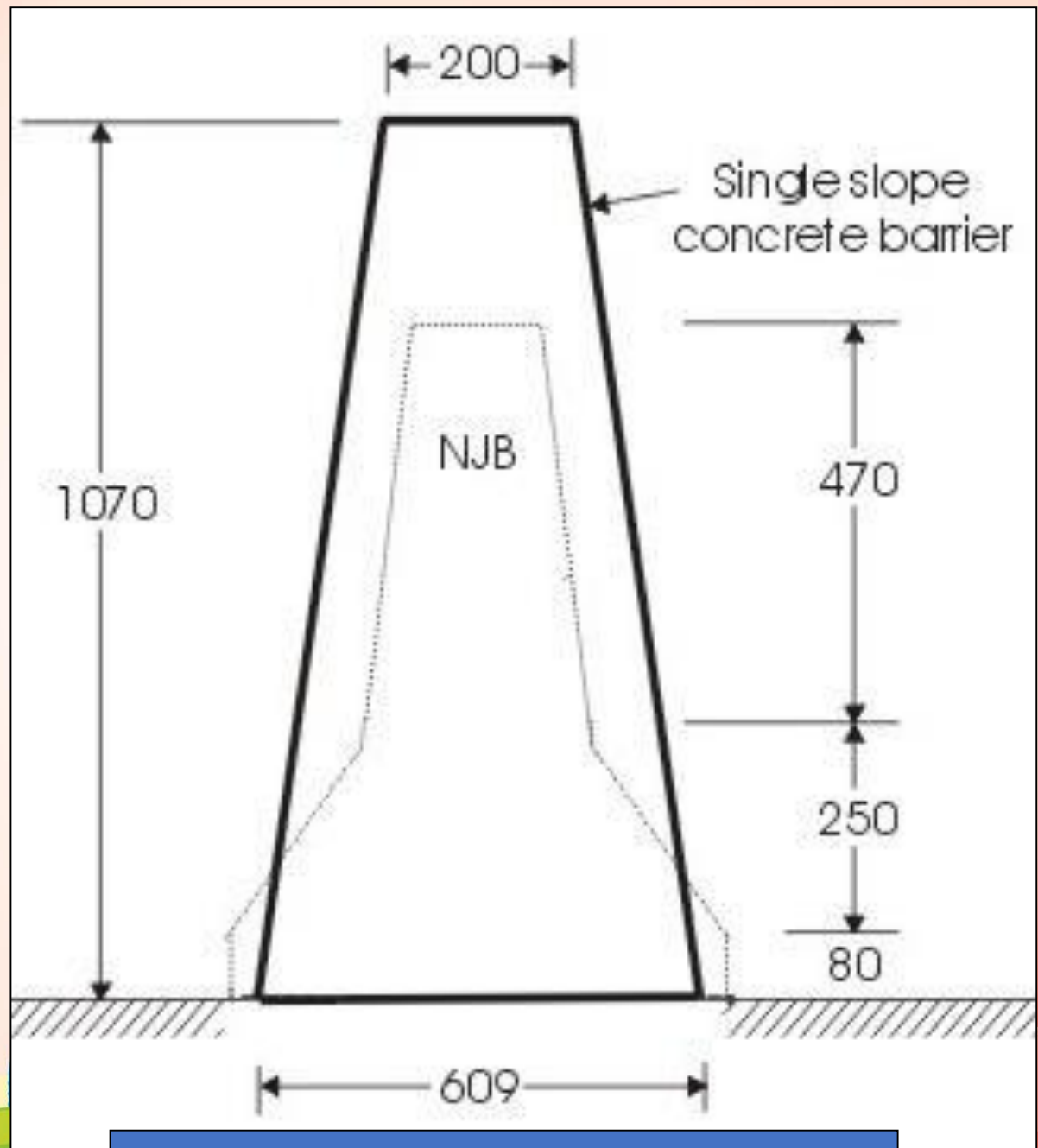
## Rigid barrier



## Vertical Face Barrier



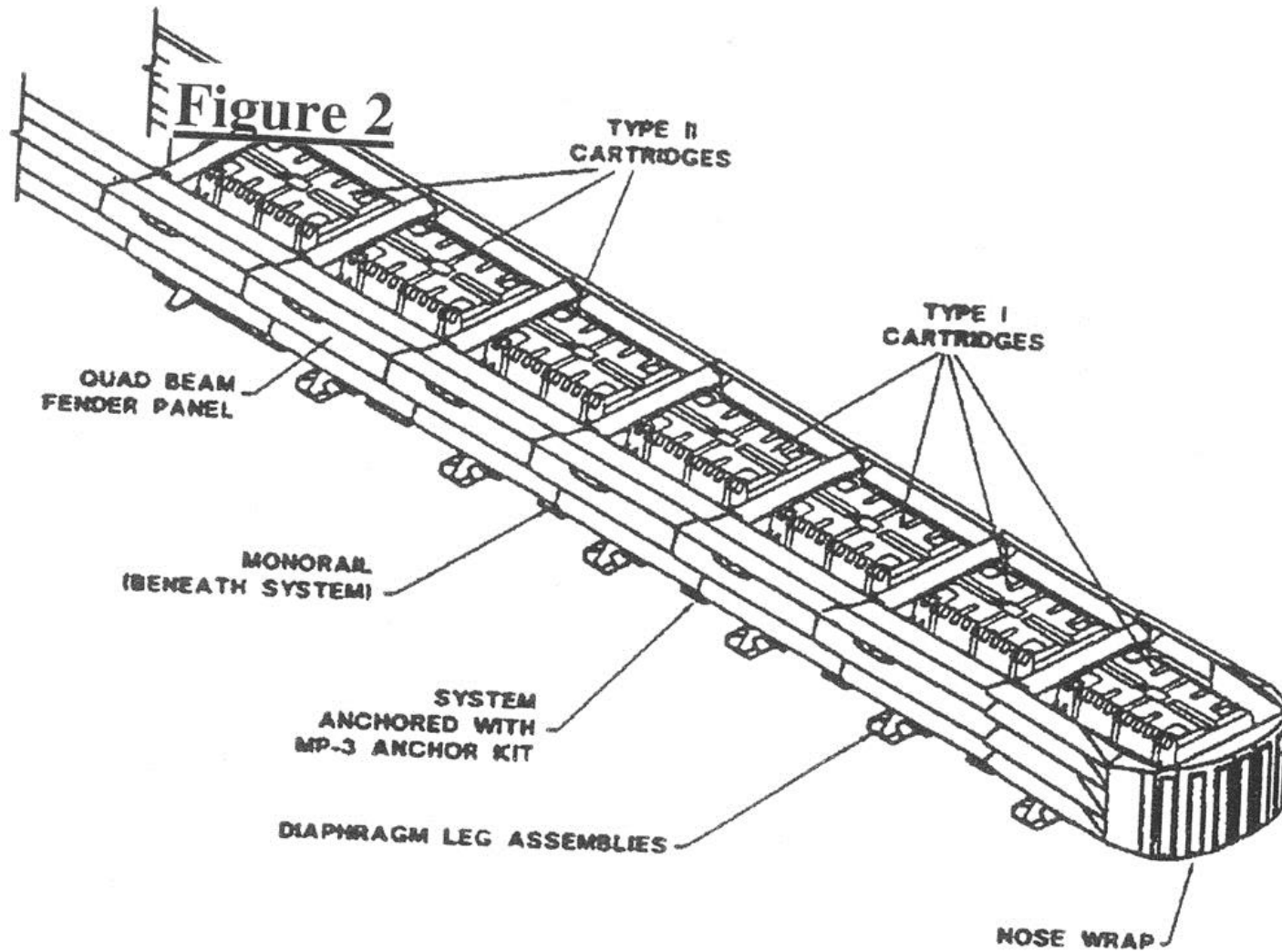
## Rigid barrier



Constant (single) Slope Barrier







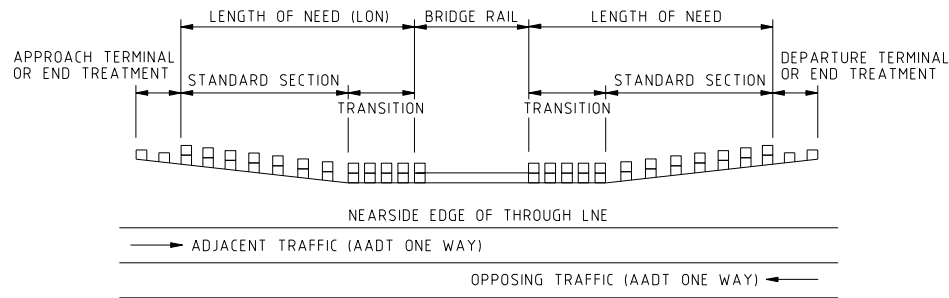
Impact Attenuator

# Good safety barrier must be carefully designed

- Length of need
- Barrier length
- Offset to the barrier
- Deflection
- Proximity to kerbs (avoid vaulting)
- Stiffen (prevent pocketing)
- Mounting height (watch for vaulting)
- End treatments (prevent spearing)



