Road Restraints Part 1

A ***crash*** course into road restraint systems

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- Background / History
- Types of Road Restraint Systems
- Design Considerations

Safety Moment

How have you challenged someone who behaves in a way that is unsafe?

- Unsafe behaviour can occur in or out of the workplace, on or off site.
- Are you comfortable challenging people? is there a positive environment around challenge?
- Do you have / know the procedures to report / record any incidents / near misses, to ensure nothing happens again?
- Do you have plans for activities that mitigate or eliminate any hazards before someone can be exposed to them?
- AECOM have red cards for challenging, Lifeguard for reporting and SHE Procedures for preventing issues. However there may be more specific to your role or area that you should be aware of.

Introduction to Road Restraint Systems (RRS)

Why are RRS required:

- To prevent vehicles from impacting with or entering roadside hazards.
- To prevent vehicles crossing from one carriageway to another.
- To absorb some of the energy from the impact cause by an errant vehicle striking it.
- To redirect the vehicle along the line of the barrier to prevent it from turning around, turning over or re-entering the stream of traffic.

Introduction to RRS

What is a Road Restraint System?

- **Road Restraint Systems** – General name for vehicle restraint system and pedestrian restraint system used on the road.
  - **Vehicle Restraint Systems** – Systems installed on the road to provide a level of containment for an errant vehicle.
    - **Safety Barrier** – Road vehicle restraint system installed alongside, or on the central reserve of a road.
      - **Permanent** – Safety barrier installed permanently on the road.
      - **Temporary** – Safety barrier, which is readily removable and used at road works, emergencies or similar situations.
        - **Rigid** – Safety barrier that has negligible deflection during a vehicle impact.
        - **Deformable** – Safety barrier that deforms during a vehicle impact and may suffer permanent deformation.
          - **Single-Sided** – Safety barrier designed to be impacted on one side only.
          - **Double-Sided** – Safety barrier designed to be impacted on both sides.
    - **Transitions / Terminals**
      - **Transition** – Interface between two vehicle restraint systems of different designs and / or performances that provides a gradual change from first to the second to prevent the hazards of an abrupt variation. Designed to connect two specific systems.
      - **Terminal** – The treatment of the beginning and or end of a safety barrier to mitigate the effects of an impact from an errant vehicle. Can provide an anchorage for the barrier system.
        - **Leading Terminal** – terminal placed at the upstream end of a safety barrier.
        - **Trailing Terminal** – terminal placed at the downstream end of a safety barrier.
    - **Arrester Bed** – Area of land adjacent to the road filled with a particular material to decelerate and arrest errant vehicles.
    - **Crash Cushion** – Road vehicle energy absorption device installed in front of a rigid object to reduce the severity of impact.
      - **Redirective** – Crash cushion designed to contain and redirect an impacting vehicle.
      - **Non-Redirective** – Crash cushion designed to contain and capture an impacting vehicle.
    - **Vehicle Parapet** – Safety barrier installed on the edge of a bridge or on a retaining wall or similar structures where there is a vertical drop / near vertical drop and which may include additional protection and restraint for pedestrians and other road users.
  - **Pedestrian Restraint Systems** – Systems installed to restrain and to provide guidance for pedestrians.
    - **Pedestrian Guardrail** – Pedestrian or "other users" restraint system along the edge of a footway or footpath intended to restrain pedestrians and other users from stepping onto or crossing a road or entering other area likely to be hazardous.
    - **Pedestrian Parapet** – A pedestrian or "other users" restraint system along a bridge or on top of a retaining wall or similar structure which is not intended to act as a road vehicle restraint system.

Notes: "Other users" includes provision for equestrians, cyclists and cattle.

"Pedestrian guardrails" are not intended to act as a road vehicle restraint system.

History - Selby

The Selby Rail Crash

History - Selby

- Location where the Land Rover left the carriageway

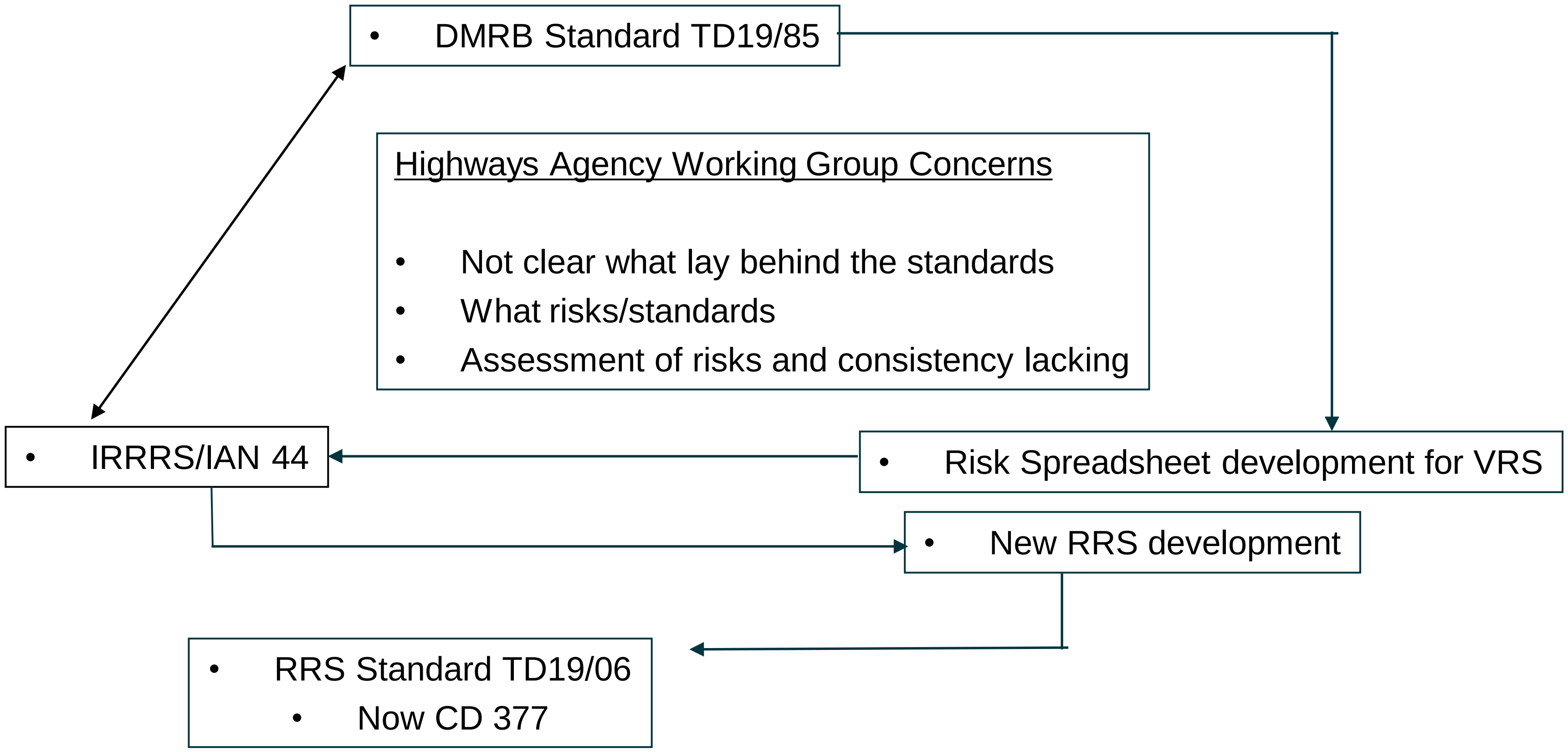
- Final Position of the Land Rover and trailer

