NRA

An tÚdarás um Bóithre Náisiúnta
National Roads Authority

A Guidance Document for the Implementation of the CEDR Forgiving Roadsides report

Foreword

Under the Government's Road Safety Strategy that covers the period from 2013 to 2020, Ireland is now moving towards a Safe Systems approach to road safety. The Safe Systems approach recognises that, even with an emphasis on the prevention of road collisions through better roads, education and enforcement, some collisions will inevitably occur. Roads should, therefore, be designed to expect and accommodate some degree of human error.

The Safe Systems approach to road safety is built on three key concepts - Human Behaviour, Human Frailty and Forgiving Systems. The Forgiving Systems concept seeks to reduce the number of fatalities caused by run-off crashes by making roads more forgiving of driver error through the implementation of a range of safety enhancement measures.

Recent studies have shown that approximately 45 per cent of fatal road crashes in the European Union are single vehicle incidents. These crashes are generally classified as run-off-road crashes, i.e. the vehicles left the road and entered the roadside. A key priority of the National Roads Authority during the period of the Road Safety Strategy is, accordingly, to implement forgiving roadsides systems that will help to reduce the incidence of run-off fatalities by ensuring that, in the event of a crash, the impact energies are below the threshold likely to produce either death or serious injury.

I am confident that Forgiving Roadsides will provide a significant contribution to road safety. This will be achieved by providing drivers of errant vehicles that leave the main carriageway with adequate recovery space in the roadside in which to bring the vehicle under control, while also ensuring that, where a collision does occur in the roadside, appropriate treatments are in place to limit the impact forces on vehicle occupants to minor levels.

There are many thousands of km of 'legacy' national roads in Ireland – roads that have not benefitted from the major national road improvement programme that was undertaken over the last decade. A common feature of many of these legacy roads is the presence of stone walls, ditches, trees and other obstacles along the edges of the roads. A key challenge in the coming years for the Authority, in partnership with local authorities, is to put in place appropriate road safety treatments to make these roads safer – even incremental safety improvements can make a big difference.

Of course, safety on our roads is not only about high standards of road design, construction and maintenance. It is essential that all road users - motorists, motorcyclists, cyclists and pedestrians – behave responsibly at all times and obey the rules of the road.

Fred Barry
CEO
National Roads Authority.

Summary

A key target of the Government's Road Safety Strategy 2013 – 2020 is to achieve a reduction of collision fatalities on Irish roads to 25, or less, per million population by 2020. This means reducing deaths from a total of 162 in 2012 to 124 or fewer by 2020. The strategy also includes a provisional target for the reduction of serious injuries by 30%, from 472 (2011) to 330 by 2020, or 61 per million population.

The strategy to deliver these ambitious targets involves the adoption of a Safe Systems approach to road safety. The **Safe Systems Approach** builds on existing road safety interventions and comprises the following key principles:

Human Behaviour — no matter how well we are trained and educated about responsible road use, people make mistakes and the road transport system needs to accommodate this.

Human Frailty — the finite capacity of the human body to withstand physical force before a serious injury or fatality can be expected is one of the main design considerations.

Forgiving Systems — roads that we travel on, vehicles we travel in, speeds we travel at and the attitudes of road users to each other, need to be more forgiving of human error.

The concept of Forgiving Roads has the objective of minimising the consequences of driving errors, rather than preventing them.

Under the Safe System approach, addressing severe run-off-road crashes through safer roads and roadsides involves providing roads that:

- minimise the risk of vehicles leaving the carriageway (e.g. via delineation).
- provide adequate recovery space when vehicles do run off the road.
- ensure that any collision that does occur in the roadside will be with objects that limit the impact forces on vehicle occupants to minor levels (no fatal or serious injury outcomes).

This document builds on the work done by CEDR TG Road Safety[1], under the Chairmanship of Ireland, when in 2009 they commissioned a road safety project on Forgiving Roadsides. The CEDR report was carried out by IRDES ERA-NET[2] 'Safety at the Heart of Road Design' Team, in consultation with CEDR Technical Group Road Safety.

The *Forgiving Roadsides Design Guide* was published on the CEDR website in 2013 [C.9]. http://cedr.fr/home/fileadmin/user_upload/Publications/2013/T10_Forgiving_roadsides.pdf

The CEDR report identifies the main types of obstacles that may be found on roadsides and which

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[1] Confederation of European Directorate of Roads Technical Group Road Safety

[2] IRDES (Improving Roadside Design to Forgive Human Errors) was one of a number of research projects co-funded by ERA-NET (11 national road administrations, including Ireland)

may represent a risk to vehicle occupants in the event of a driver losing control of the vehicle. Roadside obstacles, which are identified in Chapter 2, are categorised under the following three headings;

Single Fixed Objects, including:

- Trees.
- Rocks and boulders
- Utility poles and lighting posts
- Safety barrier terminals and transitions
- Headwalls
- Headstones
- Fencing at an angle to travel direction, within the Clear Zone

Continuous Hazards, including:

- Embankments and slopes
- Ditches
- Road restraint systems
- Kerbs
- Permanent water bodies
- Pavement edge

Dynamic roadside hazards, including:

- Bicycles
- Pedestrians
- Parking
- Temporary advertising signs on timber posts or trailers

Chapter 3 describes common treatment solutions to make roadsides safer and identifies three categories of works that should be considered:

Removing and Relocating Obstacles.

- The Clear Zone concept.
- Arrester beds in lane diverge areas.
- Safe plantation.
- Roundabouts.

Modifying Roadside Elements.

- Breakaway devices.
- Ditch and slope treatments.
- Route-Based Curve Treatments
- Crashworthy masonry structures.
- Shoulder modifications.
- Modification of retaining walls and rock cuts.
- Safety barrier terminals.
- Safety barrier transitions.

Shielding Obstacles.

- Rigid barriers.
- Semi-rigid barriers.
- Flexible barriers.
- Temporary safety barriers.
- Underriders.
- Kerb-barrier combinations.
- Impact attenuators.

A key recommendation of this report is that new roads should be designed to provide a more forgiving environment for errant vehicles. This can best be achieved through the provision of a Clear Zone to the side of the roadway.

Clear Zones, which are discussed in Chapter 3, should be kept free of hazards and any signage located in the zone should be frangible.

For existing roads, the identification of priority locations for roadside treatment by means of road safety inspection, a programme of improving the sight distance at junctions and a programme of route-based curve treatments to provide consistent signage at bends to alert drivers to the bend severity, are the main priorities.

A review of speed limits versus design speed is also recommended, with the main purpose of identifying, prioritising and treating critical bends.

Acknowledgements

CEDR TG Road Safety, under the Chairmanship of Ireland, in 2009 commissioned an ERA-NET road safety project on Forgiving Roadsides. The report was carried out by IRDES ERA-NET 'Safety at the Heart of Road Design' Team, in consultation with CEDR Technical Group Road Safety.

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Additional inputs to this document includes reference to NRA DMRB standards, research from Austroads on '*Improving Roadside Safety*', *Method of Reducing Speeds on Rural Roads* and new European research on '*Improving the safety of cut highways*'.

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Abbreviations

Abbreviation Definition	
AADT	Annual Average Daily Traffic
AASHTO	American Association of State and Highway Transportation Officials
ADT	Average Daily Traffic
CEDR	Conference of European Directors of Roads or Conférence Européenne des Directeurs des Routes
ERA-NET	European Research Area Network
IRDES	Improving Roadside Design to Forgive Human Errors
NCHRP	National Cooperative Highway Research Programme
NRA	National Road Authority of Ireland
PTW	Powered Two-Wheeler
RISER	Roadside Infrastructure for Safer European Roads
ROR	Run-off-road
RVS	Richtlinien und Vorschriften für das Straßenwesen
SVC	Single Vehicle Crash
TG	Technical Group
TRB	Transportation Research Board

1. Introduction

In recent years, the Safe Systems approach to road safety, which was initially developed in Sweden, has been adopted by a number of countries, including Ireland, as part of their road safety strategies. This approach involves the implementation of a range of targeted measures to manage vehicles, road and roadside infrastructure, as well as vehicle speeds. The approach is built on three key concepts:

- **Human Behaviour** — People make mistakes and the road transport system needs to accommodate this.

- **Human Frailty** — The finite capacity of the human body to withstand physical force before a serious injury or fatality.

- **Forgiving Systems** — Roads that we travel on, vehicles we travel in, speeds we travel at and the attitudes of road users to each other, need to be more forgiving of human error.

The key aims of this report are to examine best practice in the area of Forgiving Roadsides, identify appropriate revisions to our road design standards, as well as to increase awareness among designers of the role that the roadside plays in crash severity and the tools available to create more forgiving roadsides.

This document builds on the work done by CEDR TG Road Safety, under the Chairmanship of Ireland, when in 2009 they commissioned a road safety project on Forgiving Roadsides. The *Forgiving Roadsides Design Guide* was published on the CEDR website in 2013 [C.9]. http://cedr.fr/home/fileadmin/user_upload/Publications/2013/T10_Forgiving_roadsides.pdf

The CEDR report has been prepared following extensive consultation and discussion with road safety experts in various E.U. countries. The specific aim was to identify best practice for the treatment of roadsides, to provide a safer and more forgiving environment to cater for incidents involving errant vehicles.

The concept of Forgiving Roadsides fulfils the Safe Systems strategy of making roads more forgiving of human error by minimising the consequences of driver errors, rather than preventing them. The range of possible treatments to provide Forgiving Roadsides has been categorised as follows:

- Removal and relocation of obstacles

- Modifying roadside elements

- Shielding obstacles

The idea of a fourth category called “Delineating road obstacles” is suggested in the Roadside Design Guide of AASHTO [B.1] and mentioned in [B.17]. It recommends that the driver’s awareness of hazards should be increased when other treatments are not possible, for example, by a signing programme on bends and/or a review of the appropriateness of existing speed limits.

This report describes common roadside hazards and identifies best practice for the treatment of those hazards. Through the implementation of appropriate treatment measures, roadsides on national roads will be made more forgiving in the event of loss of control incidents, thereby reducing the number of fatalities and serious injuries on our roads.

2. Roadside Hazards

The CEDR report categorises Roadside Hazards under the following headings:

- Single Fixed Obstacles
- Continuous Obstacles
- Dynamic Roadside Hazards

2.1. Single Fixed Obstacles

Studies have shown that single or point objects make up the highest number of potential hazards along the roadside. According to [B.5], point hazards are defined as permanent installations of limited length. They can be natural or artificial, human-made structures comprised of different materials. Clearly, large rigid structures such as bridge abutments cause the most severe crashes, as they do not provide sufficient energy absorbance. In the following paragraphs, different examples of hazardous single fixed obstacles are highlighted.

2.1.1. Trees and Other Vegetation

Collision analyses have shown that tree crashes claim a significantly higher number of fatally injured victims than any other roadside obstacle. According to the RISER project, trees become particularly hazardous when the diameter exceeds 20 cm (see [A.2]) – in France a figure of 10 cm is considered dangerous. See Figure 1.

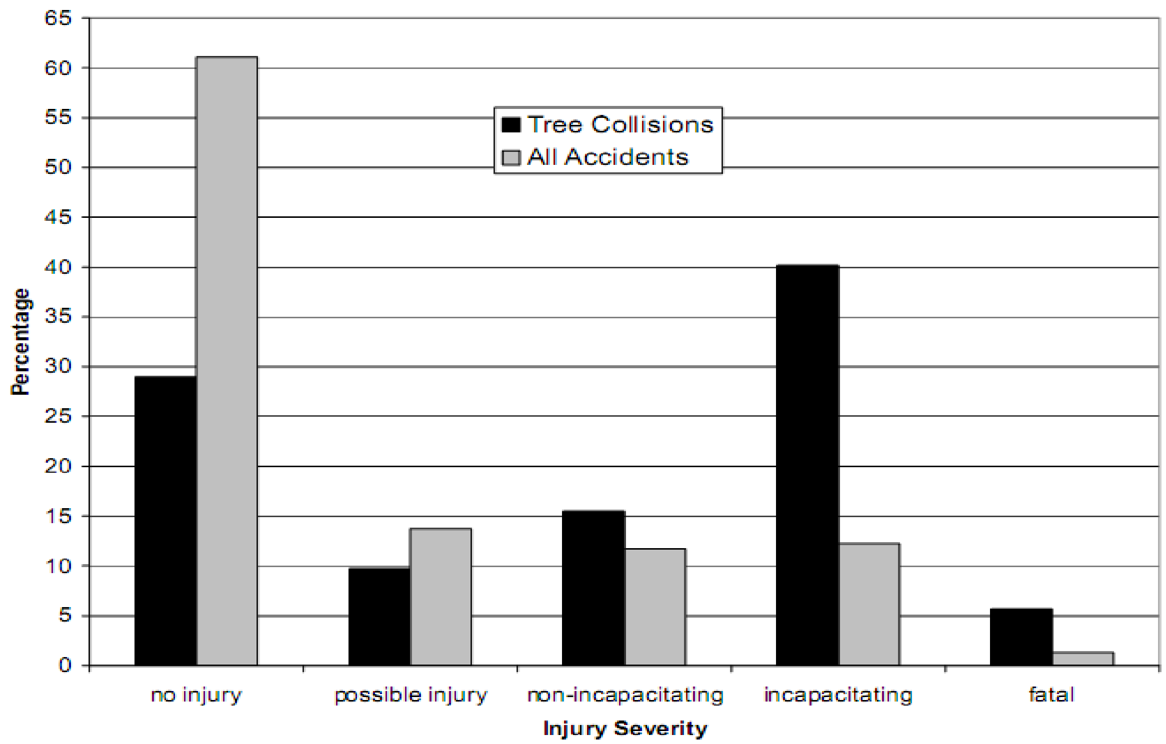


Figure 1 - Relative frequency of injury severity for tree collisions and all collisions [A.8].

A guide from the NCHRP [B.3] contains an interesting analysis of the relationship between the average distance of trees to the travel lane and tree crashes. It shows that shorter distances result in more crashes. The example pictures in Figure 2 shows trees that are located too close to the road without delineation or shielding.

Figure 2 - Examples of hazardous trees located on the roadside

2.1.2. Utility Poles

Utility poles typically carry power or telecommunications overhead cables. The poles are often made of rigid wood or concrete and can therefore be described as "unforgiving", since the energy absorbance ability is minimal. See Figure 3.

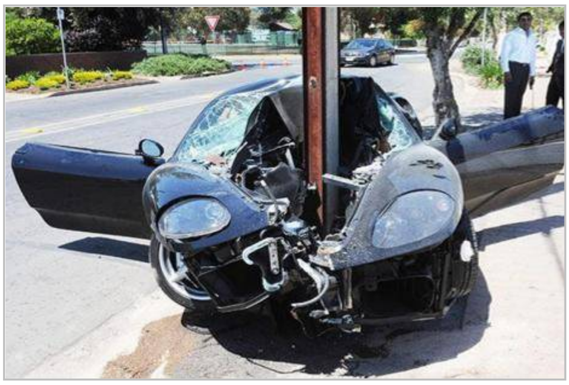


Figure 3 - Two examples of hazardous utility poles

2.1.3. Sign and Lighting Posts and Supports

The structures described here carry lighting or traffic information signs. Generally, they must be located close to the roadway and cannot be removed or relocated. They are hazardous if they are non-breakaway during impacts. Figure 4 shows examples of hazardous poles on the roadside.

Figure 4 - Examples of hazardous poles

2.1.4. Abutments

Abutments, overpasses, bridge piers and walls of underpasses are mostly made of rigid concrete and are considered extremely hazardous. Examples of a hazardous bridge abutment and an overpass are depicted in Figure 5.

