Urban roadside barriers and alternative treatments

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Foreword

The mission of the Land Transport Safety Authority (LTSA) is "to undertake activities that promote safety in land transport at reasonable cost."

With this purpose in mind, the LTSA is committed to the development and review of safety standards, guidelines, rules, and codes of practice for land transport. The aim is to achieve a high standard of nationwide consistency.

Preface

Motor vehicle crashes with roadside barriers in the urban speed environment can result in death. In the five year period from 1990 to 1994, there were 952 report injury crashes which involved collision with a roadside barrier. These crashes resulted in 75 deaths, 251 serious injuries and 1,086 minor injuries.

The severity of roadside barrier crashes can be reduced by implementing barrier systems that are inherently safer or by undertaking alternative engineering measures. In some situations, a reduction in crash severity may be possible by using alternative engineering measures in conjunction with a barrier system.

The philosophy of this guideline is that all alternative engineering measures should be considered before installing a roadside barrier because in many situations the barrier itself will constitute a hazard, albeit less than the unprotected roadside object.

This guideline sets out to document some of the pitfalls of roadside barriers. It deliberately avoids recommending specific barrier products or installation details because every situation is site specific and requires sound engineering judgement. Nevertheless, it is hoped that the material contained in this guideline is of assistance in guiding practising engineers to the relevant literature.

I would like to thank all those who contributed to the compilation of this document and commend to you the widespread use of this guideline.

Alan Woodside,
Acting Director, Land Transport Safety

1. Introduction

These guidelines are for Road Controlling Authorities and traffic engineering practitioners who are responsible for minimising the severity of roadside barrier crashes in the urban speed environment.

Installing a roadside barrier is one way of preventing hazardous roadside objects from being struck by errant vehicles. Other alternatives include the removal of the hazardous object, modification of the object so that it is no longer considered hazardous and improving the road environment to reduce the likelihood of errant vehicles.

In practice it is often difficult to predict which of the alternatives will result in the greatest reduction in crash severity. In many situations the installation of a roadside barrier may itself constitute a hazard, albeit less than the unprotected roadside object. The philosophy of this guideline is that the practitioner should identify (or predict) the causes of crashes at the site in question and, where feasible, treat the causes rather than the effects.

The guideline does not give details on product performance or layout because every situation is site specific and requires sound engineering judgement. Wherever possible, reference is made to literature that is supported by field tests and research.

2. Reasons for roadside barrier use

Roadside barriers are typically installed to prevent errant vehicles from colliding with hazardous roadside objects such as those shown in Table 2.1.

Table 2.1: Hazardous roadside objects

Man-made	Natural
Signs	Trees
Abutments (bridge, pier)	Rock outcrops
Culverts	Bodies of water
Embankments	Cliffs
Ditches	
Electricity substations	
Retaining walls	
Poles	

Roadside barriers are also sometimes used to protect pedestrians, bystanders or property.

However, installing a roadside barrier may increase the target area for an errant vehicle, reduce lateral clearance on roadways, and pose special problems at its ends.

When problems with roadside objects arise, the following options should be considered:

- improve the road environment to reduce the likelihood of errant vehicles
- remove or reduce the hazard so that it no longer requires shielding
- leave the hazard unshielded
- install a barrier.

In all situations a traffic barrier should only be installed if it reduces the severity of potential crashes.

3. Alternatives to roadside barriers

3.1 Alternative engineering measures

In most situations there are alternative engineering measures that should be considered prior to the installation of roadside barriers. Many of these measures aim to improve the information that road users receive from the road environment.

The potential for road crashes can be reduced by ensuring that the road environment relays accurate information to the driver. In most situations it is more beneficial to treat the cause of road crashes rather than the effect.

For example, loss of control crashes on an urban bend may be caused by poor delineation, and an appropriate treatment may be to improve road markings or signage. In contrast, the installation of a roadside barrier may be viewed as treating the effect, with the result being the introduction of an unnecessary roadside hazard.

Most urban guardrails are located on bends. This is reflected in the injury crash data (Appendix 1) with 60 percent of loss of control crashes when cornering right and 20 percent when cornering left. A further five percent of the data is comprised of road users who 'miss' (overrun) an intersection.

Alternative engineering measures that should be considered prior to the installation of a roadside barrier include:

- relocation or modification of hazardous objects
- marking of hazardous objects
- road geometry and pavement surface
- pavement markings
- reflective raised pavement markers
- street lighting
- permanent warning signs
- chevron sight boards
- frangible sight rails.