History – Review of Standards

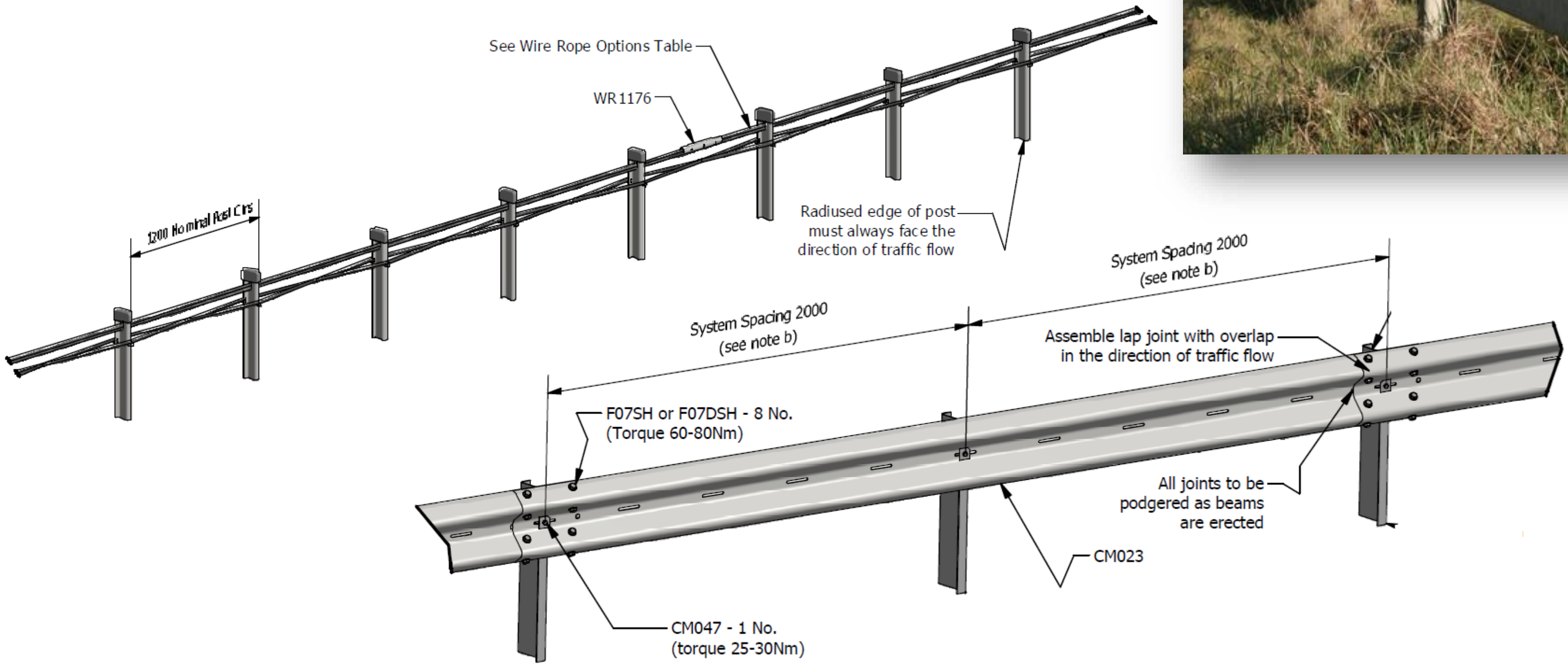
- Following this accident the Deputy Prime Minister set up a Highways Agency Working Group to review the standards for the provision of nearside safety fences on major roads

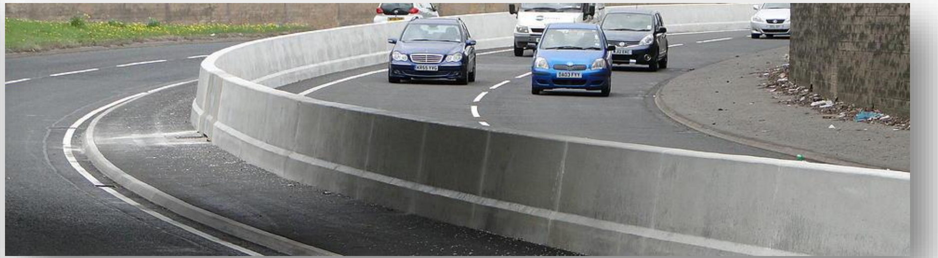
- Concerns:
  - Not clear what lay behind standards
  - It was not clear what risks the standard was trying to consider and then control
  - The standard was written for new works with no need to manage risks for other types of work.
  - It was not clear how risks were assessed when granting departures.
  - It was not clear how consistency in overseeing organisations advice on safety was ensured.

History - Overview

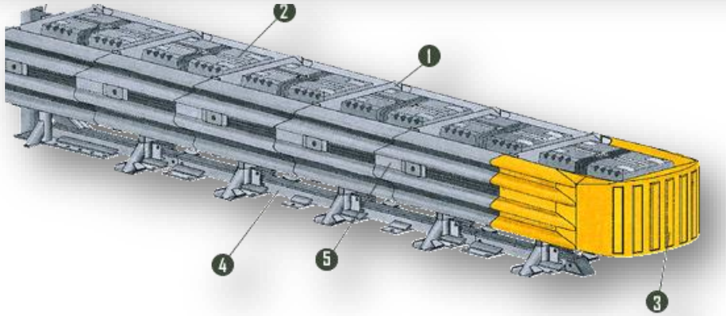


Type of Barriers





Type of Terminals



Parapets and Guardrails

Design Considerations

Once you know what hazards need to be protected by a VRS (covered in the next part of this training) what do you need to think about?