Figure 5 - Examples of a hazardous bridge abutment (left) & overpass (right)

2.1.5. Safety Barrier Terminals and Transitions

Safety barriers are forgiving roadside treatments intended to shield hazardous obstacles and/or to prevent vehicles from running off the roadway. However, the ends or transitions between two different types of rails can be hazardous roadside objects.

Figure 6 depicts two examples of dangerous safety barrier terminations. In the picture on the right, a transition between the bridge rail and roadway guardrail is missing. In both pictures the ends of the barrier have no proper end treatment.

Figure 6 - Examples of hazardous safety barrier terminations

2.1.6. Rocks and Boulders

Rocks and boulders are dangerous obstacles when located too close to the roadway. See Figure 7.

Figure 7 - Examples of hazardous rocks on the roadside

2.1.7. Drainage Features

Where a vehicle runs off the road, drainage features like culverts or culvert ends become hazardous roadside obstacles. They are commonly used to channel a water course. The examples in Figure 8 depict hazardous drainage structures.

Figure 8 - Examples of hazardous drainage features

2.2. Continuous Hazards

Continuous hazards are distributed objects that are of considerable length, often making it impractical to remove or relocate them. On the following pages, several examples of continuous hazards and their impacts on roadside safety are presented.

2.2.1. Embankments and slopes

An embankment is a man-made ridge of earth or stone that carries a road or railway. The term comprises all types of sloping roadsides, including cut and fill slopes (see Figure 9). A cut slope is the face of an excavated bank required to lower the natural ground line to the desired road profile. In contrast, a fill slope is the face of an embankment required to raise the desired road profile above the natural ground line. How hazardous a slope is depends on its height or depth, its steepness and distance to the roadway.

Figure 9 - Examples of hazardous cut (left) and fill slopes (right)

2.2.2. Ditches

Ditches are defined as drainage features created to channel water, which mostly run parallel to the roadway. They are formed by the sideslope and backslope planes, and are intended to provide adequate drainage and snow storage capacity. See Figure 10 below.

Figure 10 - Examples of hazardous cut (left) and fill slopes (right)

2.2.3. Road Restraint Systems

After trees and utility poles, road restraint systems (e.g. steel safety barriers, cable barriers, etc.) are the third most dangerous roadside obstacles [C.1]. Although, as outlined above, barrier terminals and transitions are hit more frequently, the barrier rails themselves can also be considered roadside hazards.

Safety barriers are, therefore, a special case as they can be both hazards and forgiving roadside treatments for safety. See Figure 11 below.

Figure 11 - Examples of collisions with safety barriers

2.2.4. Kerbs

In many urban environments kerbs are commonly used to help prevent run-off-crashes. Kerbs serve two purposes; to prevent motorists from driving onto the roadside, and to facilitate efficient drainage of the roadway.

It should be noted that kerbs – like road restraint systems – are a treatment to improve roadside safety, but they can also prove a hazard for motorists.

2.2.5. Permanent Water Bodies

The term permanent water body describes rivers, lakes, canals or small ponds that are located close to the roadside. Obviously, the risk of drowning arises when an errant vehicle enters the water body.

2.2.6. Pavement Edge Drop-offs and Other Continuous Obstacles

Pavement edge drop-offs are another roadside hazard that needs to be treated. Shoulders may not always be flush with the roadway surface. Such shoulder edge drop-offs can be caused by soil erosion next to the pavement, rutting by frequent tyre wear or from repaving, where material is added to the lane but not to the adjacent shoulder. See Figure 12.

Figure 12 - Pavement-Edge Drop-off

2.3. Dynamic roadside hazards

Dynamic roadside features [B.4] includes facilities for the following:

- bicycles,
- pedestrians, and
- parking manoeuvres.
- temporary advertising signs on timber posts or trailers.

In contrast to the hazards discussed earlier in this Chapter, dynamic hazards are not fixed, but moving. Dynamic roadside features are more prevalent in urban environments, which are generally more complex than rural roadsides. Research regarding the relationship between dynamic roadside elements and roadside safety is limited. While bicycle lanes and sidewalks provide additional Clear Zones for drivers, bicycle hardware, such as racks may be potential hazards for drivers. However, the associated risks typically relate to the pedestrians using the sidewalk, rather than the drivers of vehicles. This requires a different approach to roadside treatments to protect pedestrians on the sidewalk.

3. Treatments to make roadsides forgiving

In the previous chapter, various potential hazards were highlighted which can impact on roadside safety. This chapter outlines the appropriate treatments for those hazards and considers the following three strategies to improve roadside safety:

- Removing and relocating obstacles (see Chapter 3.1)
- Modifying roadside elements (see Chapter 3.2)
- Shielding obstacles (see Chapter 3.3)

Delineation and signage are normally the recommended treatments if all of the three measures above are deemed inappropriate for a particular location. These treatments can help a driver to avoid hitting roadside hazards.

Based on the steps identified in [B.5] for the treatment of roadside hazards, the following procedure should be used to determine the optimum treatments for roadside hazards:

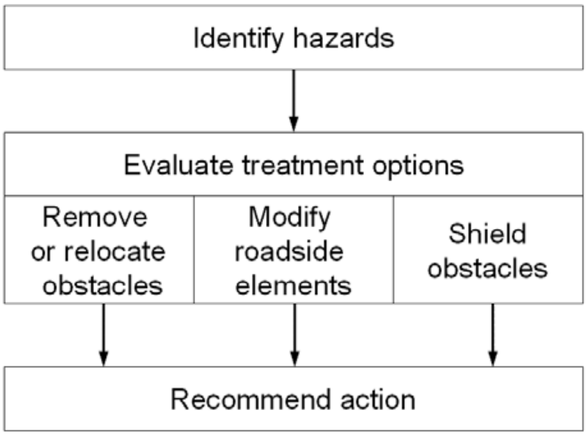


Figure 13 - Procedure for forgiving roadside treatments

The three steps in Figure 13 can be applied either on existing roads or in the planning phase for a new road.

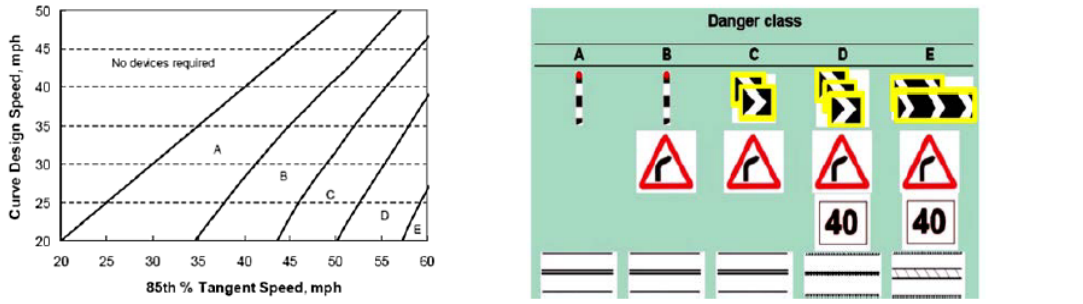
For new road developments, it is essential that potential hazards are identified and considered as early as possible during the planning phase. The provision of a Clear Zone (often called safety zone) is usually the most appropriate treatment.

On existing roads, the identification of hazards may be established by road safety inspections or by reference to collision histories. Hazards can be identified by considering traffic volumes and speeds, road geometry, surface properties and the expected severity of crashes.

Road safety inspections have identified inconsistent signage of bends as being an issue on unimproved single carriageway roads. The procedure outlined in Figure 13 recommends modifying these roadside elements to give a more consistent message to the driver.

Some very good examples of this procedure are described in the recent Austroads publication 'Methods of Reducing Speeds on Rural Roads ' [A.21]. as shown in Figure 14. It describes route-based treatments as a method of ensuring consistency of signing of curves along a section of road. Each curve is classified based on risk factors, such as:

- design speed,
- tangent speed,
- sight distances etc.



Source: Bonneson, Pratt, Miles and Carlson (2007). Source: TRL and Department for International Development (2001).

Figure 14 - Route-based Curve Treatments – Curves

The National Roads Authority is proposing to use a similar procedure:

- using speed differential to identify bend severity, and
- without the use of advisory speed limit signs

Once the risk of the curve has been identified, signs and markings for that curve are installed according to this risk category. The higher the risk category the more treatments are installed. These will include:

- advance curve warning signs,
- chevron markers
- guide posts and
- profiled road markings.

A major consideration in the design of new roads is the determination of the desirable Clear Zone. Based on data such as design speed, slope information, curvature, topography and non-removable road furniture, the Clear Zone requirements can be determined. The desirable Clear Zone width forms the basis for the removal or relocation of obstacles.

Shoulder Rumble Strips is another treatment mentioned in the CEDR forgiving roadside design guide [C.9]. Rumble strips are road safety features used to alert road users straying off the road or drifting into the opposing lane of traffic both by causing a vibro-tactile and an audible warning. They are intended to reduce road accidents caused by drowsy or inattentive motorists and can be distinguished in shoulder, centreline or transverse rumble strips.

A shoulder rumble strip is a longitudinal design feature installed on a paved roadway shoulder near the outside edge of the travel lane. It is made of a series of indented or raised elements intended to alert inattentive drivers through vibration and sound that their vehicles have left the travel lane. On divided highways, shoulder rumble strips are typically installed on the median side of the roadway as well as on the outside (right) shoulder.

In Ireland shoulder rumble strips with raised ribbed lines (vibro-tactile) are typically used on our motorways, as opposed to the option of milled lines.

3.1. Removing and Relocating Obstacles

3.1.1. The Clear Zone concept

The most effective roadside improvement can be accomplished by providing a Clear Zone, i.e. an obstacle-free area with a flat and gently graded ground. This provides motorists with room and opportunity to regain control of their vehicle in case of a run-off.

Objects that cannot be eliminated should be relocated outside the Clear Zone. It may be divided into two areas: the recovery zone (hard shoulders) and the limited severity zone (See Figure 15)

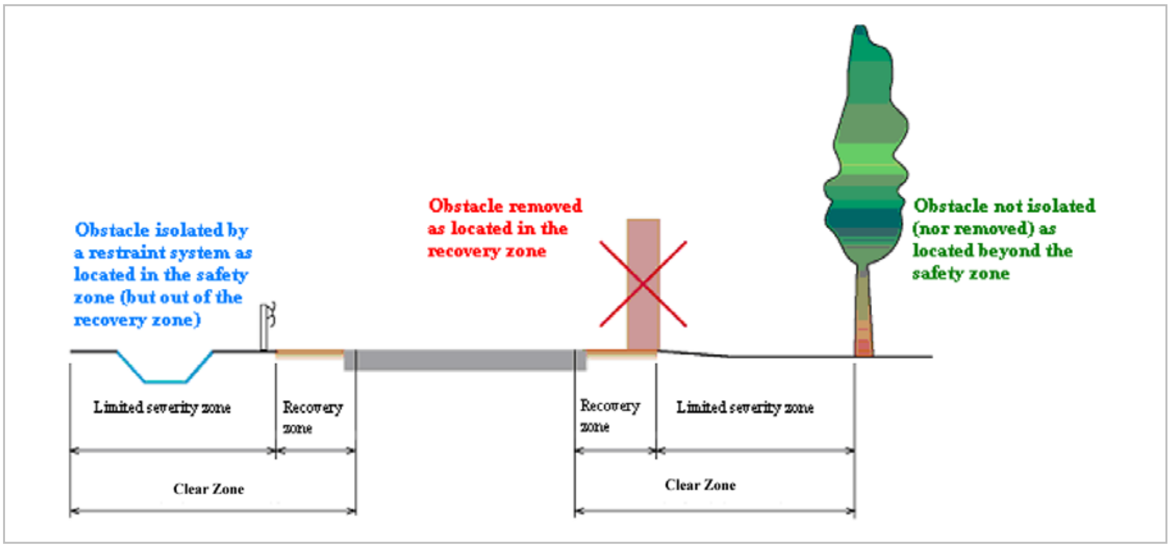


Figure 15 - Clear Zone definition, as depicted in [B.9]

- The width of Clear Zones varies throughout the world, depending on the underlying policy and practicability. The national dimensions for a Clear Zone of 7 different European countries have been determined in the RISER project. Common criteria for determining the dimensions are design speed, side slope gradients, road type, horizontal alignment (straight or curved roads), driving lane width and percentage of heavy-vehicles.

The Clear Zone requirements (See Figure 16) in the Irish DMRB TD 19 would be seen as best practice.

	Design Speed (km/h)		
	85	100	120
Horizontal radius (m)	**Required Width of Clear Zone (m)**		
Inside of bend or Straight	**6.5**	**8.0**	**10.0**
Outside of bend ≥1,000m	6.5	8.0	10.0
" 900m	7.1	8.8	12.4
" 800m	7.7	9.6	14.9
" 700m	8.3	10.4	17.5
" 600m	8.8	11.2	20.0
" 500m	9.4	12.0	
" 400m	10.0	12.8	
" 300m	10.6		

Figure 16 - Required Clear Zone – Irish DMRB TD 19

A recent Austroads research report [A.19], not included in the CEDR document, discusses traversable open drains in the Clear Zone. The report found that, if drain sides are too steep, errant vehicles may roll over, increasing the severity of a run-off-road crash. The Austroads report, therefore, recommends that the side slopes of table drains should be flat enough to minimise the possibility of errant vehicles overturning. Side slopes not steeper than 1:4, ideally with a desirable slope of 1:6, are preferred. Austroads reported that run-off-road crash likelihood more than doubles for steep roadsides (1:3.5 or steeper) compared to flat roadsides (1:6 or less).

In the Irish NRA DMRB TD 19/12 [B.30], side slopes steeper than one in five are not recommended in the Clear Zone, to minimise the risk of road crashes.

Research undertaken in Spain [A.20], not included in the CEDR document, examined the design of the roadside of a motorway, in the event of an out of control vehicle leaving the carriageway and entering the road bank (i.e. roadside drainage area).

The results of the research, computer simulations and full-scale field tests, lead to a proposed new road bank design (See Figure 17) where a vehicle could leave the carriageway, descend the slope and return to the road with no significant damage. On the basis of this research, a road bank with this geometry was designed, called the “OASIS Road Bank”

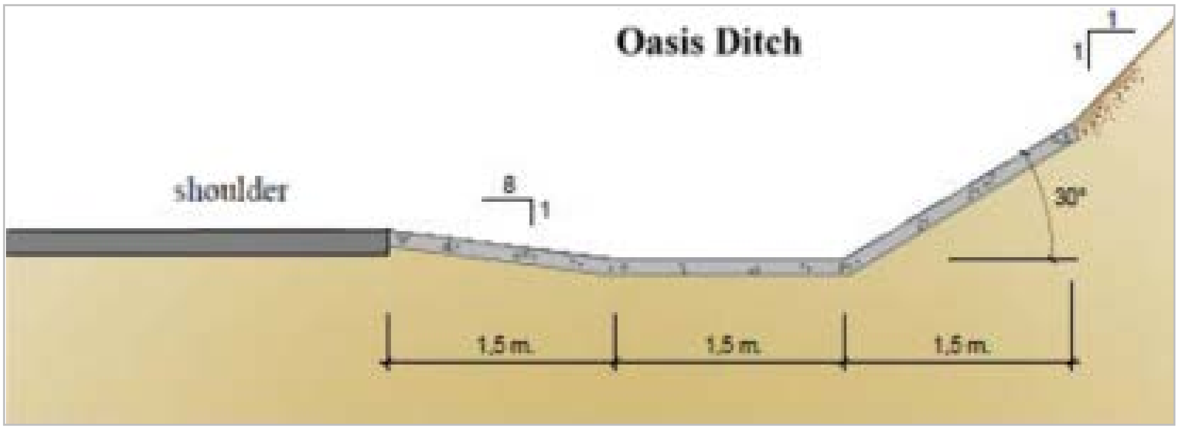


Figure 17 - OASIS Road Bank (Source: [A.20])

The Spanish study indicates that, by removing safety barriers from the verge, the cost of motorway maintenance can be reduced. In the absence of a safety barrier, machinery can enter the bottom of the road bank and carry out maintenance works with greater freedom and at reduced operating costs.