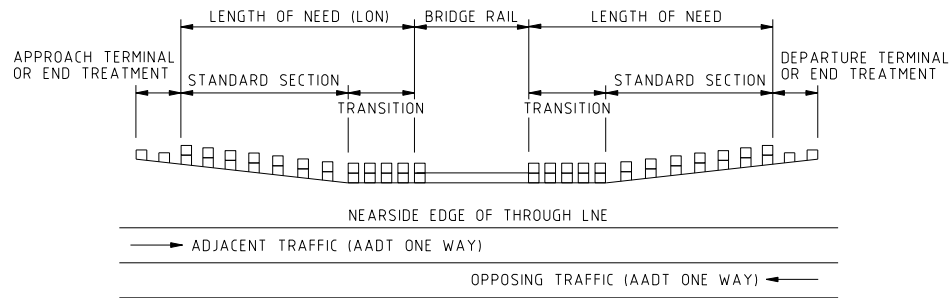




## Length of need

**This is the length of the barrier that is needed to shield the object or area of concern**

Critical design factors  
with safety barriers



## Barrier length

**This is the LON (nearside) plus the LON (offside) plus the length of the hazard, plus the end terminals**

Critical design factors  
with safety barriers



## Avoid placing kerbs near barriers

Have a paved, smooth surface between the lane and the crash barrier (so that an impacting vehicle can hit the barrier at the correct height)





**Have paved smooth surface between  
lane and barrier**



Kerb & Channel – do not use on high speed roads. Place barrier at the kerb face or more than 3 m behind it.

Semi-mountable kerb – place the barrier either 0-1m, or more than 3m, behind the kerb.

Mountable kerb – no restrictions where to place the barrier.