Design Considerations – Site Visit

June 2021 street view

March 2023 site photo

Design Considerations - ERIC

- Eliminate
- Isolate
- Reduce
- Control

- VRS is a control measure (and a hazard in itself)

- Can you remove the hazard or reduce the risk to the road user?
- Traffic sign posts of 76 mm or 89 mm diameter, with 3.2 mm wall thickness, are classed as passively safe already / 2 post signs of the same dimension with a 1500mm post spacing

Design Considerations – Containment Level

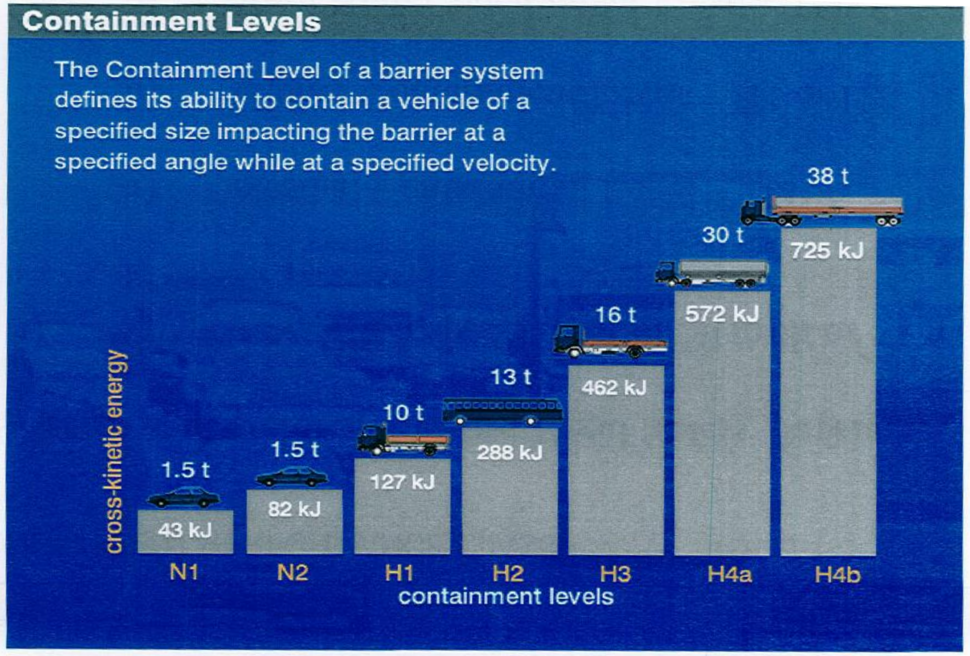
Permanent Deformable and Rigid Safety Barriers:

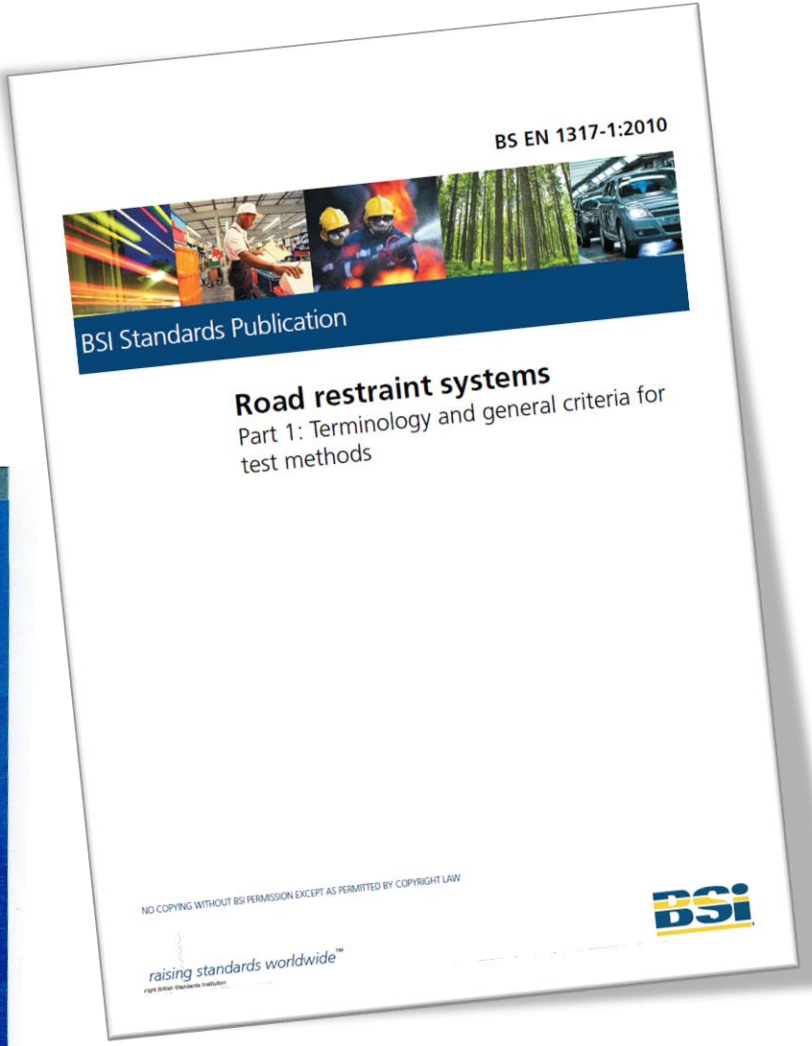
(i) **On roads with a speed limit of 50 mph or more:**