The corresponding hydraulic calculations were made to verify that it was able to independently remove water from the side slopes of the motorway. The report states that the designed road bank can transport the expected amount of water for up to 2 km.

Recovery Area

A recovery area is a side strip next to the pavement and is available for drivers of errant vehicles to perform recovery manoeuvres. It must be free of obstacles so that drivers can return to the travel lane or stop the vehicle, if necessary. The recovery zone is commonly defined as a hard or soft shoulder lane located immediately beyond the carriageway edge line.

Providing a recovery zone can include the following treatments:

- Hard shoulder construction.
- Soft shoulder construction.
- Enhancement of existing shoulders.
- Median shoulders.

A hard shoulder is a paved surface immediately beyond the carriageway edge line. The skid resistance of the surface should be as good as the main carriageway surface in order to avoid skidding crashes. Hard shoulders are commonly used to provide emergency lanes, parking lanes, bicycle or pedestrian lanes, except on motorways where the use of the hard shoulder is prohibited. According to studies of Elvik and Vaa [A.12], rural roads with hard shoulders have a crash rate reduction of about 5 to 10 percent compared to rural roads without shoulders.

In contrast to hard shoulders, soft shoulders are unpaved areas beyond the paved carriageway.

Examples of shoulders are shown in Figure 18.


Figure 18 - Examples of a hard (left) and soft shoulder (right)

The dimensions of shoulders have been the subject of much discussion among road engineers and safety experts. Wider shoulders may encourage higher driving speeds as drivers may view a wide shoulder as an extra lane.

Limited Severity Zone

Some guidelines distinguish between the hard shoulder and the rest of the Clear Zone. The limited severity zone (Figure 19) is not intended to prevent vehicles from leaving the road, but to minimize the severity in case of a run-off. It is defined as the area beyond the hard shoulder, but is still part of the Clear Zone.

Any hazardous obstacles in this zone should be removed or treated appropriately. This includes single hazards, such as poles, light supports and trees, as well as continuous hazards such as walls. In some countries, the side slope gradient is taken into account for the Clear Zone width.

Figure 19 - Limited severity zone, no hard shoulder

Figure 20 gives a list of Edge Treatments / limited severity zones on Rural Road Layouts, from the Irish DMRB TD 9. This would be seen as best international practice.

Type of Road	Capacity (AADT) for Level of Service D	Edge Treatment
Type 3 Single (6.0m) Carriageway (S2)	5,000	0.5m hard strip. Cycle Facilities Footways where required,
Type 2 Single (7.0m) Carriageway (S2)	8,600	0.5m hard strips. Cycle Facilities Footways where required
Type 1 Single (7.3m) Carriageway (S2)	11,600	2.5m hard shoulders

Type of Road	Capacity (AADT) for Level of Service D	Edge Treatment
Type 3 Dual (7.0m + 3.5m) Divided 2+1 lanes Primarily for retro fit projects	14,000	0.5m hard strips. Cycle Facilities
Type 2 Dual Divided 2 +2 Lanes (2x7.0m) Carriageways.	20,000	0.5m hard strips Cycle Facilities
Type 1 Dual Divided 2+2 Lanes (2x7.0m) Carriageways	42,000	2.5m hard shoulders
Standard Motorway Divided 2 +2 Lane (2X7.0m) (D2M)	52,000	2.5m hard shoulders
Wide Motorway Divided 2+2 Lane (2X7.5m) (D2M)	55,500	3m hard shoulders

Figure 20 - Edge Treatment on Rural Road Layouts – Irish DMRB TD 9

Median Shoulders

The median, also called central reserve, separates lanes of traffic travelling in opposite directions. Although not part of the roadside, medians can help to reduce run-off-road crashes and minimize their severity. An additional benefit of medians includes the provision of recovery areas for errant vehicles and emergency stopping. In urban areas, medians are commonly used as areas for pedestrian refuge and for traffic control device placement. They can also be planted to improve the visual environment. Previous research studies have found three safety trends regarding medians [A.14]:

- Crashes between opposing vehicles are reduced with medians.
- Median-related crashes decrease as the median width increases beyond 30 feet (9.1 metres). Up to 30 feet, the crashes increase as the median width increases.
- The effect of median widths on the total number of crashes is uncertain.

In Ireland, all Motorways and dual carriageways have median barriers, as per Irish DMRB.

3.1.2. Arrester beds in lane diverge areas

Arrester beds in lane diverge areas are treatments for vehicles that have lost their braking ability. They reduce the speed of the vehicle and prevent it from going off the road, with no impact against a crash cushion. While they are often used on roads with long downgrades e.g. in mountainous areas, they are also called emergency escape ramps or runaway truck lanes as they are mainly designed to accommodate large trucks to prevent roadside crashes.

The surface of the arrester bed is made of a specific material that increases rolling resistance and allows the vehicle to decelerate. Arrester beds are typically comprised of a layer of granular material of suitable aggregate size and geometry, specifically designed to favour the sinking of vehicle wheels. Examples are shown in Figure 21.

A number of arrester beds have been constructed in Ireland, notably in Letterkenny on the N13, near the Dry Arch Roundabout.

Figure 21 - Examples of arrester beds

3.1.3. Safe plantation

Following the principle of Clear Zones, hazardous plants or trees should be removed from the roadside. However, grass, weeds, brush and tree limbs can also obscure or restrict a driver's view of traffic signs, approaching vehicles, wildlife and livestock, as well as pedestrians and bicycles. Where hazardous plants have been removed, an appropriate maintenance regime should be put in place to prevent the future growth of plants and trees in the Clear Zone.

Controlling roadside vegetation helps to reduce crashes and injuries.

On the motorways and dual carriageways in Ireland, the motorway maintenance contractors are charged with maintaining the vegetation. On the rest of the network this function is carried out by the various local authorities.

3.1.4. Roundabouts

The possibility of a vehicle entering the centre of the roundabout is increased due to the 90 degree angle of approach to a roundabout. It is, therefore, advised to keep this area free from any objects.

It is not possible to protect objects in the centre of a roundabout with a safety barrier due to the 90 degree angle of approach, as safety barriers are tested at angles of impact of only 30 degrees.

The CEDR report states that features, hazardous plants or trees should not be placed in the centre of roundabouts.

The revised Irish Junction Standard (NRA TD 301), to be published shortly will now specifically address these issues and will prohibit features, hazardous plants or trees in the centre of roundabouts.

3.2. Modifying roadside elements

In some cases, it is not possible to remove hazardous obstacles from the Clear Zone. In such circumstances, single and continuous hazards should be modified in order to minimise the risk of personal injury and property damage in the event of a crash. The risks posed by such hazardous obstacles should be reduced by making them breakaway or crashworthy. The following chapters show different treatments to make non-removable obstacles more forgiving.

3.2.1. Breakaway Devices

Breakaway devices have the advantage of a reduced likelihood of impact damage and injury, but the disadvantage that a falling pole can be a hazard to surrounding traffic, pedestrians and property. Non-breakaway poles may be appropriate if pedestrian traffic is high, or overhead electric lines are nearby. However, breakaway poles are preferred in most roadside areas. An example of a spliced pole is shown in Figure 22.

Figure 22 - Breakaway/spliced pole (left) and slip base (right)

- *Slip-base poles*: A characteristic of slip base poles is that, when impacted at normal traffic speeds, they are generally dislodged from their original position (See Figure 23). The design enables the pole to slip at the base and fall if a collision occurs.

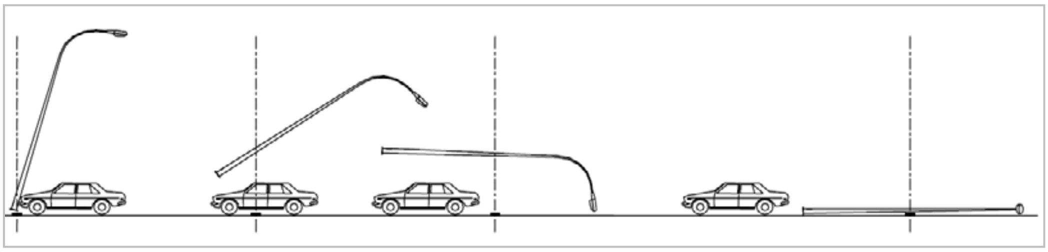


Figure 23 - Vehicle impacting a slip base pole

- *Breakaway transformer base*: A transformer base, commonly made of cast aluminium, is bolted to a concrete foundation. The bottom flange of the pole is bolted to the top of the transformer base.

- *Breakaway connectors*: Breakaway connectors are fused or unfused connectors in the base of poles. When breakaway poles are used, the electrical conductors must also be breakaway.

Passively Safe roadside features are currently referenced in NRA TD 19 and are specified in Series 1200 of the NRA Specification. However, there is no standard currently addressing the design requirements for such features. It is proposed to revise NRA TD 19 and remove all non-safety-barrier elements from the standard and to publish a new design standard dealing specifically with the roadside and roadside feautures.

3.2.2. Ditch and slope treatments

Ditches are used as drainage features on roadsides. They should be designed wide enough to provide adequate drainage and snow storage capacity. If ditches are considered hazardous, they should be modified to increase safety. Depending on the shape of the ditch, several types of treatments can be considered:

- *Buried drainage*: The preferred treatment is to backfill the ditch after drainage pipes have been installed. This eliminates any hazardous sideslopes from the Clear Zone.

Modify slope ratio: If a ditch cannot be removed or backfill, the slopes should be kept as shallow as possible. Recoverable slopes have a slope ratio of 4:1 or flatter. For higher traffic volumes, sideslopes should be designed with a 6:1 ratio. Although the risks arising from backslopes are generally less than that of foreslopes, a ratio of 3:1 or flatter is recommended. Examples of safe ditches are depicted in Figure 24.

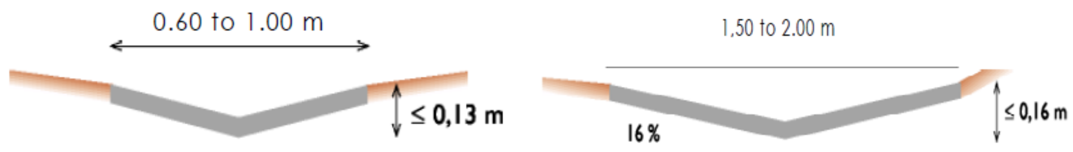
- *Bottom modifications*: Ditch bottoms can either be sloped or flat. The rounding of the ditch bottom prevents vehicles from a rollover, and a rounded bottom ditch with a foreslope of 4:1 and backslope 2:1 is recommended. For reasons of safety, the width of the bottom should be at least 1 metre. In [B.2], a minimum width of 1.2 metres is preferred. Very shallow and wide ditch bottoms may require additional buried drainage.

Cover ditches: Another common treatment is to cover the ditch with gutters or other appropriate drainage system. This is particularly recommended at roadsides where a deep ditch is required. Examples are given in Figure 25.

- *Modify masonry structures in ditches*: Ditches often include drainage features such as culverts, kerbs or control dams which are made of rigid, non-energy-absorbent material. These structures should be made crashworthy by modifying their shape.

- *Isolate most dangerous ditches*: Isolating ditches involves shielding them from errant vehicles. The space required for an adequate road restraint system must be taken into account. This type of treatment is discussed in Chapter 3.3 (Shielding Obstacles).

- *False cutting:* this involves the provision of an embankment which creates a ground division between the road section and the external environment so that the roadside appears to be in a cutting, similar to a linear artificial hill.



Shallow ditch   Wide and shallow ditch[3]

Figure 24 - Examples of safe ditch design [B.9]

Covered rectangular gutter   Longitudinal slot gutter

Figure 25 - Examples of covering ditches

Irish NRA DMRB TD 19 requires a 1:5 embankment within the Clear Zone, to minimise the risk of rollover crashes.

3.2.3. Crashworthy masonry structures

Masonry structures, such as parapets, culverts and kerbs, can often be found on roadsides. They generally have minimal energy absorbance and are very hazardous obstacles for errant vehicles. If

[3] The slope gradient may be specified in different ways. Either ratios (e.g. 4:1, 1:4) or percentages are common.

they cannot be removed from the Clear Zone, these structures should be modified.

Masonry structures such as bridge piers, walls or buildings, which cannot be removed or relocated, should be shielded with an appropriate road restraint system.

If a vehicle runs off the road into a ditch, culvert ends can be hazardous obstacles. If they cannot be removed, safer designs should be considered. A common treatment for culvert ends is bevelling (see Figure 26)


Figure 26 - Bevelled culvert end (left) and parapet (right)

Short parapets, mostly found at bridges to protect errant vehicles from running off the slope, are hazardous due to their rigidness. When the parapet is too short to protect errant vehicles, it should be extended to an adequate length.

Kerbs may also be categorised as masonry structures. They serve as drainage control, pavement edge or walkway delineation. Kerbs are not considered as obstacles if their height does not exceed 20 cm. However, hitting a vertical kerb may cause an errant vehicle to mount or launch. When kerbs must be used on high-speed roads, the shortest possible kerb height and flattest slope should be used to minimise the risk of loss of control due to a vehicle striking the kerb.

The shape of the kerb is a safety-relevant feature that depends on the operating speed of the roadway. Vertical kerbs (See Figure 27) should be used on low-speed roads, since they may cause vehicle rollovers at high impact speeds. Sloping kerbs are configured such that a vehicle can safely ride over the kerb. They prevent vehicles from being redirected back into the traffic stream and are, therefore, the recommended option for highways and high-speed roads.


Figure 27 - Vertical kerb (left) and sloping kerb (right)

Often, kerbs are used in combination with road restraint systems. Kerb-barrier combinations are discussed in Chapter 3.2 of this document.

In Ireland, kerbs are discussed in NRA TD 19 both in terms of where they are considered as a hazard and also regarding the maximum height of a kerb in front of a safety barrier. The Irish Standards are in line with the recommendations of the Forgiving Roadside Document.

3.2.4. Shoulder modifications

Shoulder treatments that promote safe vehicle recovery include shoulder widening, shoulder paving and the reduction or, if possible, elimination of pavement edge drop-offs. Shoulders may not always be flush with the roadway surface. Such shoulder edge drop-offs can be caused by soil erosion next to the pavement, rutting by frequent tyre wear or from repaving, where material is added to the lane but not to the adjacent shoulder. This hazard should be treated by bevelling the edges or by levelling the pavements. It is common to slope the edge with an angle of 45 degrees.

Pavement edge drop-off can be a particular problem on newly overlaid roads. Figure 28 shows a typical standard detail for Ireland, which recommends drop off of between 35 and 45mm.