3.2 Relocation or modification of hazardous objects

The most effective method of removing the need for roadside barriers is to relocate or modify the hazardous object or situation so that it is no longer hazardous. This may require part or full relocation or modification and may be economically justified by reductions in crash numbers and severity.

3.3 Marking of hazardous objects

Objects within and close to traffic lanes can be a hazard to traffic. They should be highlighted using uniform methods when they cannot be removed by, for example, reflectorised markers, paint markings and traffic signals. [Refer LTSA/TNZ (1) Part II, Section 5.]

Hazardous objects sometimes protected by roadside barriers include:

- abutments, piers and kerb ends
- utility poles, trees with trunk diameter more than 100 mm
- ends of medians, sight rails, handrails and roadside barriers.

3.4 Road geometry and pavement surface

Poor road geometry or pavement surface can be the major contributing cause of some loss of control crashes at bends and intersections. This is especially so where the standard of these road elements is below that of the surrounding road environment (e.g. incorrect camber and/or poor pavement condition).

As previously discussed, the cause of road crashes should be addressed (for example, resurface and monitor troublesome slippery sites) rather than addressing the effect (that is, installation of roadside barriers to contain errant vehicles).

3.5 Pavement markings

Pavement markings are a fundamental delineation device and include centrelines, lane lines, edge lines, diagonal shoulder markings, no- overtaking lines, flush medians, continuity lines, limit lines, and others. [Refer LTSA/TNZ (1) Part 11.]

Pavement markings aid road users in their assessment of changes in the road alignment. They also highlight the position of features within the road system that may be geometrically substandard or constitute a hazard. Effective use of pavement markings will improve road safety by ensuring the road user has sufficient information to drive safely.

3.6 Reflective raised pavement markers

Reflective raised pavement markers (RRPMs) provide both close and distant delineation of the road at night, provide enhanced reflectivity in wet conditions, and provide audible and tactile signals when driven over. RRPMs can be used on centrelines, lane lines, no overtaking lines, edge lines and flush medians. [Refer LTSA/TNZ (1) Part 11 Section 4.]

Cyclist safety (Section 7) should be carefully considered before installing ceramic studs or RRPMs, (especially edge line RRPMs) as these devices may “throw” a cyclist or force them further out into the traffic lane.

3.7 Street lighting

Street lighting has a major effect in delineating the roadway at dusk and at night. At some sites however, the information relayed to the driver may be ambiguous due to the layout of the lamps. This may often occur where lamps have been fitted to existing utility poles (electricity or telephone) rather than following a street lighting layout design.

Common problems at curves include a missing lamp in the middle of a bend or other street lighting in the distance giving the impression that the roadway is straight.

At intersections street lighting increases a driver’s awareness of roadway delineation (for example, solid centreline, limit lines, continuity line, channelisation) and reduces the likelihood of road users misinterpreting the layout or existence of an intersection.

All new street lighting installations should incorporate the use of frangible poles.

3.8 Permanent warning signs

3.8.1 T- Intersection Warning Signs

If insufficient information is given in advance a road user may 'miss' (overrun) the end of some T and Y-intersections (for example, those intersections preceded by crest curves or substandard horizontal alignment, or intersections with a poor background environment).

In some situations, installing a permanent warning sign may be sufficient to avoid installing a roadside barrier.

Table 3.1 outlines the sign types and location requirements for T-intersection permanent warning signs.

Table 3.1: T-Intersection Permanent Warning Signs

Sign legend	Sign type	Operating speed	Distance from intersection
Stop ahead "x" m	PW-1 70 km/h	50 km/h 100 m	65 m
Give Way ahead "x" m	PW-2	50 km/h 70 km/h	65 m 100 m
None (symbolic) PW-1 0.1	PW-1 0 70 km/h	50 km/h 100 m	65 m

Signs should be located where approaching drivers have an uninterrupted view of them for at least 60 m. [Refer LTSA/TNZ (1) Part 1 Section 6.]

3.8.2 Curve warning and advisory speed signs

Curve warning and advisory speed signs indicate to drivers the speed they can take a curve at without causing discomfort to the driver or passengers. They also warn road users of changes in the horizontal alignment that are not clearly defined by the surrounding environment or other road markings or delineation devices.

Curve warning signs can often warn the driver earlier than other devices such as chevron sight boards and curve indicators which are erected at the curve itself.

A curve warning sign (PW-16 through PW-23) should be located where approaching drivers have an uninterrupted view of it for at least 60 metres in the urban situation. Advisory speed signs (PW-25) are erected with the curve warning sign if justified by the warrant guidelines. [Refer LTSA/TNZ (1) Part 1 Appendix 3.]