(a) Normal Containment Level = N2

(b) Higher Containment Level = H1 or H2

(c) Very High Containment Level = H4a



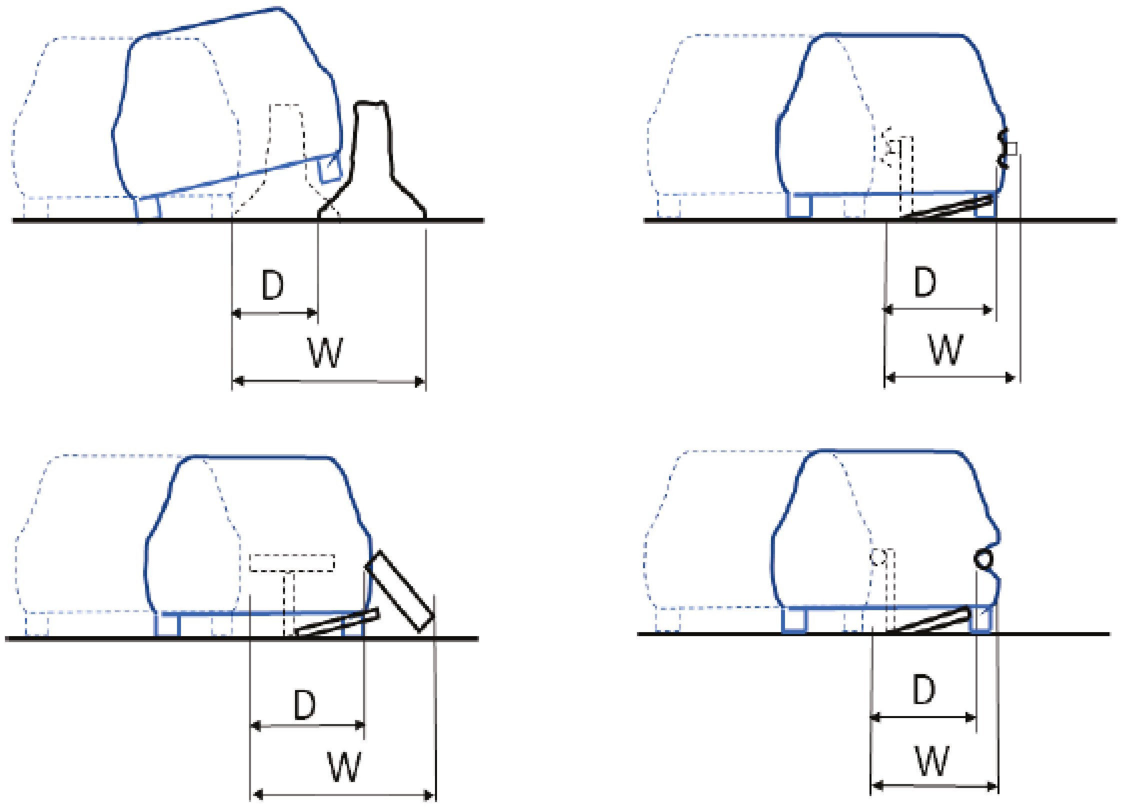


Design Considerations – Containment Level: Central Reservation

- Where 2-way AADT>=25000

Design Considerations – Working Width

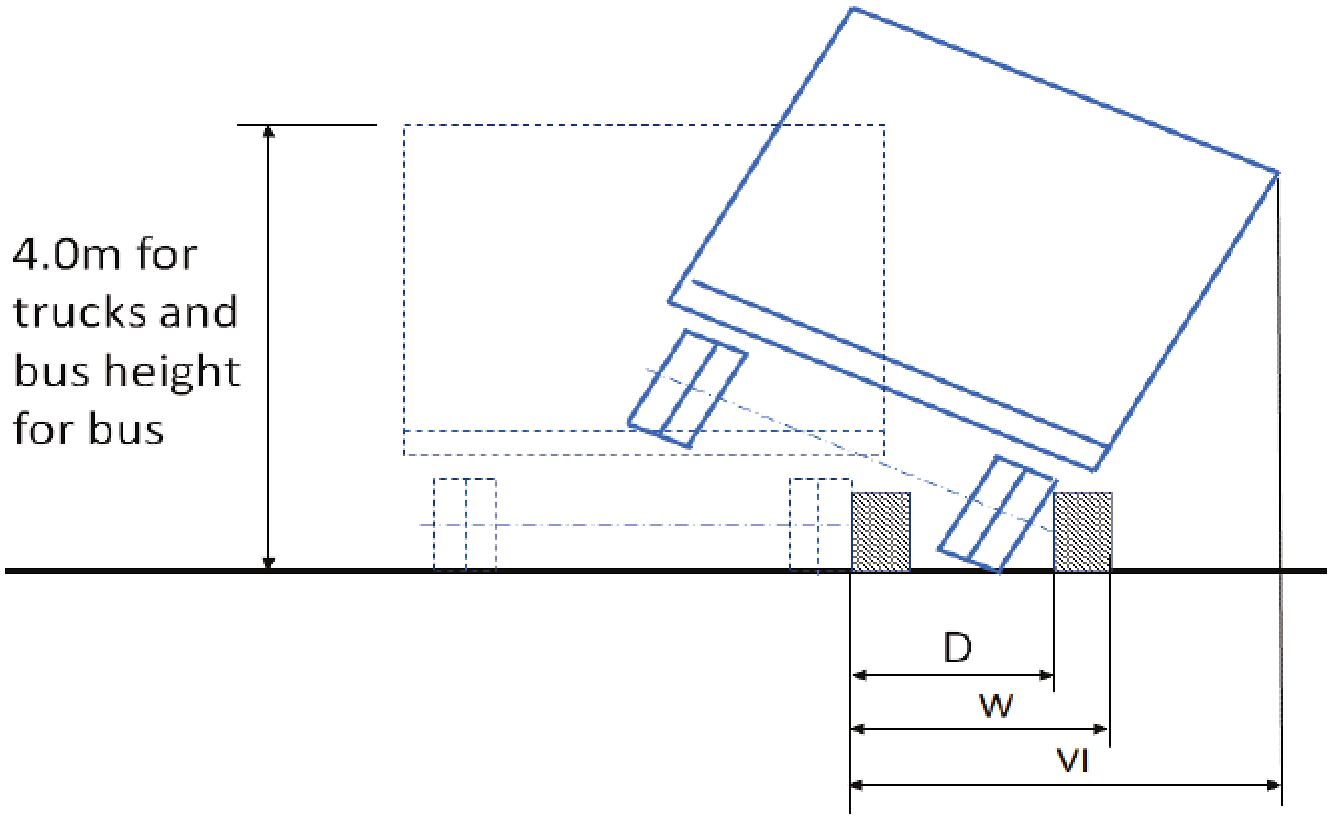
Class	Working Width [m]
W1	$W_N \leq 0.6$
W2	$W_N \leq 0.8$
W3	$W_N \leq 1.0$
W4	$W_N \leq 1.3$
W5	$W_N \leq 1.7$
W6	$W_N \leq 2.1$
W7	$W_N \leq 2.5$
W8	$W_N \leq 3.5$



- Post spacing increase from W1 to W8 for deformable systems

Design Considerations – Vehicle Intrusion Class

Klass	Vehicle Intrusion [m]
VI1	$VI_N \leq 0.6$
VI2	$VI_N \leq 0.8$
VI3	$VI_N \leq 1.0$
VI4	$VI_N \leq 1.3$
VI5	$VI_N \leq 1.7$
VI6	$VI_N \leq 2.1$
VI7	$VI_N \leq 2.5$
VI8	$VI_N \leq 3.5$
VI9	$VI_N > 3.5$