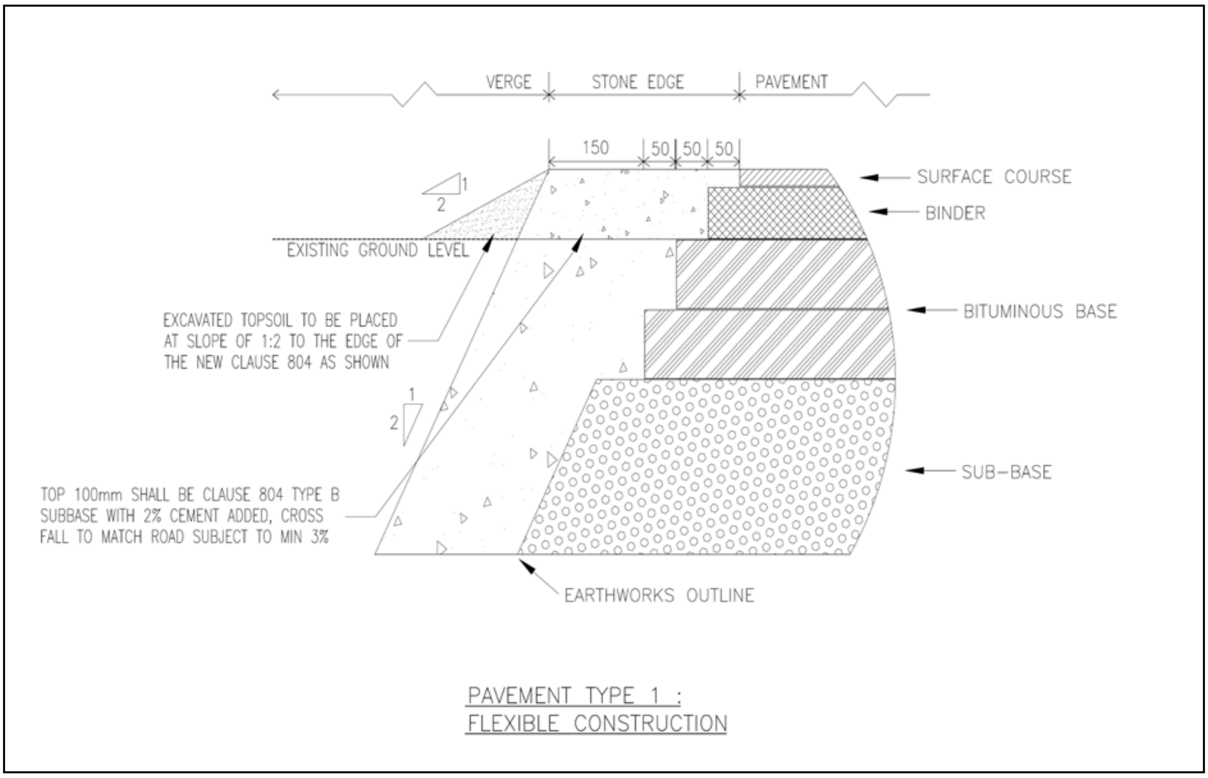


Figure 28 - Pavement Edge Detail in Ireland – RCD 700/1

In Ireland, a pavement edge detail has been developed to prevent edge drop off; this detail was published as a circular to Local Authorities in 2012 and is currently being prepared as a Road Construction Detail for publishing shortly.

Skid resistance is dealt with by NRA HD 28 and the NRA Addendum to HD 36. In 2013, additional work was commissioned in this area, which resulted in the publication of an Interim Advice Note 05/13 titled, 'Surfacing Materials for New and Maintenance Construction, for use in Ireland'.

3.2.5. Modification of retaining walls and rock cuts

If the skid resistance of a paved shoulder is insufficient, treatments to increase surface friction should be applied. Moreover, any other hazardous surface damages such as potholes or cracks should be eliminated from the shoulder.

According to [B.9], a wall is acceptable in the Clear Zone when it meets the following conditions:

- longitudinal to the road or virtually (offset < 1/40th);
- smooth or with no protrusion or edge likely to block a vehicle;
- heights over 70 cm;
- sufficiently sturdy to withstand an impact.

If a hazardous wall or continuous rock outcrop cannot be removed from the Clear Zone, the extremities should be treated or isolated, if possible. Walls and rock faces should allow a vehicle to slide in the event of an impact. Therefore, rough surfaces should be smoothed and any cavities between protrusions filled with masonry. Examples of wall treatments are depicted in Figure 29.

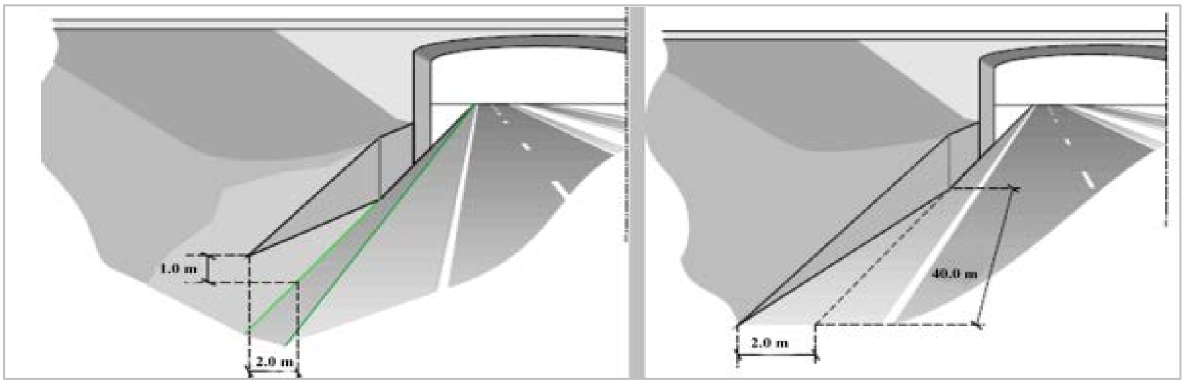


Figure 29 – Example of end design of a retaining wall close to the carriageway [B.16]

In Ireland, NRA TD 19 allows retaining walls to incorporate a concrete barrier of the profile shown in the NRA Road Construction Details rather than require a separate barrier, provided the surface of the wall presents a smooth traffic face for at least 1.5m above the carriageway level.

3.2.6. Safety barrier terminals

Safety barriers belong to the group of road restraint systems and are explained in more detail in Chapter 3.3 (Shielding Obstacles).

There are two types of safety barrier terminals;

- they can either redirect vehicles back onto the carriageway, or
- stop a vehicle immediately so that it cannot pass through the barrier.

If the terminals are intended to stop a vehicle, they have to be treated as energy absorbing devices and must be tested according to EN 1317.

When terminals appear as hazards, as explained in Chapter 3.3, countermeasures should be implemented. For rigid barriers, the most appropriate way to modify the terminal is to make it semi-rigid. This causes the vehicle to crash into a deformable barrier first, which guides the vehicle onto the rigid one. The problem with this installation is the transition between the two barrier types, which is discussed in Chapter 3.2.7 below.

The second option is to make them breakaway so that, on impact, the terminal breaks and swings back behind the barrier [B.22] . A deflection from the traffic lane towards the roadside is also an appropriate measure, as shown in Figure 30.

Figure 30 - Deflecting breakaway safety barrier terminal

A further method of treating hazardous safety barrier terminals is to shield them separately by means of crash cushions. This method is discussed in Chapter 3.3.7.

In Ireland, NRA TD 19 states that the preferred option for an upstream terminal is a ramp down terminal at flare of 1:20 away from the road. Where this is not possible a full height P4 terminal is required on all roads of design speed 100km/h or greater.

3.2.7. Safety barrier transitions

The transition between two safety barriers must ensure that errant vehicles can slide continuously along the barrier. This is particularly important in the case of the transition between semi-rigid and rigid barriers. The transition has to be firm enough to ensure a change without snagging on the rigid barrier. This transition is depicted in Figure 31.

Figure 31 - Transition between semi-rigid and rigid barrier

The transition between a flexible barrier and a semi-rigid barrier is commonly constructed by overlapping the flexible one in front. This enables vehicles to slide smoothly onto the semi-rigid barrier. The same installation can be used when flexible and rigid barriers are connected.

In Ireland, NRA BD 52 requires that all transitions are tested in accordance with the ENv 1317 Part 4 and to prevent snagging requires that no significant changes in the dynamic deflection occur over a short length. A dynamic deflection of 10 to 12 times the change in Working Width is required between different barriers.

3.3. Shielding Obstacles

In many cases, removing or modifying hazardous objects from a roadside is not feasible. To prevent collisions of vehicles with these objects, the third recommended treatment involves shielding hazardous objects through the use of Road Restraint Systems (RRS). The object is fully protected, so that errant vehicles crash into the RRS, which reduce the severity of the impact. While these treatments may appear as hazardous objects themselves, the severity of crashes would be greater in the absence of RRS.

Shielding obstacles are divided into (i) vehicle and (ii) pedestrian restraint systems, as depicted in Figure 32.

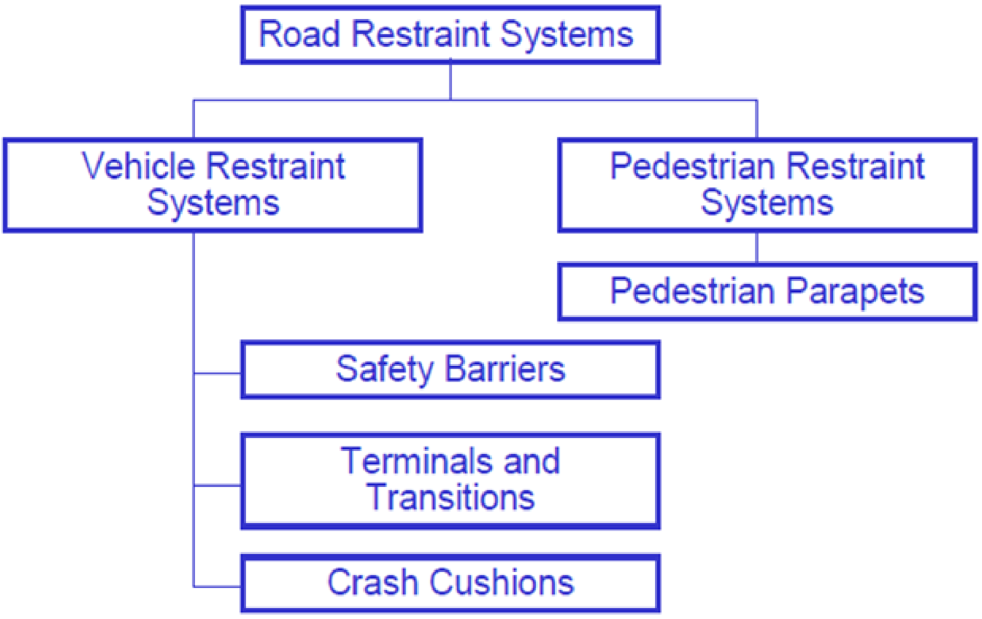


Figure 32 - Classification of Road Restraint Systems

The key purpose of RRS is to protect drivers and passengers of errant vehicles, as well as to prevent collisions with opposing traffic.

The most important group of RRS is safety barriers. These prevent errant vehicles from leaving the roadway and therefore reduce the risk and severity of collisions with hazardous objects. Safety barriers can be installed either on the roadside or in the median.

Safety barriers are categorised in the following three groups, according to their deflection level:

- Rigid
- Semi-rigid
- Flexible

The deformation criteria states that safety barriers should remain intact after an impact and debris should not cause injury or damage to vehicle occupants or other road users. More detailed information is provided in Appendix 1.

The use of safety barriers and other restraint systems is usually subject to national regulations and standards. In Ireland, these standards are covered by NRA TD 19 (for barriers), NRA BD 52 (for parapets) and Series 400 of the NRA Specification.

3.3.1. Rigid Barriers

Rigid barriers are typically of concrete construction. They retain their shape and position when hit by a vehicle, leading to severe impacts. They have the advantage of a small footprint, since they do not deflect. This is particularly important for median installations where the barrier is close to the traffic lane, as shown in Figure 33.

Figure 33 - Examples of rigid median barriers

Typical applications are high speed motorways, where total restraint is required. Rigid barriers show the best performance in terms of containment, but have a higher injury risk.

In Ireland, it is a requirement that all Motorways have concrete barriers in the median; this is required for both road safety and health and safety reasons; as a concrete barrier requires less maintenance then a steel barrier.

3.3.2. Semi-rigid barriers

Semi-rigid barriers are the most common alternative to rigid barriers, as they normally lead to less severe collisions. They are typically of steel construction.

Semi-rigid barriers have two main functions:

- they prevent errant vehicles from leaving the roadway, and
- they absorb the energy of the impact by deformation.

This results in less severe crashes and better performance in terms of redirection. It should be noted that subsequent collisions with other vehicles or obstacles may still occur, due to redirection.

The most commonly used type of semi-rigid barrier is the W-beam, which can be seen in Figure Concrete modular barriers, which can be deformed when hit by a vehicle, are also considered as semi-rigid barriers.

Figure 34 - Typical installations of W-beam semi-rigid barriers

3.3.3. Flexible barriers

Typical examples of flexible barriers are cable barriers and safety fences. Flexible barriers cause the least damage to vehicles and pose the smallest risk of injury to vehicle occupants, compared to all other barrier types. The main disadvantage of flexible barriers is that they require more space behind them, since they can deflect by up to three metres. The slope in the area of deflection should also be flat enough to ensure that the vehicle is redirected safely. Similar to semi-rigid installations, flexible barriers may, however, cause crashes where a vehicle is deflected from a barrier and subsequently collides with another vehicle or obstacle.

In Ireland, NRA TD 19 requires all verge side barriers to have an impact severity rating of A and as such only Flexible and semi-rigid barriers are allowable in the verge. The available working width would normally decide on the type of barrier provided.

In Ireland, Type 2 and 3 roads (2+2 and 2+1 roads) Dual Carriageways would normally require a flexible barrier within the median, however due to increasing maintenance requirements, semi-rigid alternatives are now being considered.

3.3.4. Temporary safety barriers

Temporary barriers (See Figure 35) are mainly used to shield construction sites from traffic. They can be made from steel, concrete or plastic polymers. As temporary barriers cannot be integrated into the road surface as permanent barriers, they do not offer the same level of protection. However, safety at road work sites is influenced by a range of other factors. Traffic speed at these locations is lower (e.g. through speed limits), so the impacts on barriers are initially less severe. Additionally, one or more lanes are usually closed, which results in more careful driver behaviour.

In Ireland, temporary safety barriers are not covered by the National Road Standards, but instead are addressed at a very minimal level by the Ashbourne document and Chapter 8 of the Traffic Signs Manual. It is proposed that greater guidance should be given for National Roads within the NRA Standards

Figure 35 - Common temporary safety barriers (Sources: [B.22], [C.7])

3.3.5. Underriders

Steel safety barriers increase the likelihood of motorcyclists being injured or even killed, when the rider impacts with the vertical post. The problem is that motorcycles have no crush zone to reduce the impact of the vehicle on the barrier and the rider falls off the bike during the crash. Typically, collisions with the posts of barriers are a main factor for injuries, when the rider slides into the restraint system. Other risk sources are the upper and lower edges, as well as too low mounting height.

Motorcyclists can also slide through the barrier and crash into a hazardous object behind. Safety treatments using underriders, which are mounted at the bottom of the barrier, prevent the motorcyclist from passing under the barrier, as well as shielding them from the posts and the barrier edges [B.20]. The use of such underriders should be confined to locations which have a high incidence of motorcycle crashes. Figure 36 provides examples of underriders.

Figure 36 - Example of underriders leading to a continuous shape (Source: [B.20])

It is important to note that any underrider applied to a safety barrier will modify its behaviour. In certain circumstances, they could decrease the overall safety outcome of the protection system. Any barrier with an underrider will, therefore, have to be tested according to EN1317-8 (when available) or to the relevant national standard.

In Ireland, underriders have not been considered and are not addressed in the Standards. It is considered that the negative effect on the road user would outweigh any benefit to the Motorcyclist.