Avoid  
kerbs near  
barriers



X

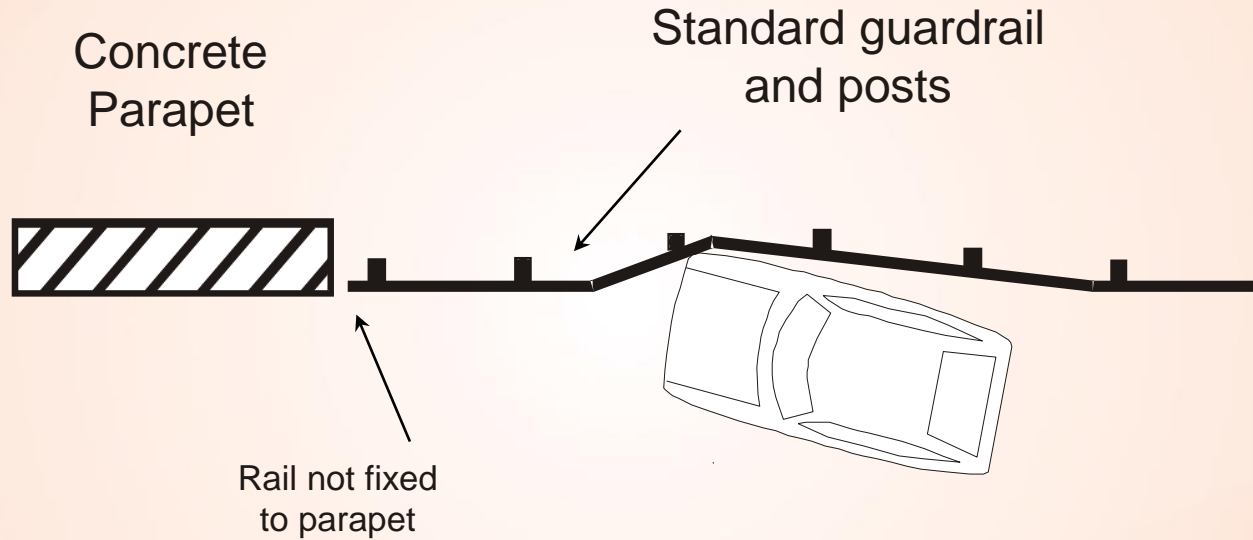


# Pocketing and Stiffening of W beam

To prevent pocketing - close-up the post spacing's at connection points



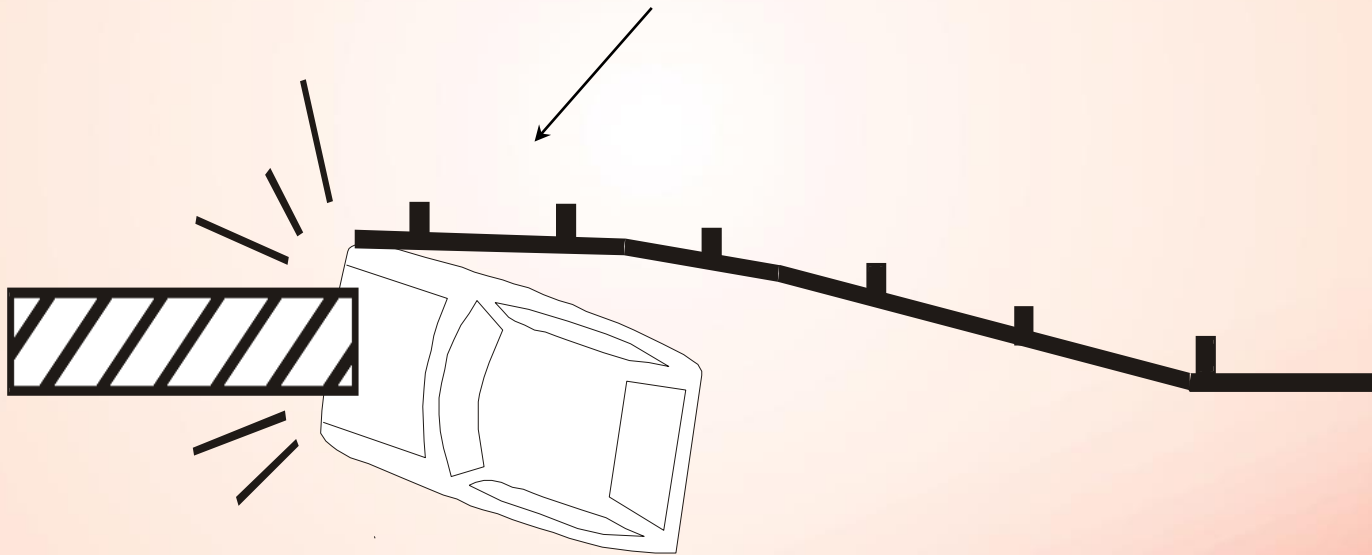
# "Pocketing"





## “Pocketing”

Guard rail deflects and leaves the parapet exposed



Stiffen (prevent pocketing)

2







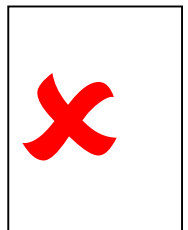


Use approved terminals to prevent “spearing”