3.9 Chevron sight boards

Chevron sight boards consist of a reflectorised white material chevron on a matt black background. Black and yellow chevron boards may be used in special circumstances where black and white chevrons do not stand out against the background environment (for example, in areas of high snow fall).

3.9.1 At T-intersections

Chevron sight boards may be used at the head of T-intersections where the background environment is either nonexistent or so poor that other warning devices (for example, permanent warning signs PW-1, PW-2, PW-10.1) are failing to prevent 'overrun' of the intersection. For urban areas the length of chevron sight board is typically 2.4 metres. [Refer LTSA/TNZ (1) Part II Section 5.]

3.9.2 At dangerous horizontal curves

Chevron sight boards can emphasise dangerous horizontal curves, especially at sites with poor geometry (for example, vertical curvature preceding horizontal curvature) or a poor crash history or where advisory speed signs (PW-25) have been erected and speeds through the curve are consistently higher than the advisory speed. For urban areas the length of chevron sight board is typically 2.4 metres, although at difficult sites the length may be increased using an additional 1.2 metre length.

Supplementary curve advisory speed panels may be added to the chevron board where appropriate. [Refer LTSA/TNZ (1) Part 11 Section 5.]

Chevron sight boards should be erected on all curves with an advisory speed of 15 km/h.

3.9.3 Chevron curve indicator

Chevron curve indicators may be used with chevron sight boards on curves with high deflection angles where additional delineation is required throughout the curve.

In urban areas, where space is limited, the chevron curve indicator may replace the chevron sight board at a curve. However, chevron curve indicators have considerably less visual impact than a chevron board.

Chevron curve indicators should be mounted at a constant height above the road pavement and at a constant distance from the edge of the traffic lane. This ensures the driver receives guidance of the horizontal and vertical components of the curve. [Refer LTSA/TNZ (1) Part 11 Section 5.]

3.10 Frangible sight rails

A sight rail delineates the roadway by providing continual guidance through tight bends with limited visual background. They can also provide a target background at the head of T-intersections.

Sight rails are not intended to stop errant vehicles and should be constructed of light frangible material (coloured white) that will minimise any safety hazard to the road user. Careful consideration of the end treatment of sight rails is required to ensure that the rail itself does not become a hazard.

In most situations the use of conventional delineation devices should be considered before the installation of sight rails. [Refer Land Transport (2).]

3.11 The installation of roadside barriers

Having considered the alternatives to roadside barrier installation, there will be situations where engineering judgement concludes that the safest road environment will result from installing a roadside barrier. This will most likely be in conjunction with some of the above alternative engineering measures. As previously discussed, the decision to install a roadside barrier needs to be justified on the basis of reducing the crash severity to all road users.

4. Safety characteristics of roadside barriers

4.1 General

A roadside barrier may itself constitute a hazard. Therefore, evaluation of the relative hazard of the barrier versus the hazard of the unshielded object is required. A barrier should only be installed if it reduces the severity of potential crashes.

Roadside barriers (e.g. guardrail, wire rope) are examples of longitudinal traffic barrier systems that have been developed primarily for use on high speed, high volume roads. They typically require considerable length in order to develop full design strength and to ensure that appropriate end treatments are provided.

Longitudinal barriers function primarily by redirecting errant vehicles. To function correctly they should redirect and/or contain errant vehicles without subjecting the vehicle occupants to conditions more hazardous than collision with the unshielded object. The barrier should be able to do this for a range of vehicle sizes, weights, speeds and impact angles.

Although collision with a roadside barrier may be assessed as less severe than a collision with an unshielded object, consideration must be given to the likelihood of rebounding vehicles entering opposing traffic lanes which may result in a more severe crash.

At many urban sites the roadside barrier is often installed over short lengths at severe or moderate bends or at the head of T-intersections. The characteristics of crashes (speed, impact angle) at these sites may vary considerably from their rural counterparts. Therefore, sound engineering judgement is required to establish whether the roadside barrier will perform as intended in the urban situation.

The probability or frequency of crashes does not, in general, have an effect on the severity of potential crashes.

4.2 End treatments

The ends of roadside barriers can be extremely hazardous if left untreated and may penetrate vehicle compartments or motorcycles.

An end treatment has two functions. It must provide an anchor that allows the full tensile strength of the barrier system to be developed during downstream impacts, and it must be crashworthy during end on impacts.

To be crashworthy an end treatment should not penetrate, vault, or roll a vehicle involved in an end-on crash. End treatments must develop the full tensile strength of the standard barrier element and have the same redirectional characteristics. Both upstream and downstream end treatments need to be provided.