3.3.6. Kerb-barrier combinations

Guidelines for the use of kerbs in conjunction with barriers, as well as research on the safety of kerb-barrier combinations, have been reviewed as part of this report. Research indicates that, in general, barriers should not be installed alongside kerbs. Instead, Clear Zones, free of any roadside obstacles, are recommended. The following issues, as well as their various interactions, need to be carefully considered:

- Kerb height.
- Kerb shape or slope.
- Offset distance from kerb to barrier.
- Barrier type.
- Barrier height.

According to [B.28], the roadside designer should consider a maximum kerb height of 100 mm when installed alongside barriers. The kerb slope should be 1:3 (vertical : horizontal) or flatter. Barriers installed behind kerbs should not be located closer than 2.5 metres for a traffic lane with an operating speed greater than 60 km/h. In some European countries (e.g. Austria), it is common to place the kerb under the barrier, i.e. the kerb is flush with the face of the barrier. Figure 37 depicts a design chart for kerb-barrier combinations. Most roadside design guidelines do not recommend using rigid barriers in combination with kerbs.

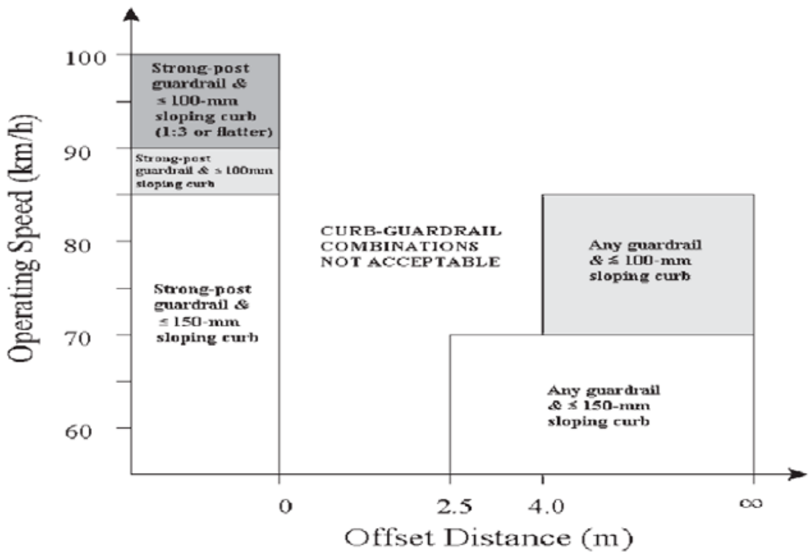


Figure 37 - Kerb-barrier combinations by operating speed and offset distance

In Ireland, the maximum height of kerb in front of a barrier is 80mm, however NRA TD 19 and NRA BD 52 do not address the distance from the kerb to the barrier. It is considered that this issue should be addressed in a future revision of the Standards.

3.3.7. Impact attenuators

Impact attenuators or crash cushions are restraint systems which are used to reduce the consequences of crashes with point objects. Typically, they afford protection in all directions. They should only be used if an appropriate installation for safety barriers is not possible.

Crash cushions can be categorised as follows:

- Multiple plastic boxes, made heavier by internal bags filled with salt, water or foam and connected with steel cables.
- Sack devices, made from synthetic fibre sacks containing cylindrical sink elements, filled with expanded clay, linked together and leaning against lightened steel cusp.
- Valved tubes protected by sliding steel blades and connected with steel cables.

Examples of common impact attenuators are depicted in Figure 38.

Figure 38 - Examples of crash cushions

In Ireland, there are no specific standards requiring the use of crash cushions; however reference is made to EN 1317 Part 3 in NRATD 19 where a crash cushion is required. The need for crash cushions is normally a specific issue e.g. at toll gates, and as such would be addressed in the Contract Documents for the specific scheme.

4. Comparison Between Forgiving Roadsides Treatments and Current Irish NRA DMRB Standards

This Chapter outlines the main recommendations in this CEDR Forgiving Roadsides report, the corresponding Irish NRA DMRB standards and recommended actions to be undertaken over the lifetime of the Government's Road Safety Strategy 2013-2020.

Most of the actions recommended relate to NRA DMRB TD19 standard and, in particular, to issues in relation to the Clear Zone.

The following issues are discussed:

- Clear Zone
- Landscaping
- Passive Safety
- Embankments Gradients
- Drainage
- Hard Shoulder and Edge Drop-off
- Safety Barriers -
  - Motorcycle
  - Kerbs
  - Terminals and Transitions

CEDR Forgiving Roadside Document	Standard Applicable	Standards Extracts	Recommendation/ Conclusion	Action Required
CLEAR ZONE				
The Clear Zone concept The most obvious roadside improvement can be accomplished by providing a so-called Clear Zone (safety zone), i.e. providing an obstacle-free area with a flat and gently graded ground. Removing hazardous roadside features provides motorists with room and opportunity to regain control of their vehicle in case of a run-off. Objects that cannot be eliminated should be relocated outside the Clear Zone. The Clear Zone can be divided into two areas: the recovery zone (shoulders) and the limited severity zone. The width of Clear Zones varies throughout the world depending on the underlying policy and practicability. Within the project RISER, the national dimensions for a Clear Zone of seven different European countries have been determined.	NRA TD 19	2.8 The Clear Zone is the total width of traversable land on the nearside or offside, within the road boundary, which is to be kept clear of unprotected hazards. This width is available for use by errant vehicles. The zone is measured from the nearest edge of the trafficked lane: i.e. the hard shoulder or hard strip forms part of the Clear Zone (see Chapter 4). **3.9** Hazard mitigation measures shall be considered by the Designer prior to designing a safety barrier. A safety barrier shall only be introduced if the hazard cannot be mitigated. The mitigation measures for hazards within the Clear Zone are listed below in order of preference: a) Remove; b) Relocate; c) Re-design the hazard to reduce the risk to road users e.g. introducing a passively safe sign post; d) Revise the road layout or cross-section to lower the risk, e.g. increase the width of the hard shoulder, improve the road alignment, etc.; e) Reduce impact severity (e.g. by using a breakaway feature or by setting a culvert flush with the existing ground); f) Provide a suitable safety barrier.	Although, NRA TD 19 lists the order of preference to have a Clear Zone first, this is normally the most expensive option and therefore D&B jobs result in extensive lengths of Safety Barrier.	Standards Section to investigate changes to NRA TD 19 to make the mitigation preferences a 'shall' instead of a 'should'. And require a departure to install a safety barrier.

<table>
<tr><th>CEDR Forgiving Roadside Document</th><th>Standard Applicable</th><th>Standards Extracts</th><th>Recommendation /Conclusion</th><th>Action Required</th></tr>
<tr><td>CLEAR ZONE</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Common criteria for the dimensioning are:
• Design speed
• Side slope gradients
• Road type
• Traffic flow/volume
• Horizontal alignment (straight or curved roads)
• Driving lane width
• Percentage of heavy-vehicles
• Evaluation of personal and third party risks</td><td>NRA TD 19</td><td><table>
<tr><th></th><th colspan="3">Design Speed (km/h)</th></tr>
<tr><td></td><td>85</td><td>100</td><td>120</td></tr>
<tr><td>Horizontal radius (m)</td><td colspan="3">Required Width of Clear Zone (m)</td></tr>
<tr><td>Inside of bend or Straight</td><td>6.5</td><td>8.0</td><td>10.0</td></tr>
<tr><td>Outside of bend ≥1,000m</td><td>6.5</td><td>8.0</td><td>10.0</td></tr>
<tr><td>" 900m</td><td>7.1</td><td>8.8</td><td>12.4</td></tr>
<tr><td>" 800m</td><td>7.7</td><td>9.6</td><td>14.9</td></tr>
<tr><td>" 700m</td><td>8.3</td><td>10.4</td><td>17.5</td></tr>
<tr><td>" 600m</td><td>8.8</td><td>11.2</td><td>20.0</td></tr>
<tr><td>" 500m</td><td>9.4</td><td>12.0</td><td></td></tr>
<tr><td>" 400m</td><td>10.0</td><td>12.8</td><td></td></tr>
<tr><td>" 300m</td><td>10.6</td><td></td><td></td></tr>
</table>
Table 4/1: Required Clear Zone Width</td><td>The NRA TD 19 required clear zone widths are consistent with good practice in other European Countries.</td><td>No further action required.</td></tr>
</table>

CEDR Forgiving Roadside Document	**Standard Applicable**	**Standards Extracts**	**Recommendation/Conclusion**	**Action Required**
LANDSCAPING				
3.1.3 One major objective of this guideline is to prevent trees from growing in hazardous locations.	A Guide to Landscape Treatments for National Road Schemes in Ireland (NRA, 2006), -------- NRA TD 19	Page 5: In addition, the NRA TD 19 (Part 8A of *NRA Design Manual for Roads and Bridges*) deals with potential obstruction, falling and impacts of hazards within a specified Clear Zone, including potential obstruction, falling and impacts of hazards within a specified Clear Zone, including those relating to the maximum allowable girth of mature trees and many larger shrub species. Page 12: The following provides a summary of the most important policy principles for best practice in the design, preparation, implementation, maintenance and management of landscape treatments on national road schemes. § Clear Zones, identified for the purposes of road safety and appropriate to the design of the road, should be maintained free of all specific hazards, including inappropriate planting. -- *Trees 3.18* When evaluating new plantings or existing trees, the maximum allowable girth should be 175mm measured at 1m above the ground when the tree has matured. When removing trees within the Clear Zone, complete removal of stumps is preferred. However, to avoid significant disturbance of the roadside vegetation, larger stumps may be mitigated by grinding or cutting them flush to the ground and grading around them.	Currently these NRA Landscape Guidelines are only brought in by the Contract and are not mandatory. Recommend making these guidelines a mandatory standard. ____________ NRA TD 19 is more conservative than most European Standards. E.g. 314mm girth in France and a RISER recommendation of 628mm	NRA Environment Section _________ NRA Standards Section to investigate.

CEDR Forgiving Roadside Document	Standard Applicable	Standards Extracts	Recommendation /Conclusion	Action Required
PASSIVE SAFETY				
If hazardous obstacles cannot be removed from the roadside safety zone, they need to be modified in order to minimize injury or property damage at a crash. Poles or supports are commonly made break-away and masonry structures (e.g. walls, curbs or buildings) are made crashworthy. Quite a number of specifications exist to make obstacles more forgiving.	NRA TD 19	3.16 Structures tested and passed as passively safe for the appropriate speed class in accordance with IS EN 12767, Passive Safety of Support Structures for Road Equipment – Requirements and Test Methods, are not considered a hazard. 3.17 The following obstructions within the Clear Zone should be considered as hazards requiring mitigation unless they comply with the above requirements: a) Wooden poles or posts with cross sectional area greater than 22,500mm^2 that do not have breakaway features; b) All fences (including timber post and rail fences) if not being used as a road boundary; c) Tubular steel posts or supports greater than 89mm diameter tube by 3.2mm thick, or equivalent strength; d) Lighting columns; e) Trees having a girth of 175mm or more measured at 1m above the ground; f) Substantial fixed obstacles extending above the ground by more than 150mm; f) Concrete posts with cross sectional area greater than 15,000mm^2; g) Drainage items, such as culvert headwalls and transverse ditches that are not detailed to be traversed safely.	Contractors mostly still choosing to use barrier; may be implications of cost with these systems.	Further investigation needed regarding cost vs. barriers. Again, making a use of barrier as a departure may increase use of these systems.

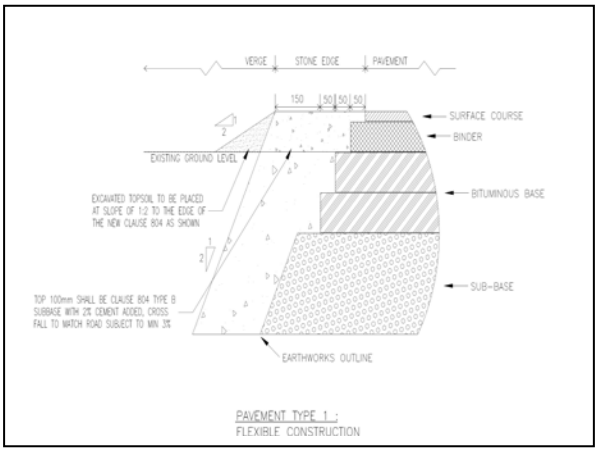
CEDR Forgiving Roadside Document	Standard Applicable	Standards Extracts	Recommendation/ Conclusion	Action Required
EMBANKMENT GRADIENTS				
In many national standard documents, certain side slope treatments are mentioned. In general, the steeper the slope, the higher is the risk for drivers of errant vehicles. Slopes should thus be kept as shallow as possible. For higher traffic volumes, side slopes should be designed with a 6:1 ratio.	NRA TD 19	**Terrain Classes** **4.6** The Terrain Classes are defined as: Class 1: Slope is equal to or less steep than 1:5 (falling) or 1:2 (rising). The area is considered as level terrain. Class 2: Slope steeper than 1:5 (falling). In most cases it is not possible to drive on such a slope without overturning. These areas are considered hazards if it is not possible to remove the risk of overturning.	NRA TD 19 requires a 1:5 embankment within the Clear Zone, to minimise the risk of rollover crashes.	Recommend strengthening the requirement for 1:5 side slopes within the Clear Zone, by requiring a departure for side slopes steeper than 1:5.

CEDR Forgiving Roadside Document	Standard Applicable	Standards Extracts	Recommendation/Conclusion	Action Required
DRAINAGE				
Modify slope ratio: If a ditch cannot be removed, the slopes should be kept as shallow as possible. In general, the steeper the foreslope or backslope, the higher the risk for drivers of errant vehicles. So-called recoverable sideslopes permit the driver to regain control over the vehicle. Recoverable slopes have a slope ratio of 4:1 or flatter. For higher traffic volumes, sideslopes should be designed with a 6:1 ratio. Although the influence of backslopes is generally less than that of foreslopes, a ratio of 3:1 or flatter is recommended. ------------------ If a vehicle runs off the road into a ditch, culvert ends can be hazardous obstacles. If they cannot be removed, safer designs need to be considered. A common treatment for culvert ends is bevelling (see Figure 30).	NRA TD 19 ------- RCD/500/19	**Terrain Classes** **4.6** The Terrain Classes are defined as: Class 1: Slope is equal to or less steep than 1:5 (falling) or 1:2 (rising). The area is considered as level terrain. Class 2: Slope steeper than 1:5 (falling). In most cases it is not possible to drive on such a slope without overturning. These areas are considered hazards if it is not possible to remove the risk of overturning.	NRA TD 19 requires a 1:5 embankment within the Clear Zone, to minimise the risk of rollover crashes. Detail to be included to show bevelled head wall.	Recommend strengthening the requirement for 1:5 side slopes within the Clear Zone, by requiring a departure for side slopes steeper than 1:5. Recommend the Standards section include the new RCD within the latest drainage revisions.

<table>
<tr><th>CEDR Forgiving Roadside Document</th><th>Standard Applicable</th><th>Standards Extracts</th><th>Recommendation /Conclusion</th><th>Action Required</th></tr>
<tr><td>HARD SHOULDER AND EDGE DROPOFF</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shoulder treatments that promote safe recovery include shoulder widening, shoulder paving as well as the reduction of pavement edge drops</td><td>NRA TD 27

NRA Circular 09/11</td><td>3.15 The hard shoulder is provided adjacent to the nearside of the traffic lanes to offer a place to stop in emergencies, clear of mainline traffic. It also provides access for emergency vehicles and additional road space during temporary traffic management. On all-purpose single carriageways, the hard shoulder also provides safe areas for slow moving vehicles to pull over to allow other traffic to overtake.