Design Considerations – Impact Severity Level

A safety barrier´s level of impact severity gives an assessment of the safety for occupants in an impacting vehicle

For example:

- Impact severity class A: safety barrier
- Impact severity class B: vehicle parapet
- Impact severity class C: non deformable concrete barriers

Impact severity level	Index values	
A	ASI ≤ 1.0	THIV≤33 km/h
B	ASI ≤ 1.4	
C	ASI ≤ 1.9	

Design Considerations – Length of Need

Required to ensure that:

1. Barrier performs as expected / tested
2. An errant vehicle that gets behind the barrier doesn't collide with the hazard you want to protect

- TD 19 specified specific lengths if the minimum length from the RRRAP is less than the specific lengths
- CD 377 specifies the greater of the lengths specified by the RRRAP or the manufacturer.
- From experience most systems still tested to TD 19 minimum requirements

Safety Barrier Containment Level	MINIMUM "full height" lengths of safety barrier[1]	
	In advance of hazard	Beyond hazard
Normal (N2 or N2)	30 m	7.5 m
Higher (H1 or H2)	30 m	10.5 m
Very High (H4a)	45 m	18 m

TABLE 3-1

Notes: 1. These are minimum lengths. Manufacturers may require longer lengths than specified above. (Refer to Chapter 1 Paragraph 1.42 Length of Need.)

Design Considerations - Setback

- CD 127 Highways Cross Section

Table 2.24 Set-back

Location	Desirable minimum set-back value (mm)	Available relaxations described in notes
In verges with no adjacent hard strip or hard shoulder	1200	Notes 1) and 2)
In verges with an adjacent hard strip or hard shoulder	600	Note (3)
Central reserves	1200	Notes 1) and 2)

Notes:
Relaxations to set-back are permitted as follows:

1) Relaxation to 600mm for roads of speed limit 50mph or less (including temporary mandatory speed limits).
2) Relaxation to 1000mm at existing roads with physical constraints (e.g. a structure) where it could be difficult to provide the desirable value.
3) Relaxation to 450mm where it is considered necessary to position the VRS away from the edge of an existing embankment in order to provide support to the foundation.

- Drainage, road furniture, other hazards and visibility can affect the level of set-back achieved.

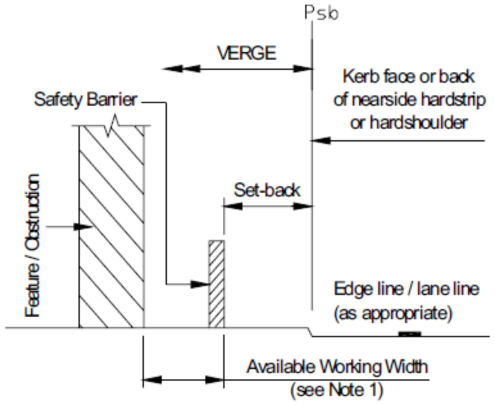


Figure 3-4 (a). Safety Barrier at Verge

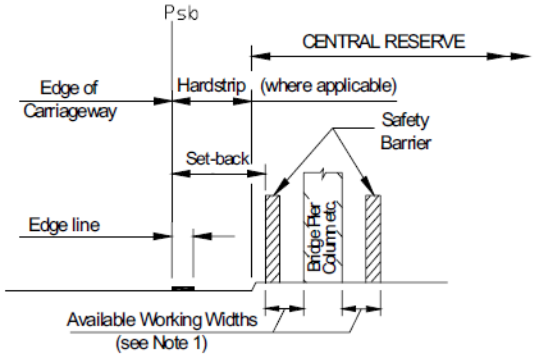


Figure 3-4 (b). Safety Barrier at Central Reserve (with Offside Edge Line)

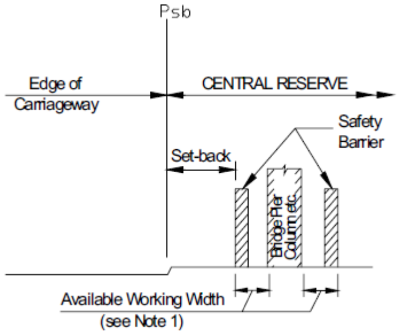
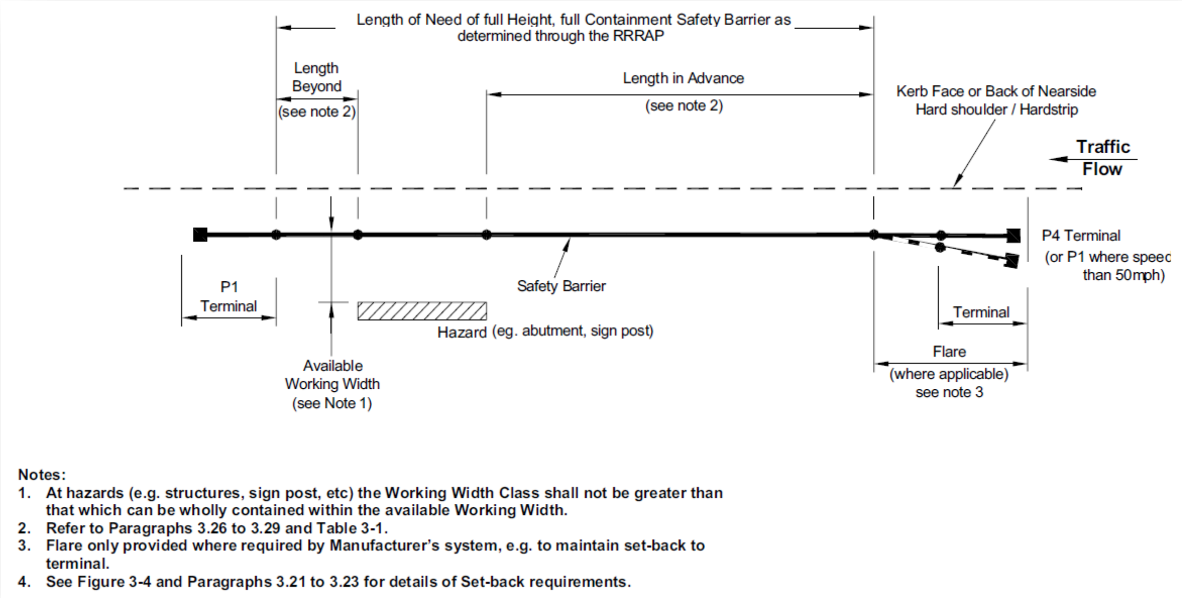