**Take care to create a safe termination of the crash barrier**

**WHY?**





## Use approved terminals to prevent “spearing”

Because unsafe terminals spear through impacting vehicles and kill people

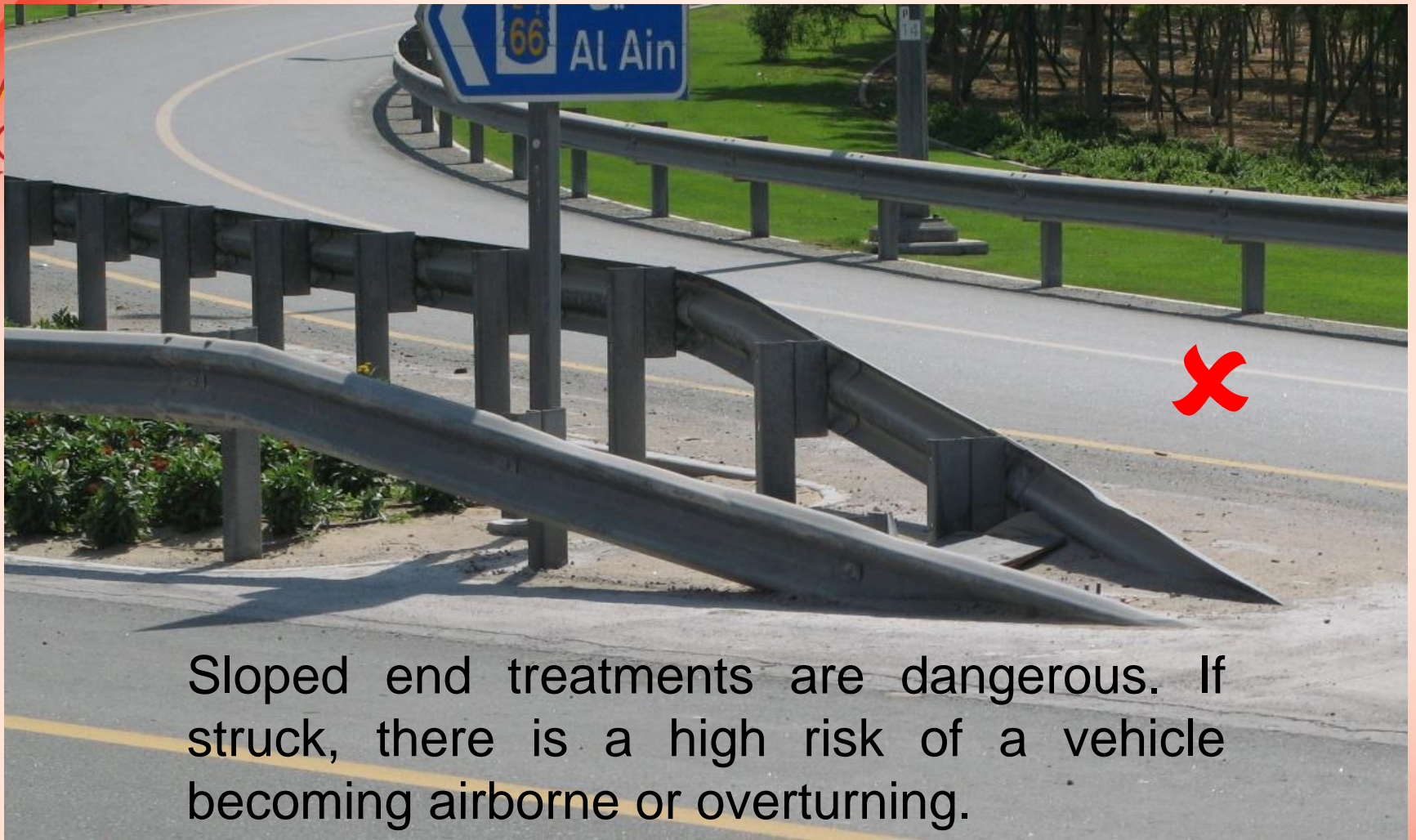






Safe end terminals  
are essential





Sloped end treatments are dangerous. If struck, there is a high risk of a vehicle becoming airborne or overturning.







People die everyday from collisions with the ends of concrete barriers around the world. Never leave such hazards within the clear zone on your roads.



## Example from CAREC RSE Manual 3

157. A rural highway in rolling desert terrain has been open to traffic for less than 2 years. It is lightly trafficked but speeds are high (at least 100 km/h), and there has been a recent spate of run-off-road crashes that happened mostly at nighttime. The highway is a four-lane divided road with a 20 m wide median. There are few roadside hazards other than culverts, but the highway is on fill and the grades of some side slopes have been questioned.



158. The local police joins on an inspection of this highway. They outline their knowledge of the crashes. Note that the line marking has not been installed even though this road has been open to traffic for 2 years. There is no delineation of horizontal curves. There are a few short lengths of barrier along the highway, generally at the steeper roadsides and some culverts.

159. With the police, conclude the crashes may be mainly due to driver fatigue and inattention. The highway joins two major cities about 450 km apart, and this section is about midway between the two. Driver fatigue is likely. Work through the five-step roadside hazard management strategy:













## Low cost recommendations for this site

- Line marking – white thermoplastic lane line and a tactile edge line on the full length of both carriageways.
- Install plastic guideposts on the outside of the shoulder at standard spacings.
- Shoulder sealing (up to 1.5 m) around the outside of all curves with a reported crash history, or a radius that is less than half of its neighboring curves.
- Install several (minimum three) CAMs around the outside of these curves (for both directions).
- Monitor. If crashes continue, some slope flattening and/or installation of WRSB should be discussed and agreed on.





## In your groups

- Look at this new high speed rural highway.
- It has just been opened to traffic.
- You are part of the pre/post opening stage audit team
- Discuss the safety concerns.
- What do you find?
- What do you recommend?



## Case study



What do you recommend here? Explain your decision making.



## Case study



What do you recommend here? Explain your decision making.



## Case study



What do you recommend here? Explain your decision making.



## Case study



What do you recommend here? Explain your decision making.

## Case study



What do you recommend here? Explain your decision making.





## 2. Single vehicle run-off-road crashes

This session is an opportunity for us to open discussion about what your organisation can do/should do to reduce run-off-road crashes in your country as part of your national Road Safety Action Plan.

I look forward to hearing of your successes.