Hardened Verge is required on Type 2 and 3 Dual Carriageways, where hardened verge is ‘An area of the verge set aside for emergency situations for vehicles to stand or park. The surface should be sufficiently strengthened to support vehicles safely without sinking into the surface.’



(See Figure 28)</td><td>NRA Circular regarding edge drop-off needs to be incorporated into the Standards.</td><td>NRA Standards Section</td></tr>
</table>

CEDR Forgiving Roadside Document	**Standard Applicable**	**Standards Extracts**	**Recommendation/ Conclusion**	**Action Required**
HARD SHOULDER AND EDGE DROPOFF				
If the skid resistance of a paved shoulder is insufficient, treatments to increase surface friction should be applied. Moreover, any other hazardous surface damages such as potholes or cracks need to be eliminated from the shoulder	HD 36	**3.16** The same levels of PSV and AAV must be used on different traffic lanes across the carriageway and in the hard shoulder.	Consistent with report	No Action required

CEDR Forgiving Roadside Document	Standard Applicable	Standards Extracts	Recommendation/Conclusion	Action Required
MOTORCYCLE SAFETY BARRIERS				
Steel safety barriers increase the likelihood of motorcyclists being injured or even killed. Safety treatments are so-called underriders, which are mounted at the bottom of the barrier and prevent the motorcyclist from passing through the barrier, as well as appearing as shielding for posts and edges. Any underrider applied to a safety barrier will modify its behaviour. Under special circumstances, they could decrease the overall safety outcome of the protection system. Any barrier with an underrider will therefore have to be tested according to EN1317-8 (when available)	Not addressed	N/A	Motorcycle underriders affect the barrier performance and would need approximately 3 additional tests per barrier, therefore substantially increasing the cost for an unproven problem and system.	No action required, until further direction given by European Standards.

CEDR Forgiving Roadside Document	Standard Applicable	Standards Extracts	Recommendation/ Conclusion	Action Required
SAFETY BARRIERS - KERBS				
As a general practice, barriers should not be installed alongside kerbs. Instead, Clear Zones free of any roadside obstacles are recommended. The following issues, as well as their various interactions, need to be carefully considered: • Kerb height. • Kerb shape or slope. • Offset distance from kerb to barrier. • Barrier type. • Barrier height. According to [B.28], the roadside designer should consider a maximal kerb height of 100 mm when using alongside barriers. The kerb slope should be 1:3 (vertical : horizontal) or flatter. Barriers installed behind kerbs should not be located closer than 2.5 metres for traffic lane with operating speed greater than 60 km/h. In some European countries (e.g. Austria), it is common to place the kerb under the barrier, i.e. the kerb is flush with the face of the barrier. Figure 37 depicts a design chart for kerb-barrier combinations.	NRA TD 19	**5.42** Kerbs in front of a safety barrier can contribute to the vehicle overturning or ascending the safety barrier. If kerbs in front of the safety barrier cannot be avoided on roads with a Design Speed of 85 km/h or more, the kerbs should be splayed over the full height by at least <u>45°</u> to the vertical and not higher than <u>80 mm</u>.	NRA TD 19 addresses issue of kerb height and is well below recommendation. NRA TD 19 does not make any reference to the allowable distance between the kerb and barrier. Consideration needs to be made regarding kerb camber, reference to rigid barriers and the distance to the barrier.	NRA Standards Section to consider.

CEDR Forgiving Roadside Document	Standard Applicable	Standards Extracts	Recommendation/ Conclusion	Action Required
SAFETY BARRIERS – TERMINALS AND TRANSITIONS				
If the terminals are aimed at stopping the vehicle these have to be treated as energy absorbing devices and have to be tested according to ENV 1317-4. In most reviewed guidelines, a deflection from the traffic lane towards the roadside is an appropriate measure to make terminals forgiving.	NRA TD 19	6.4 Options for terminating barriers in order of preference include: a) Returning the barrier such that the end is buried in a cutting face or bund. b) Ramping the barrier down to ground level, where the terminal is not in the direct line of traffic. c) Terminating at a full height terminal of Performance Class P4 where the terminal is in the direct line of traffic. Terminating barriers described in sections (a) and (b) above shall have a flare of 1:20 away from the road. Direct connections to vehicle parapets shall be considered as transitions (see Chapter 7).	Report considers a tapered terminal more forgiving then a P4 terminal. Consider revising Standard to reflect this. This would have a major cost saving regarding maintenance, however would need the land available.	NRA Standards Section to consider.
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The transition between two safety barriers has to ensure that vehicles slide along the barrier in a smooth way, without any interruption. It also has to be stiff enough to ensure a change.	NRA TD 19	7.6 The design of transitions should be such that changes in Working Width and Containment Level are introduced gradually and evenly along the length of the transition. Additionally the length of the transition should be sufficient to ensure that no significant changes in the dynamic deflection occur over short lengths: a length of at least 10 to 12 times the change in Working Width should normally be provided. Where a transition is made to an immovable barrier, the working width should be assumed to be zero for the purpose of this calculation.	Consistent with report	No Action required

5. Recommendations

Chapter 2 of this report identifies the most common hazards that may be encountered on our road network. These roadside hazards were examined under three different categories - single fixed objects, continuous hazards and dynamic roadside hazards.

Chapter 3 considered the various Forgiving Roadside treatments that may be applied in order to improve roadside safety. The key recommendations identified include the following:

Removing and Relocating Obstacles.

- The Clear Zone concept.
- Arrester beds in lane diverge areas.
- Safe plantation.
- Roundabouts.

Modifying Roadside Elements.

- Breakaway devices.
- Ditch and slope treatments.
- Route-Based Curve Treatments
- Crashworthy masonry structures.
- Shoulder modifications.
- Modification of retaining walls and rock cuts.
- Safety barrier terminals.
- Safety barrier transitions.

Shielding Obstacles.

- Rigid barriers.
- Semi-rigid barriers.
- Flexible barriers.
- Temporary safety barriers.
- Underriders.
- Kerb-barrier combinations.
- Impact attenuators.

As stated in Chapter 3, the most effective roadside improvement can be accomplished by providing a Clear Zone. The creation of a Clear Zone can significantly reduce the severity of a roadside crash by providing an obstacle-free area which gives a motorist room and opportunity to regain control of a vehicle in the case of a run-off. However, Clear Zones cannot always be provided for various reasons, particularly at locations where there are space limitations, and alternative treatments will have to be considered in such circumstances.

The report recommends that the following approaches should be adopted for the implementation of Forgiving Roadside treatments on new roads and existing roads.

5.1. New Roads

A key recommendation of this report is that new national roads should be designed to provide a more forgiving roadside environment for errant vehicles.

This can best be achieved through the provision of a Clear Zone. Clear Zones should be kept free of hazards and any signage located in the zone should be frangible.

The incorporation of the strategies and treatments identified in Chapter 3 of this report into new scheme designs will help to make new roads safer for all road users. Accordingly, new designs should typically provide that:

- sufficient land is identified at design stage to accommodate the Clear Zone.
- the side slopes in the Clear Zone are 'forgiving', to allow for driver error.
- objects should not be placed in the Clear Zone, if possible,
- where it is not possible to avoid placing an object in the Clear Zone e.g. road signs, the poles or posts should be 'forgiving',
- 'unforgiving' objects are shielded by the provision of safety barriers.

5.2. Existing Road Network

There are currently over 5,500 km of national roads, of which over 2,000 km are 'legacy' roads, i.e. roads which have not benefitted from the major national road improvement that was undertaken over the last decade, and which have not, therefore, been designed to current standards.

A feature of many 'legacy' national roads is the presence of stone walls, ditches and trees on the roadside.

The provision of Clear Zones on these 'legacy' roads will not always be feasible due to space limitations and other considerations. Alternative treatments, as outlined in Chapter 3, will, therefore, need to be considered.

Typically, appropriate roadside treatments that should be considered on the existing road network, where it is not possible to provide a Clear Zone, would include some or all of the following measures:

- identification of priority locations for roadside treatment,
- a programme of Route-Based Curve Treatments to provide consistent signage at bends to alert drivers of the bend severity,
- the removal, where possible, of hazardous objects in the roadside.
- the treatment, through the use of safety barriers and/or other appropriate measures discussed in Chapter 3, of hazardous objects that cannot be removed from the roadside.

6. Conclusion

Road safety has always been the foremost consideration in the design of new road schemes in Ireland. The adoption by Government of the Safe Systems approach to road safety during the period of the Road Safety Strategy 2013 - 2020 demonstrates the Government's continued commitment to strive to reduce the number of fatalities and serious injuries on Irish roads.

The aim of roadside safety management is to provide a forgiving area on both sides of the carriageway that will minimise the likelihood and severity of run-off road crashes. In the context of safe system objectives, this would translate to road design practice that aims to provide roadsides that minimise the risk of death or serious injury as a result of a road departure by an errant vehicle.

It is, of course, the case that road crashes cannot be eliminated – an unfortunate fact that forms the underlying basis of the Safe Systems concept. However, it is incumbent on everyone involved in road design, construction and maintenance to continue to seek new ways to improve road safety and to minimise the occurrences of crashes on our roads.

This report demonstrates that, through the sharing of information and research, road authorities in the international community can co-operate to develop new and innovative solutions to mitigate the impacts of crashes on our roads.

The implementation of the Forgiving Roadside strategies outlined in this report, which have been developed following extensive consultation with international road safety experts, will provide a safer and more forgiving environment to cater for incidents involving errant vehicles.

The challenge is to put in place appropriate strategies and programmes to make roads safer for all road users. This can be achieved through the development and implementation of appropriate road design standards and procedures, together with a comprehensive Road Safety Audit / Road Safety Inspection programme. Together, these measures can play a very significant role in implementing the concept of Forgiving Roadsides in the design of new roads or realignment of existing roads.

The key recommendations set out in Chapter 5 have been determined based on international road safety best practice. The implementation of these roadside treatments, which involve,

a) minimising the risk of vehicles leaving the carriageway (e.g. through improved delineation),

b) providing adequate recovery space when vehicles do run off the road and

c) ensuring that any collision that does occur in the roadside is with objects that limit/reduce the impact forces on vehicle occupants to minor levels (no fatal or serious injury outcomes),

will save lives.

It is, however, recognised that the implementation of appropriate treatments throughout the national road network will take time to deliver and will be largely dependent upon the availability of financial resources. It will, therefore, be necessary to prioritise works, though a targeted programme, at those locations on the network where roadside hazards have been identified.

References

A. Scientific reports and research papers

[A.1] P. Waugh. Forgiving Roadsides – A Way Forward. Paper presented in *Road Safety: Gearing up for the future*. Perth, WA, August 2001

[A.2] RISER consortium. *D06: European Best Practice for Roadside Design: Guidelines for Roadside Infrastructure on New and Existing Roads*. RISER deliverable, February 2006

[A.3] RISER consortium. *D05: Summary of European Design Guidelines for roadside infrastructure*. RISER deliverable, February 2005

[A.4] G. Dupre and O. Bisson. *Recovery zone*. RISER Seminar on Safer Roadside Engineering. Budapest, Hungary, November 30, 2005

[A.5] S. Matena et al. *Road Design and Environment – Best practice on Self-explaining and Forgiving Roads.* RIPCORD-ISEREST deliverable D3, 2005

[A.6] L. Herrstedt. *Self-explaining and Forgiving Roads – Speed management in rural areas*. Paper presented in ARRB Conference, October 2006

[A.7] Roads and Traffic Authority NSW. Fatal Roadside Object Study in *Road Environment Safety Update 20*. New South Wales, Australia, March 2004

[A.8] N.J. Bratton and K.L. Wolf. Trees and Roadside Safety in U.S. Urban Settings. In *Proceedings of the 84th Annual Meeting of the Transportation Research Board*. Washington D.C., USA, January 2005

[A.9] K.K. Mak and R.L. Mason. *Crash Analysis – Breakaway and Non-Breakaway Poles Including Sign and Light Standards Along Highways*. FHWA, August 1980

[A.10] FEMA. Final report of the Motorcyclists & Crash Barriers Project. Belgium

[A.11] J.C. Sutts and W.W. Hunter. *Injuries to Pedestrians and Bicyclists: An Analysis Based on Hospital Emergency Department Data*. FHWA, Washington D.C., USA, 1999

[A.12] R. Elvik and T. Vaa. The Handbook of Road Safety Measures. Emerald Group Pub Norway, 2004

[A.13] L. Rens. *Brief Overview and Latest Developments concerning EN Standards on Road Restraint Systems.* Technical seminar on concrete safety barriers in Brussels, June 2009

[A.14] N. Stamatiadis, J. Pigman. Impact of Shoulder Width and Median Width on Safety. In *NCHRP Report 633*. Washington D.C., USA, 2009

[A.15] G. Camomilla: *Una rivoluzione necessaria: la trasformazione dei bordi laterali stradali "Le Strade" Magazine 7-8-2008*

[A.16] AITEC :*Cemento e sicurezza; impieghi stradali* CD December 2006

[A.17] R. Thomson, J. Valtonen. Vehicle Impacts in V Ditches. In *Transportation Research Record 1797*. Pages 82-88. 2002

[A.18] Marko Kelkka. Safety of Roadside Area. Analysis of full-scale crash tests and simulations. Finnish Road Administration, Central Administration. Finnra reports 10/2009, 161 p. + app. 5 p. ISSN 1459-1553, ISBN 978-952-221-142-2, TIEH 3201124E-v, Helsinki 2009

[A.19] Austroads Ltd. *Improving Roadside Safety: Summary Report*, ISBN 978-1-925037-48-7, February 2014

[A.20] Jorge Mijangos Linaza and Lidia Hipólito de Gregorio*. Improving the safety of cut highways. OASIS project research.* Proceeding of 17th IRF World Meeting & Exhibition, Riyadh, Saudi Arabia (November 9 - 13, 2013)

[A.21] Austroads Ltd. *Method of Reducing Speeds on Rural Roads – Compendium of Good Practice AP-R449-14,* March 2014

B. Standards and guidelines

[B.1] AASHTO. Roadside Design Guide. 3rd edition, March 2002

[B.2] Alberta Ministry of Infrastructure and Transportation. *Roadside Design Guide*. Alberta, Canada, November 2007

[B.3] T.R. Neuman et al. *Volume 3: A Guide for Addressing Collisions with Trees in Hazardous locations*. NCHRP Report 500. Washington D.C., USA, 2003

[B.4] Transportation Research Board. *Safe and Aesthetic Design of Urban Roadside Treatments*. In NCHRP Report 612. Washington D.C., USA, 2008

[B.5] Government of Western Australia. *Main Roads Western Australia Assessment of Roadside Hazards*. Technology and Environment Directorate. Western Australia, May 2007

[B.6] R.W. Eck and H.W. McGee. *Vegetation Control for Safety, A Guide for Local Highway and Street Maintenance Personnel*. Federal Highway Administration (FHWA). U.S. Department of Transportation, August 2008

[B.7] W.J. Fitzgerald. *W-Beam Guardrail Repair: A Guide for Highway and Street Maintenance Personnel*. Federal Highway Administration (FHWA). U.S. Department of Transportation, November 2008

[B.8] H.W. McGee and D. Nabors and T. Baughman. *Maintenance of Drainage Features for Safety, A Guide for Local Street and Highway Maintenance Personnel*. U.S. Department of Transportation, July 2009

[B.9] L. Patte et al. *Handling lateral obstacles on main roads in open country*. Sétra Guidelines. November 2002. Translated August 2007