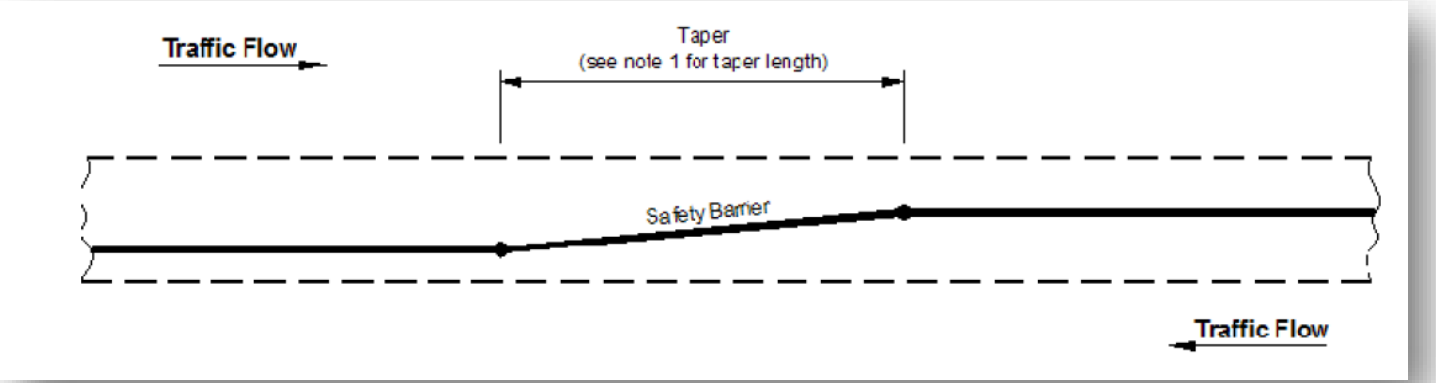
Figure 3-4 (c). Safety Barrier at Central Reserve (with no Offside Edge Line)

Design Considerations – Locations of hazards



Design Considerations – Taper lengths and transitions

Taper lengths - Changes in horizontal alignment (setback)



Transition length: Gradual change in performance

Design Considerations – Taper lengths and transitions

Transition length - Gradual change in performance

Design Considerations – Taper lengths and transitions

Taper and transition lengths are required to avoid 'pocketing'

- Change in type, cross-section or material
- Manufacturer-specific

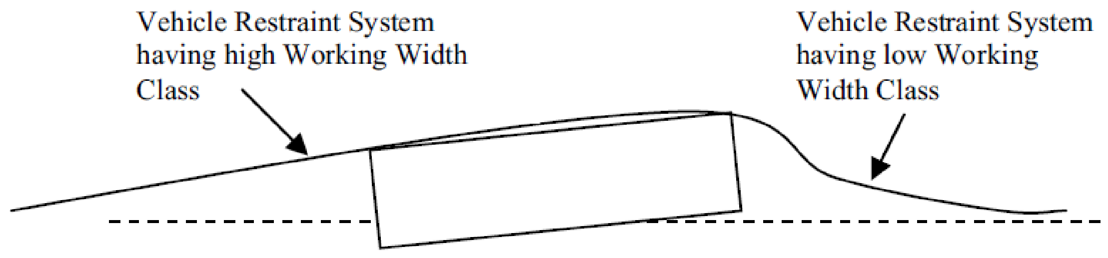


Figure 6-1 Example of Pocketing

Taper lengths and transition lengths required to avoid pocketing
If an errant vehicle hits a section of barrier where the performance changes rapidly say from W4 to W2 the first section would deflect more than the next. The errant vehicle would then in effect hit the end of the W2 barrier causing unacceptably high decelerations to the vehicle and its occupants

Design Considerations – Posts / foundations

Driven posts

- Posts driven into the ground / foundation
- Most commonly used post type

Socketed Posts

- Posts socketed into a concrete pad foundation
- Easily removeable from the foundations (useful if the VRS has to be replaced often)
- Useful in poor ground conditions
- If there are bound materials greater than 150mm thick present

Design Considerations – Height of systems

If the system is close to the carriageway the height is generally measured relative to the carriageway, if its far away from the carriageway it may be measured at the post

As designers we don’t tend to specify the height, its specific to the chosen system.

However, it must be considered if:

- We’re raising the height of the carriageway
- Adding / removing kerbs
- Changing the position of the VRS relative to the road
- Have sudden deviations in the ground height underneath the VRS

If height tolerances of the system are not met, then it may not perform as expected in a collisions.

Parapet heights vary based on anticipated NMU usage

Design Considerations – Motorcycle guard

Posts cause most of the damage to motorcyclists

When you get traffic data for VRS assessments request splits by vehicle type, especially if there are sharp bends where motorcyclists are most at risk of falling or skidding .

Design Considerations – Terminal Design

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Design Considerations – Terminal Design

- P4 or P1 ??
- P4s typically 8-12m in length

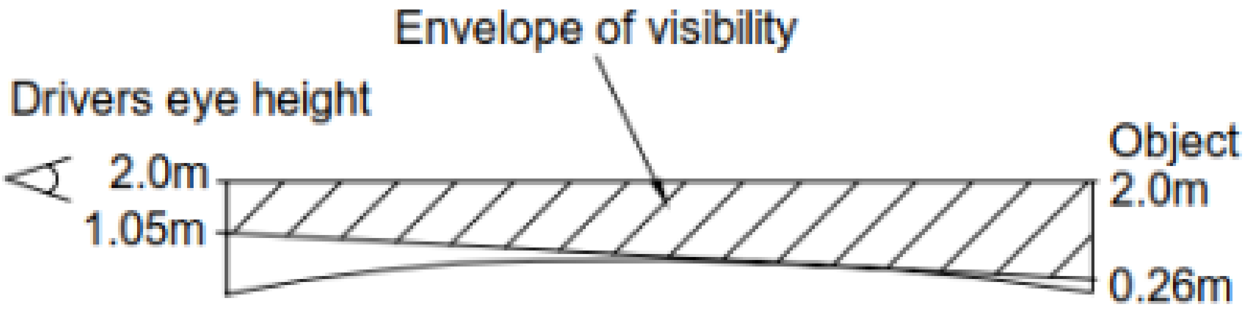
(some systems shorter such as OBEX systems below)

Also available are P2 terminals: they're not as high a performance as a P4, but still suitable where a P1 is suitable, however they generally do not have a ramped end, and can easily be installed in areas of hard standing as opposed to soft verges.

Design Considerations - visibility

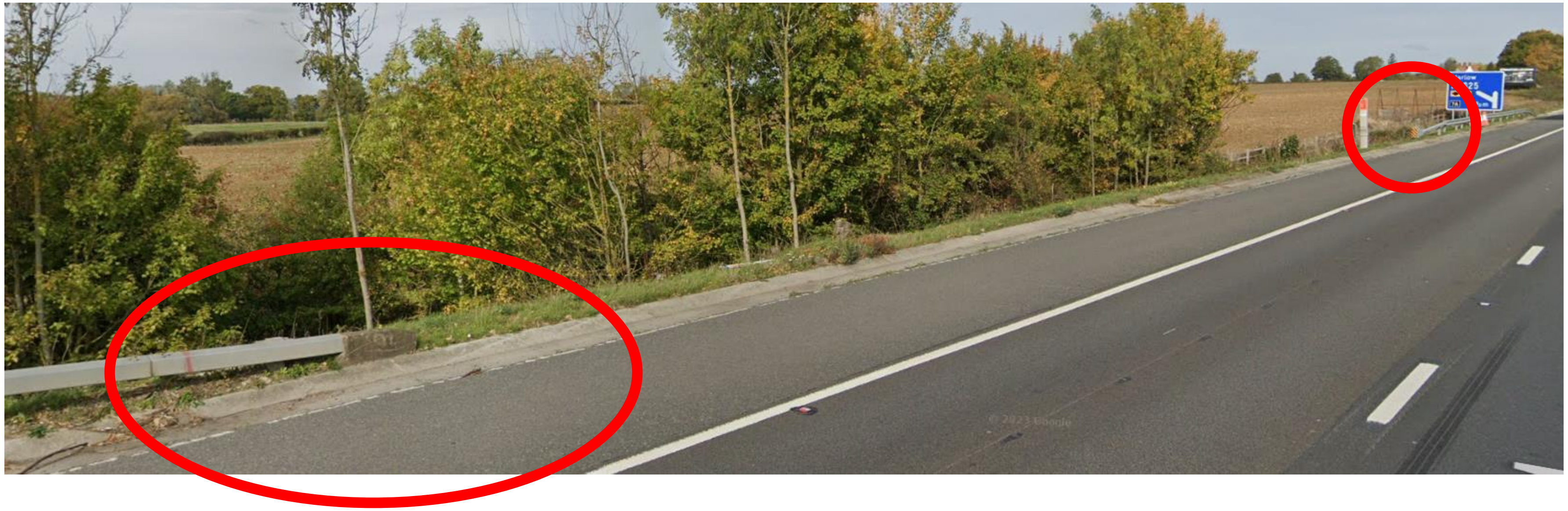
- Rails at small setbacks can impact stopping sight distance
- Especially to the low object height
- Especially around bends

- Visibility is often checked when carrying out the geometric design
- Don't forget to do it while carrying out VRS design



Design Considerations – Gap closures

- Gaps in verge VRS mean more approaches, more potential for head on collisions with terminals, more terminals are required, therefore higher costs and greater maintenance requirements. As well as more chance for errant vehicles to travel behind the VRS
- Gaps of up to 50m shall be closed, gaps of up to 100m should be closed
- In England gaps of up to 100m shall be closed



Design Considerations – Non motorised users

- Trunk roads may have PROWs that cross them and require gaps
- A gap may be required in a verge for the provision of telephones / crossings

Figure 3.67a Accommodating a right of way through a continuous verge safety barrier

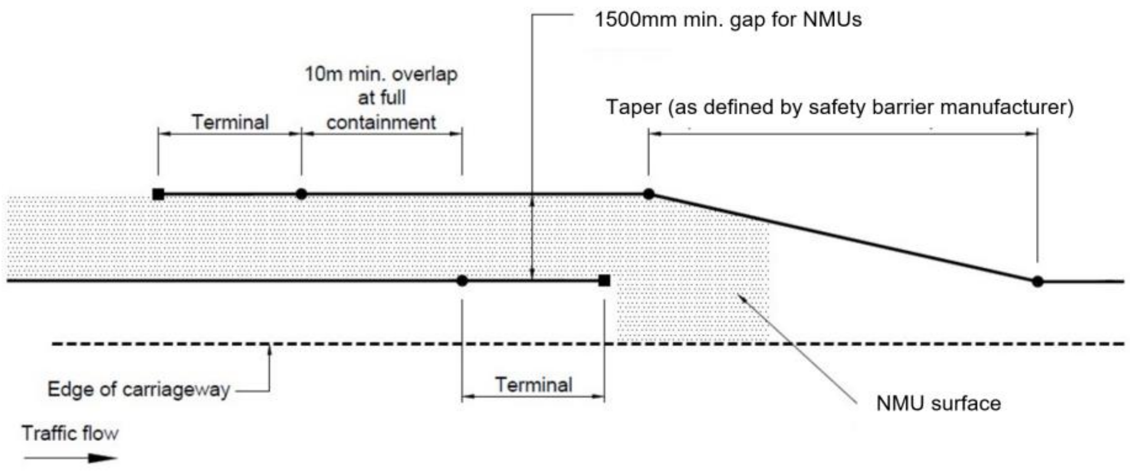
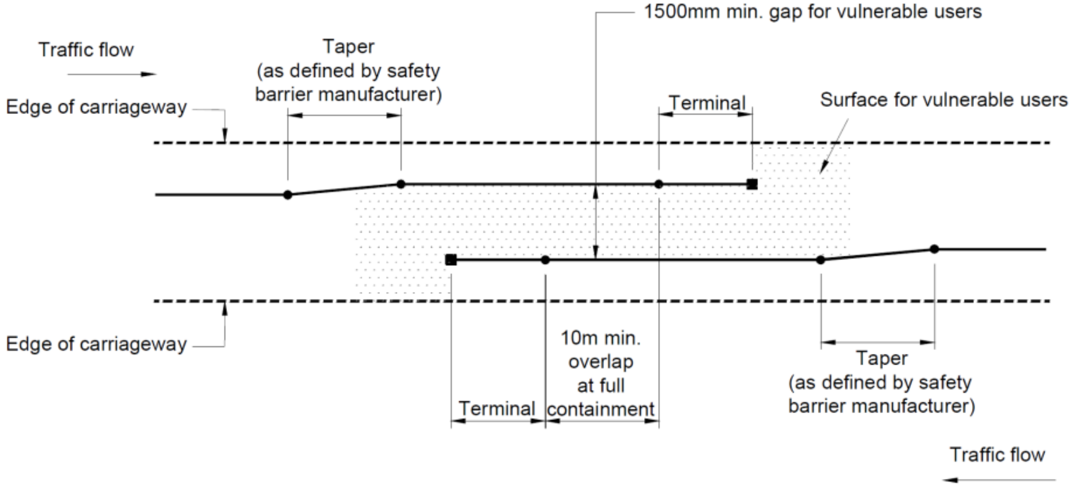