[B.10] EN 12767, Passive Safety of support structures for road equipment – Requirements and test methods

[B.11] EN 1317-1, Road restraint systems - Part 1: Terminology and general criteria for test methods

[B.12] EN 1317-2, Road restraint systems - Part 2: Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets

[B.13] ENV 1317-4, Road restraint systems — Part 4: Performance classes, impact test acceptance criteria and test methods for terminals and transitions of safety barriers; prEN 1317-4, Road restraint systems − Part 4: Performance classes, impact test acceptance criteria and test methods for transitions of safety barriers (under preparation: this document will supersede ENV 1317-4 for the clauses concerning transitions)

[B.14] EN 1317-5, Road restraint systems − Part 5: Product requirements and evaluation of conformity for vehicle restraint systems

[B.15] EN 1317-7, Road restraint systems − Part 7: Performance classes, impact test acceptance criteria and test methods for terminals of safety barriers (under preparation: this document will supersede ENV 1317-4 for the clauses concerning terminals)

[B.16] Vägar och Gators Utforming (VGU). Road and Street Design. 2004

[B.17] U.S. Department of Transportation. *Roadside improvements for local roads and streets.* Federal highway administration, USA, October 1986

[B.18] EN 1317-8, Road restraint systems - Part 8: Motorcycle road restraint systems which reduce the impact severity of motorcyclist collisions with safety barriers (under preparation)

[B.19] EN 1317-3, Road restraint systems - Part 3: Performance classes, impact test acceptance criteria and test methods for crash cushions

[B.20] FGSV. *Merkblatt zur Verbesserung der Verkehrssicherheit auf Motorradstrecken (MVMot)* R2. Ausgabe 2007, Germany

[B.21] RVS 03.03.31 Querschnittselemente Freilandstraßen, 2005, Austria

[B.22] Tasmania Department of Infrastructure, Energy and Resource. *Road Hazard Management Guide,* 2004

[B.23] EN 1317-6, Road restraint systems − Pedestrian restraint systems — Part 6: Pedestrian Parapet (under preparation)

[B.24] AASHTO. A Policy on Geometric Design of Highways and Streets (5th Edition). 2004

[B.25] Belgian median barrier on National Roads

[B.26] ANAS - Linee guida per le protezioni di sicurezza passiva Ed. 2010

[B.27] B.A.S.T. Road Safety Equipment and Steel Barrier Systems

[B.28] Transportation Research Board. *Recommended Guidelines for Curb and Curb-Barrier Installations*. In NCHRP Report 537. Washington D.C., USA, 2005

[B.29] UNI TR 11370 "Dispositivi stradali di sicurezza per motociclisti - Classi di prestazioni, modalità di prova e criteri di accettazione"

[B.30] National Roads Authority, Ireland *Safety Barriers,* NRA DMRB TD 19/12, 2012

[B.31] Guidelines for the Application of Special Speed Limits, Department of Transport, Tourism and the Arts, (Dec. 2010)

C. Web references

[C.1] Insurance Institute for Highway Safety. Fatality Facts 2008, *Roadside hazards*. Taken from http://www.iihs.org/research/fatality_facts_2008/roadsidehazards.html, visited at 25/02/2010

[C.2] http://www.car-accidents.com/guardrail-accidents.htm, visited at 03/03/2010

[C.3] Wikipedia. Runaway truck ramp. Taken from http://en.wikipedia.org/wiki/Runaway_truck_ramp, visited at 19/07/2010

[C.4] CSP Pacific. Taken from www.csppacific.co.nz, visited at 21/07/2010

[C.5] Texas Department of Transportation. *Highway Illumination Manual.* Taken from http://onlinemanuals.txdot.gov/txdotmanuals/hwi/manual_notice.htm, visited at 21/07/10

[C.6] Metropolitan Forestry Consultants, Inc. http://www.metroforestry.com/resources/RoadsideTrees1.jpg, visited at 09/08/2010

[C.7] http://intermountain.construction.com/images/2009/07_indNews_PlasticBarriers.jpg, visited at 09/08/2010

[C.8] Irish Speed Limit Review 2013 http://www.dttas.ie/roads/publications/english/speed-limit-review-2013 visited on 4th April 2014

[C.9] CEDR Forgiving Roadsides http://www.cedr.fr/home/fileadmin/user_upload/Publications/2013/T10_Forgiving_roadsides.pdf visited on 30th April 2014

ANNEX A - Glossary

Arrester bed

An area of land adjacent to the roadway filled with a particular material to decelerate and stop errant vehicles; generally located on long steep descending gradients.

Back slope (see ditch)

A slope associated with a ditch, located opposite the roadway edge, beyond the bottom of the ditch.

Boulder

A large, rounded mass of rock lying on the surface of the ground or embedded in the soil in the roadside, normally detached from its place of origin.

Break-away support

A sign, traffic signal or luminaire support designed to yield or break when struck by a vehicle.

Abutment

The end support of a bridge deck or tunnel, usually retaining an embankment.

Vehicle parapet (on bridges)

A longitudinal safety barrier whose primary function is to prevent an errant vehicle from going over the side of the bridge structure. It can be constructed from either steel or concrete.

CCTV Masts

A mast on which a closed circuit television camera is mounted for the purpose of traffic surveillance.

Carriageway

The definition of the ‘carriageway’ differs slightly amongst countries. The edge of the carriageway is delineated by either the “edge line” or, if no edge line is present, the edge of the paved area.

Central reserve

An area separating the carriageways of a dual carriageway road.

Clearance

The unobstructed horizontal dimension between the front side of safety barrier (closest edge to road) and the edge of the carriageway.

Clear/Safety zone

The area, starting at the edge of the carriageway, that is clear of hazards. This area may consist of none or any combination of the following: a ‘hard strip’, a ‘shoulder’, a recoverable slope, a non-recoverable slope, and a clear run-out area. The desired width is dependent upon the traffic volumes, speeds and on the roadside geometry.

Contained vehicle

A vehicle which comes in contact with a road restraint system and does not pass beyond the limits of the safety system.

Containment level

The description of the standard of protection offered to vehicles by a road restraint system. In other words, the Containment Performance Class Requirement that the object has been manufactured and tested to (EN 1317).

Crash cushion

A road vehicle energy absorption device (road restraint system) installed in front of a rigid object to contain and redirect an impacting vehicle (''redirective crash cushion'') or to contain and capture it (''non-redirective crash cushion'').

Culvert

A structure to channel a water course. Can be made of concrete, steel or plastic.

Culvert end

The end of the channel or conduit, normally a concrete, steel or plastic structure.

Cut slope

The earth embankment created when a road is excavated through a hill, which slopes upwards from the level of the roadway.

Design speed

The speed which determines the layout of a new road in plan, being the speed for which the road is designed, taking into account anticipated vehicle speed on the road.

Distributed hazards

Also known as 'continuous obstacles', distributed hazards are hazards which extend along a length of the roadside, such as embankments, slopes, ditches, rock face cuttings, retaining walls, safety barriers not meeting current standard, forest and closely spaced trees.

Ditch

Ditches are drainage features that run parallel to the road. Excavated ditches are distinguished by a fore slope (between the road and the ditch bottom) and a back slope (beyond the ditch bottom and extending above the ditch bottom).

Divided roadway

Roadway where the traffic is physically divided with a central reserve and/or road restraint system. Number of travel lanes in each direction is not taken into account. See also 'dual carriageway'.

Drainage gully

A structure to collect water running off the roadway.

Drop-off

The vertical thickness of the asphalt protruding above the ground level at the edge of the paved surface.

Dual carriageway

A divided roadway with two or more travel lanes in each direction, where traffic is physically divided with a central reserve and/or road restraint system. See also 'divided roadway'.

Edge line

Road markings that can be positioned either on the carriageway surface itself at the edge of the carriageway, or on the 'hard strip' (if present) next to the carriageway.

Embankment

A general term for all sloping roadsides, including cut (upward) slopes and fill (downward) slopes (see 'cut slope' and 'fill slope').

Encroachment

A term used to describe the situation when the vehicle leaves the carriageway and enters the roadside area.

Energy absorbing structures

Any type of structure which, when impacted by a vehicle, absorbs energy to reduce the speed of the vehicle and the severity of the impact.

Fill slope

An earth embankment created when extra material is packed to create the road bed, typically sloping downwards from the roadway.

Frangible

A structure readily or easily broken upon impact (see also ‘break-away support’).

Fore slope (see ditch)

The fore slope is a part of the ditch, and refers to the slope beside the roadway, before the ditch bottom.

Forgiving roadside

A forgiving roadside mitigates the consequence of the “run-off” type crashes and aims to reduce the number of fatalities and serious injuries from these events.

Guardrail

A guardrail is another name for a metal post and rail safety barrier.

Hard/Paved shoulder

An asphalt or concrete surface on the nearside of the carriageway. If a ‘hard strip’ is present, the hard shoulder is immediately adjacent to it, but otherwise, the shoulder is immediately adjacent to the carriageway. Shoulder pavement surface and condition as well as friction properties are intended to be as good as that on the carriageway.

Hard strip

A strip, usually not more than 1 metre wide, immediately adjacent to and abutting the nearside of the outer travel lanes of a roadway. It is constructed using the same material as the carriageway itself, and its main purposes are to provide a surface for the edge lines, and to provide lateral support for the structure of the travel lanes.

Highway

A highway is a road for long-distance traffic. Therefore, it could refer to either a motorway or a rural road.

Horizontal alignment

The projection of a road - particularly its centre line - on a horizontal plane.

Impact angle

For a longitudinal safety barrier, it is the angle between a tangent to the face of the barrier and a tangent to the vehicle’s longitudinal axis at impact. For a crash cushion, it is the angle between the axis of symmetry of the crash cushion and a tangent to the vehicle’s longitudinal axis at impact.

Undivided roadway

A roadway with no physical separation, also known as single carriageway.

Unpaved shoulder

See 'soft shoulder'.

Vehicle restraint system

A device used to prevent a vehicle from striking objects outside of its travelled lane. This includes for example safety barriers, crash cushions, etc. These are classified as a group of restraint systems under 'road restraint systems'.

Verge

An unpaved level strip adjacent to the shoulder. The main purpose of the verge is drainage and to provide a Clear Zone, and in some instances can be lightly vegetated. Additionally, road equipment such as safety barriers and traffic signs are typically located on the verge.

Vertical alignment

The geometric description of the roadway within the vertical plane.

Impact attenuators

A roadside (passive safety) device which helps to reduce the severity of a vehicle impact with a fixed object. Impact attenuators decelerate a vehicle both by absorbing energy and by transferring energy to another medium. Impact attenuators include crash cushions and arrester beds.

Kerb (Curb)

A unit intended to separate areas of different surfacings and to provide physical delineation or containment.

Lane line

On carriageways with more than one travel lane, the road marking between the travel lanes is called the 'lane line'.

Limited severity zone

An area beyond the recovery zone that is free of obstacles in order to minimize severity in case of a vehicle run-off.

Length of need

The total length of a longitudinal safety barrier needed to shield an area of concern.

Median

See ‘central reserve’.

Motorways

A dual carriageway road intended solely for motorized vehicles, and provides no access to any buildings or properties. On the motorways itself, only grade separated junctions are allowed at entrances and exits.

Nearside

A term used when discussing right and left hand traffic infrastructure. The side of the roadway closest to the vehicle's travelled way (not median).

Non-paved surface

A surface type that is not asphalt, surface dressing or concrete (e.g. grass, gravel, soil, etc).

Offside

A term used when discussing right and left hand traffic infrastructure. The side of the roadway closest to opposing traffic or a median.

Overpass

A structure, including its approaches, which allows one road to pass above another road (or an obstacle).

Paved shoulder

See ‘hard shoulder’.

Pedestrian restraint system

A system installed to provide guidance for pedestrians, and classified as a group of restraint systems under ‘road restraint systems’.

Pier

An intermediate support for a bridge.

Point Hazard

A narrow item on the roadside that could be struck in a collision, including trees, bridge piers, lighting poles, utility poles, and sign posts.

Recovery zone

A zone beside the travel lanes that allows avoidance and recovery manoeuvres for errant vehicles.

Rebounded vehicle

A vehicle that has struck a road restraint system and then returns to the main carriageway.

Retaining wall

A wall that is built to resist lateral pressure, particularly a wall built to support or prevent the advance of a mass of earth.

Road restraint system (RRS)

The general name for all vehicle and pedestrian restraint systems used on the road (EN 1317).

Road equipment

The general name for structures related to the operation of the road and located in the roadside.

Road furniture

See 'road equipment'.

Roadside

The area beyond the roadway.

Roadside hazards

Roadside hazards are fixed objects or structures endangering an errant vehicle leaving its normal path. They can be continuous or punctual, natural or artificial. The risks associated with these hazards include high decelerations to the vehicle occupants or vehicle rollovers.

Roadway

The roadway includes the carriageway and, if present, the hard strips and shoulders.

Rock face cuttings

A rock face cutting is created for roads constructed through hard, rocky outcrops or hills.

Rumble strip (Shoulder rumble strips)

A thermoplastic or milled transverse marking with a low vertical profile, designed to provide an audible and/or tactile warning to the road user. Rumble strips are normally located on hard shoulders and the nearside travel lanes of the carriageway. They are intended to reduce the consequences of, or to prevent run-off road events.

Rural roads

All roads located outside urban areas, not including motorways.

Safety barrier

A road vehicle restraint system installed alongside or on the central reserve of roads.

Safety zone

See 'Clear Zone'.

Self-explaining road

Roads designed according to the design concept of self-explaining roads. The concept is based on the idea that roads with certain design elements or equipment can be easily interpreted and understood by road users. This delivers a safety benefit as road users have a clear understanding of the nature of the road they are travelling on, and will therefore expect certain road and traffic conditions and can adapt their driving behaviour accordingly. (Ripcord-Iserest, Report D3, 2008).

Set-back

Lateral distance between the way and an object in the roadside for clearance).

Shoulder

The part of the roadway between the carriageway (or the hard strip, if present) and the verge. Shoulders can be paved (see 'hard shoulder') or unpaved (see 'soft shoulder'). Note: the shoulder may be used for emergency stops in some countries; in these countries it comprises the hard shoulder for emergency use in the case of a road with separate carriageways.

Single carriageway

See 'undivided roadway'.

Slope

A general term used for embankments. It can also be used as a measure of the relative steepness of the terrain expressed as a ratio or percentage. Slopes may be categorized as negative (fore slopes) or positive (back slopes) and as parallel or cross slopes in relation to the direction of traffic.

Soft/Unpaved shoulder

A soft shoulder is defined as being a gravel surface immediately adjacent to the carriageway or hard strip (if present). In some countries it is used as an alternative for hard shoulders.

Soft strip

A narrow strip of gravel surface located in the roadside, beyond the roadway (normally beyond a hard strip/shoulder).

Termination (barrier)

The end treatment for a safety barrier, also known as a terminal. It can be energy absorbing structure or designed to protect the vehicle from going behind the barrier.

Transition

A vehicle restraint system that connects two safety barriers of different designs and/or performance levels.

Travel/Traffic lane

The part of the roadway/carriageway that is travelled on by vehicles.

Treatment

A specific strategy to improve the safety of a roadside feature or hazard.

Underpass

A structure (including its approaches) which allows one road or footpath to pass under another road (or an obstacle).

Underrider

A motorcyclist protection system installed on a road restraint system, with the purpose to reduce the severity of a PTW rider impact against the road restraint system.

Appendix 1

Summaries of EN documents (EN 1317 parts 1 to 8 and EN 12767)

The European Standard **EN 1317** consists of the 8 parts (some are under preparation).