Figure 3.67b Accommodating a right of way through a continuous central reserve safety barrier



- There may be defined equestrian movements in a verge, the designed setback must allow for this (to allow horses in front or behind the VRS)

Design Considerations – Pedestrian guardrail

- **NOT** a restraint system
- Only used to influence pedestrian movements
- Can ‘trap’ pedestrians that cross on a desire line within the carriageway
- Can narrow footways
- Can narrow crossings

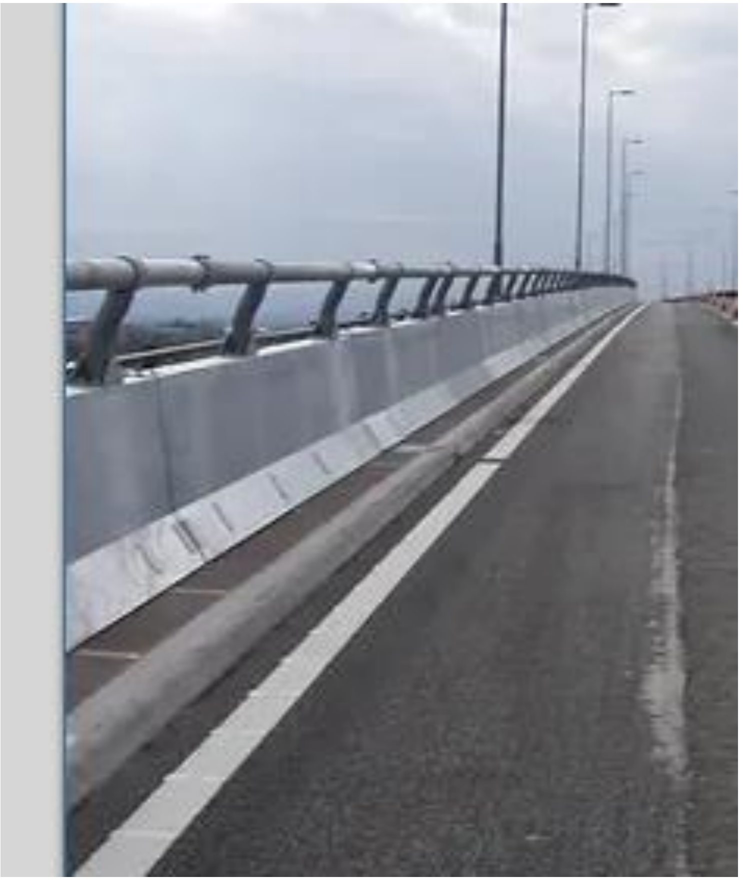
Design Considerations – Pedestrian guardrail

Design Considerations – Pedestrian guardrail

Design Considerations – Other interesting systems

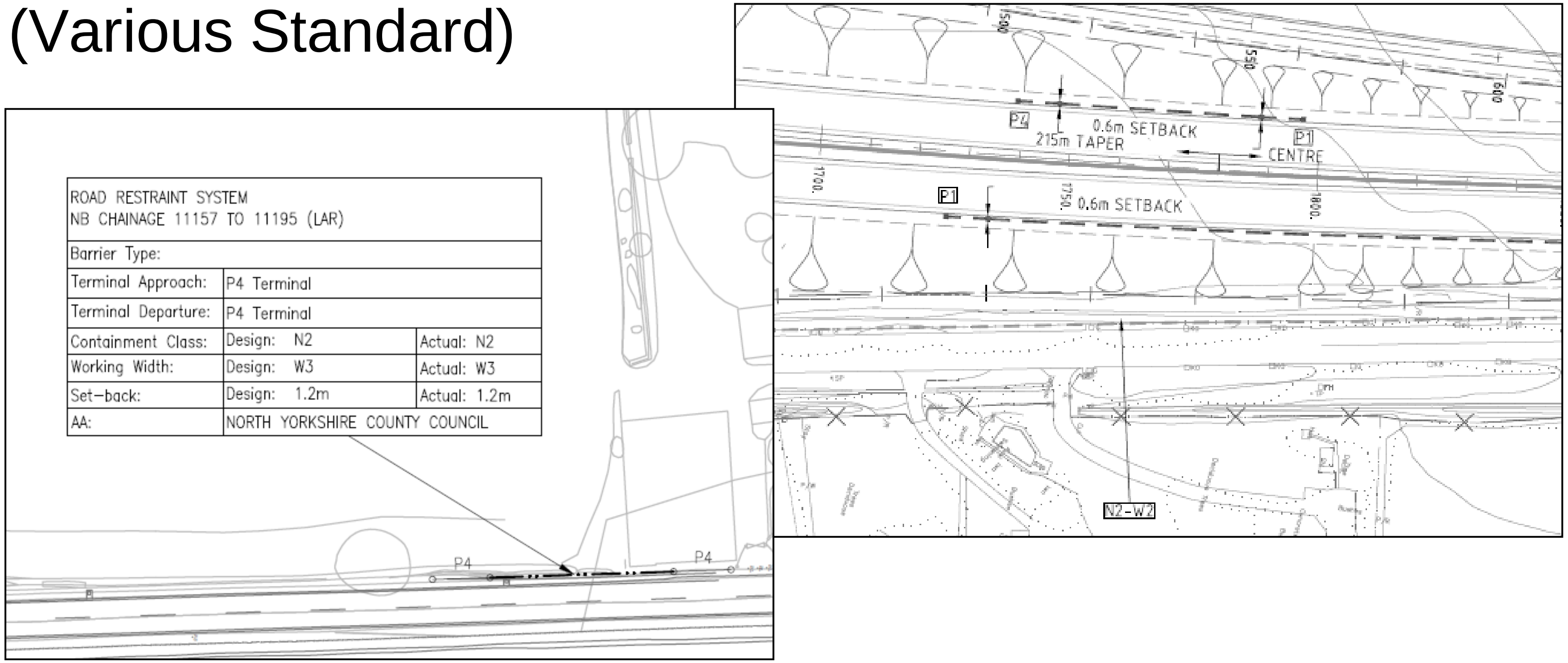
- Illuminated low level lighting beams (polyurethane membrane that fits over the top of new and existing barriers)

- Steelgard parapet: works by using heavy steel sections interlocked together and anchored at each end of the system. It doesn’t have a foundation connected to the bridge deck, so is useful if the string course of the bridge isn’t suitable for a traditional parapet (works by long chain principal)



Design Outputs

- Results of RRRAP / LARA
- Series 400 Specification including Schedules
- Drawings (Various Standard)



Thank you.

Any questions

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