- EN 1317-1, *Road restraint systems - Part 1: Terminology and general criteria for test methods*;
- EN 1317-2, *Road restraint systems - Part 2: Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets*;
- EN 1317-3, *Road restraint systems - Part 3: Performance classes, impact test acceptance criteria and test methods for crash cushions*;
- ENV 1317-4, *Road restraint systems — Part 4: Performance classes, impact test acceptance criteria and test methods for terminals and transitions of safety barriers*;
- prEN 1317-4, *Road restraint systems − Part 4: Performance classes, impact test acceptance criteria and test methods for transitions of safety barriers* (under preparation: this document will supersede ENV 1317-4 for the clauses concerning transitions)*;*
- EN 1317-5, *Road restraint systems − Part 5: Product requirements and evaluation of conformity for vehicle restraint systems*;
- prEN 1317-6, *Road restraint systems − Pedestrian restraint systems — Part 6: Pedestrian Parapet* (under preparation);
- prEN 1317-7, *Road restraint systems − Part 7: Performance classes, impact test acceptance criteria and test methods for terminals of safety barriers* (under preparation: this document will supersede ENV 1317-4 for the clauses concerning terminals);
- prEN 1317-8, *Road restraint systems - Part 8: Motorcycle road restraint systems which reduce the impact severity of motorcyclist collisions with safety barriers* (under preparation).

EN12767
Passive Safety of support structures for road equipment – Requirements and test methods

<u>EN1317-1</u>

Introduction:

In order to improve and maintain highway safety, the design of safer roads requires, on certain sections of road and at particular locations, the installation of road restraint systems to restrain vehicles and pedestrians from entering dangerous zones or areas. The road restraint systems designated in this standard are designed to specify performance levels of containment and to redirect errant vehicles and to provide guidance for pedestrians or other road users.

The standard identifies impact test tolerances and vehicle performance criteria that need to be met to gain approval. The design specification for road restraint systems entered in the test report should identify the on-road site conditions under which the road restraint system should be installed.

The performance range of restraint systems designated in this standard enables National and Local Authorities to recognize and specify the performance class to be deployed. The range of possible vehicular impact scenarios in an on-road road restraint system is extremely large in terms of speed, approach angle, vehicle type, vehicle attitude, and other vehicle and road conditions. Consequently the actual on-road impacts which occur may vary considerably from the specific standard test conditions. However, adequate implementation of the standard should identify the characteristics in a candidate safety road restraint system that is likely to achieve maximum safety and reject those features which are unacceptable.

Manufacturers may wish to modify their products following the test and clause no. 5.2, 6.2.1.5 and Annex A in EN 1317-5: 2006 set out the procedure to be followed.
Manufacturers may wish to place their products in Families, as system type tested products, and clauses 4.7 in EN 1317-2: 2010, 5.5 in EN 1317-3: 2010 and in ENV 1317-4: 2002 set out the procedure to be followed.
The modifications included in this part of the standard are not a change of test criteria, in the sense of the Annex ZA.3 of Part 5.

Scope:

This standard contains provisions for the measurement of performance under impact and impact severity levels and includes:

- Test site data
- Definitions for road restraint systems; other parts of the standard may add to these
- Vehicle specifications including loading requirements for vehicles used in the impact tests
- Instrumentation for the vehicles
- Calculation procedures and methods of recording crash impact data including impact severity levels
- VCDI mandated measurements (VCDI is not a mandated requirement)
- Informative Annexes

EN1317-2

Introduction:

This standard includes improved impact test procedures and allows for the introduction of Families of Products and a Part 2 report template.

In order to improve safety the design of roads may require the installation of safety barriers including parapets which are intended to contain and redirect errant vehicles safely for the benefit of the occupants and other road users on sections of road and at particular locations defined by the National or Local Authorities.

In this standard, several levels of performance are given for the three main criteria relating to the restraint of a road vehicle:

- the containment level;
- the impact severity level;
- the deformation as expressed by the working width.

The different performance levels of safety barriers including parapets will enable National and Local Authorities to specify the performance class of the system to be deployed. Factors to be taken into consideration include the class or type road, its location, geometrical layout, the existence of a vulnerable structure, potentially hazardous area or object adjacent to the road.

The description of a safety barrier including parapet system conforming to this Standard incorporates the relevant classes and performance levels of the product.

To ensure satisfactory product design it is imperative to consider the requirements of this standard and the references in clause 2, together with the requirements of EN 1317-1: 2010. Quality of manufacture, installation and durability must fulfill the requirements of EN 1317-5:2006.

Manufacturers may wish to modify their products following the ITT and clause nos. 5.2, 6.2.1.5 and Annex A in EN 1317-5:2006 set out the procedure to be followed. The modifications included in this part of the standard are not a change of test criteria, in the sense of the Annex ZA.3 of Part 5.

Scope:

This European standard shall be read in conjunction with EN 1317-1. These two standards support EN 1317-5.

This standard specifies requirements for:

- Impact performance of safety barriers and vehicle parapets
- Classes of containment and impact severity levels

EN1317-3

Introduction:

Based on safety considerations, the design of roads may require the installation of crash cushions at certain locations. These are designed to reduce the severity of vehicle impact with a more resistive object.

One objective of this standard is to lead to the harmonisation of current national standards and/or regulations for crash cushions and to categorize them into performance classes.

The standard specifies the levels of performance required of crash cushions for the restraint and/or redirection of impacting vehicles. The impact severity of vehicles in collision with crash cushions is rated by the indices Theoretical Head Impact Velocity (THIV) and Acceleration Severity Index (ASI) (see EN 1317-1).

The different performance levels will enable national and local authorities to specify the performance class of crash cushions. The type or class of road, its location, its geometrical layout, the existence of a vulnerable structure or potentially hazardous area adjacent to the road are factors to be taken into consideration.

Attention is drawn to the fact that the acceptance of a crash cushion will require the successful completion of a series of tests (see Table 1, 2, 3, etc.).

This European Standard is a supporting standard to EN 1317-5, which shall be read in conjunction with EN1317-1. Manufacturers may wish to modify their products following the ITT, and clause numbers 5.2, 6.2.1.5 and Annex A in EN1317-5 set out the procedure to be followed.

The modifications included in this part of the standard are not a change of test criteria, in the sense of the Annex ZA.3 of Part 5.

Scope:

This European Standard specifies requirements for the performance of crash cushions from vehicle impacts. It specifies performance classes and acceptance criteria for impact tests.

ENV1317-4

This is a preliminary standard which was aimed at specifying test methods for terminals and transitions. This standard has been discharged and will be replaced by EN 1317-4 for transitions and EN1317-7 for terminals. Until the new EN1317-4 and EN1317-7 will be published ENV1317-4 is commonly used for testing energy absorbing terminals.

prEN1317-4

Introduction:

In order to improve safety the design of roads may require the installation of safety barriers including parapets which are intended to contain and redirect errant vehicles safely for the benefit of the occupants and other road users on sections of road and at particular locations defined by the National or Local Authorities. Problems may also arise in the connection between two different safety barriers having consistent difference in design and/or in stiffness. Transitions are required to provide a smooth and safe change from one barrier to the other.

This Standard was unable to get the full support of the CEN 226 Committee and as such has not been published. Several European Countries, including Ireland, are still referring to the previous version of the Standard ENv 1317 Part 4, which specifies the direction of impact, and the methods for determining the critical impact points, for the testing of transitions.

Methods for designing transitions without specific crash tests have been looked at for the revised standard and would have been included in the standard as well as criteria to apply tested transitions to different products without the need for repeating the crash tests.

Scope:

This European Standard is therefore currently not a supporting standard to EN1317-5 but can be read in conjunction with EN1317-1.

This Part completes Part 2 of the standard because it specifies performance for transitions, considered as the linkage between safety barriers of different types.

This Standard also defines acceptance criteria for impact tests and test methods.

EN1317-5

Introduction:

This document is a product standard for vehicle restraint systems placed on the market.

This document is designed for use in conjunction with Parts 1, 2, 3, prEN 1317-6 or ENV 1317-4. To ensure the full performance of road restraint systems in use, their production and installation is intended to be controlled in accordance with this document.

Scope:

This standard includes requirements for the evaluation of conformity of the following road restraint systems produced:

- safety barriers;
- crash cushions;
- terminals (will be effective when ENV 1317-7 becomes an EN);
- transitions (will be effective when ENV 1317-4 becomes an EN);
- Vehicle / Pedestrian Parapets (only for the vehicle restraint function)

Pedestrian parapet requirements are not covered in this standard.

Requirements for the evaluation of durability with respect to weathering are included in this standard.

Requirements for other forms of durability (e.g. Marine environment, sand abrasion) are not included.

Temporary barriers are not within the scope of this standard.

prEN1317-6

Introduction:

The safety considerations of pedestrians using road bridges and footbridges and similar structures that require the installation of special road restraint systems: pedestrian parapets.

Pedestrian parapets are provided and designed to restrain and to guide pedestrians and other non-vehicle road users including cyclists and equestrians.

Aspects included in the standard are:

- Safety in use for pedestrians and other highway users (excluding motor vehicles),
- The safety considerations of pedestrians using road bridges and footbridges and similar structures
- Analysis and test methods,
- Durability,
- Evaluation of the Conformity.

Scope:

This European Standard EN 1317-6 specifies geometrical and technical requirements and defines the requirements for design and manufacture of pedestrian parapets on bridges carrying a road or cycle path or footpath/bridleway or on top of retaining walls and other similar elevated structures.

This European Standard does not cover the requirements for:

- Vehicle restraint systems or pedestrian restraint systems in residential, commercial or industrial buildings and within their perimeter,
- Non rigid rails i.e. rope, cables,

- Transparency,
- Risks relating to the climbing of children.

This European Standard covers pedestrian parapets placed on the market as kits.

NOTE 1: The authorities for railways, rivers and canals can have additional special requirements.

NOTE 2: The above requirements for pedestrian restraint systems are normally defined in National Regulations or referenced in the project specification (or documentation).

prEN1317-7

Introduction:

The design purpose of safety barriers installed on roads is to contain errant vehicles that either leave the carriageway or are likely to encroach into the path of oncoming vehicles. EN 1317-2 deals with the impact performance of a safety barrier to which a terminal may be attached.

Terminals, which are defined as the beginning and/or end treatment of a safety barrier, are required to have specified impact performances without introducing additional hazards for passenger cars.

The description of a terminal conforming to this Standard incorporates the relevant classes and performance levels of the product.

Manufacturers may wish to modify their products or use them with different barriers following the ITT and clauses 5.2, 6.2.1.5 and Annex A of EN1317-5:2008 set out the procedure to be followed.

Scope

This European Standard is a supporting standard to EN1317-5 and shall also be read in conjunction with EN1317-1.

This Part completes Part 2 of the standard because it specifies performance for terminals, considered as the end treatment of a safety barrier.

This Standard also defines acceptance criteria for impact tests and test methods.

prEN1317-8

Introduction:

In order to improve safety the design of roads may require the installation of road restraint systems, which are intended to contain and redirect errant vehicles safely for the benefit of the occupants and other road users, or pedestrian parapets designed to restrain and to guide pedestrians and other road users not using vehicles, on sections of road and at particular locations defined by the national or local authorities.

Part 2 of this standard contains performance classes, impact test acceptance criteria and test methods for barriers. Whereas the aforementioned part covers the performance of these systems with respect to cars and heavy vehicles, this part of the standard addresses the safety of the riders of powered two-wheeled vehicles impacting the barrier having fallen from their vehicle.

As powered two-wheeler riders may impact a barrier directly (in which case no protection is offered by the vehicle) special attention is given to these vulnerable road-users. In order to minimise the consequences to a rider of such an impact, it may be necessary to fit a barrier with a specific PTW rider protection system. Alternatively, a barrier might specifically incorporate characteristics limiting the consequences of a PTW rider impact.

Rider protection systems may be continuous (including barriers specifically designed with the safety of PTW riders in mind) or discontinuous. A discontinuous system is one which offers rider protection in specific localised areas judged to be of higher risk. The most common example of a discontinuous system is one fitted locally to the posts of a post and rail type guardrail - adding nothing between the posts.

The purpose of this part of the standard is to define the terminology specific to it, to describe procedures for the initial type-testing of rider protection systems and to provide performance classes and acceptance criteria for them.

Crash statistics from several European countries have shown that riders are injured when impacting barriers either whilst still on their vehicles or having fallen and then sliding along the road surface. Whilst different statistical sources show one or the other of these configurations to be predominant, all known studies show both to constitute a major proportion of rider to barrier impact crashes. Some studies showing the sliding configuration to be predominant have led to the development and use of test procedures in some European countries, evaluating systems with respect to the sliding configuration. At the time of writing, a number of such protection systems were already on the European market. It is for this reason that it was decided to address the issue of sliding riders initially, in order to bring about the adoption of a European standard in as timely a manner as possible. However, the rider on vehicle configuration should also be considered as soon as possible for a subsequent revision of this part of the standard.

Scope:

This part of the European standard shall be read in conjunction with EN 1317 parts 1 and 2. These parts of the standard all support EN1317-5.

This part of the standard specifies requirements for the impact performance of PTW rider protection systems to be fitted to barriers or for the rider protection aspect of a barrier itself. It excludes the assessment of the vehicle restraint capabilities of barriers and the risk that they represent to the occupants of impacting cars. The performance of impacting vehicles must be assessed according to EN 1317 parts 1 and 2.

This part of the standard defines performance classes taking into account rider speed classes, impact severity and the working width of the system with respect to rider impacts.

For systems designed to be added to a standard barrier, the test results are valid only when the system is fitted to the model of barrier used in the tests. EN 1317-5 describes how it may be determined whether other barrier models are sufficiently similar to the barrier tested to allow their use in conjunction with the tested system without the need for additional testing. Guidelines for making this judgment are given in Annex G.

<u>EN 12767</u>

The severities of crashes for vehicle occupants are affected by the performance of support structures for items of road equipment under impact. Based on safety considerations, these can be made in such a way that they detach or yield under vehicle impact.

This European Standard provides a common basis for testing of vehicle impacts with items of road equipment support.

This European standard considers three categories of passive safety support structures:

- high energy absorbing (HE);
- low energy absorbing (LE);
- non-energy absorbing (NE).

Energy absorbing support structures slow the vehicle considerably and thus the risk of secondary crashes with structures, trees, pedestrians and other road users can be reduced.

Non-energy absorbing support structures permit the vehicle to continue after the impact with a limited reduction in speed. Non-energy absorbing support structures may provide a lower primary injury risk than energy absorbing support structures.

In this European Standard, several levels of performance are given using the two main criteria related to the performance under impact of each of the three energy absorbing categories of support structure. Support structures with no performance requirements for passive safety are class 0.

There are four levels of occupant safety:

Levels 1, 2 and 3 provide increasing levels of safety in that order by reducing impact severity.
For these levels two tests are required:

- test at 35 km/h to ensure satisfactory functioning of the support structure at low speed.
- test at the class impact speed (50, 70 and 100) as given in Table 1.

Level 4 comprises very safe support structures classified by means of a simplified test at the class impact speed.

All the tests use a light vehicle to verify that impact severity levels are satisfactorily attained and compatible with safety for occupants of a light vehicle.

The different occupant safety levels and the energy absorption categories will enable national and local road authorities to specify the performance level of an item of road equipment support structures in terms of the effect on occupants of a vehicle impacting with the structure. Factors to be taken into consideration include:

- perceived injury crash risk and probable cost benefit;
- type of road and its geometrical layout;
- typical vehicle speeds at the location;
- presence of other structures, trees and pedestrians;
- presence of vehicle restraint systems.