As previously discussed, many roadside barrier products available have been developed and tested for use in high speed, high volume situations where enough land is available to provide the appropriate end treatments. In the urban situation the area of land available is often restricted and sound engineering judgement is needed to ensure the barrier can be safely installed and perform as intended.

Previously popular solutions to end treatments in higher speed environments included the “ramped end” (for use with rigid and flexible systems), and the “Texas Twist” (guardrail systems). Although conceptually safer than no end treatment, under some test conditions some turned-down-end designs have caused impacting vehicles to vault and roll over. They are therefore not recommended.

In the urban speed environment the “bull nose” fitting is worth considering as an end treatment. ”Fishtail” fittings should not be used at terminations where an end-on crash could occur as field experience suggests they can easily penetrate vehicles and are unforgiving towards motorcyclists.

4.3 Transitions

Roadside barriers are referred to as flexible, semi-rigid or rigid. The selection of either system is usually based on the deflection characteristics required. Flexible barriers are used when the barrier can be installed at some distance from the hazardous object. Semi-rigid or rigid barriers are required where the barrier-to-hazard distance is small.

Transition sections are required to provide continuity where different traffic barriers join, for example, where approach lane barriers join bridge abutments or bridge rails.

Transitions should be designed to prevent errant vehicles from heading towards abutments, piers and other structures due to excessive deflection.

The stiffness of a transition should increase uniformly from the more flexible to the more rigid system. This may be achieved by varying post spacing and size in accordance with the manufacturer’s design criteria.

4.4 Segmented roadside barriers at curves

Installing a roadside barrier around a curve that contains vehicle crossings is generally undesirable for the following reasons:

- errant vehicles from either direction are more likely to be impaled on the short segmented sections of barrier due to the openings at vehicle crossings.
- it is unlikely that the end treatments, transitions, and layout can be suitably designed and installed.

Due to the additional constraints of land availability and vehicle crossing regularity in urban areas, sound engineering judgement is required to ensure that the product will perform safely and to the manufacturers specifications.

5. Crash severity of roadside objects

5.1 Crash by crash analysis

Reported crash data analysis should be incorporated into the process of deciding whether or not to install a roadside barrier.

A comprehensive analysis involves reading the Traffic Crash Reports (available at LTSA offices in Auckland, Wellington and Christchurch) and considering all of the factors that have attributed to the crashes. Useful information can often be gained from reading the reporting officer's comments, viewing sketches and so on. From this analysis, an alternative treatment (such as those discussed in section 3) may become more apparent.

5.2 Severity of roadside object crashes

An analysis of the Land Transport Safety Authority crash database was undertaken for single vehicle versus single object crashes (Appendix 1) to ascertain the percentage of fatal, serious and minor crashes for various roadside objects struck.

The analysis of single vehicle versus single object crashes shown in Appendix 1 may be of assistance when considering the options of whether to remove a hazardous roadside object or protect it using a roadside barrier.

6. Pedestrians and bystanders

In some situations pedestrians or bystanders may be exposed to a higher than normal risk of being struck by an errant vehicle.

An assessment of pedestrian exposure at the site under investigation is required so that crash reductions for a number of alternative treatments can be considered. Installing a roadside barrier may reduce the injuries sustained by pedestrians but increase the severity of injuries to all road users. The desirable solution is to reduce the severity of potential crashes for all road users.

When a barrier is to be installed it may be possible to erect it away from the adjacent traffic stream and nearer the property boundary (for example, where a school playground requires some protection from errant vehicles), thereby minimising the severity to the motorist. Where footpath pedestrians require some protection the barrier is likely to be erected adjacent to the traffic stream in which case the likelihood of barrier/vehicle conflicts will be greater. However the severity of crashes for all road users in this situation should be reduced.

7. Cyclist safety issues

7.1 Roadside barrier issues

Cyclists may be exposed to unnecessary risk due to the installation of some roadside barriers. This problem is most prevalent where cyclists and motor vehicles share a kerbside lane that is not wide enough to cater for both. In such situations a cyclist may perceive a risk of being "squashed" between the barrier and the motor vehicle, with higher risk being associated with increasing barrier height and length.

To prevent motor vehicles from vaulting barriers such as a guardrail it is recommended that the front face of the barrier is positioned within 150 mm of the kerb face or greater than 3.0 metres away from the kerb [NAASRA (3)]. A barrier 3.0 metres or more from the kerb face is likely to be of benefit to the cyclist. However this type of installation should only occur where the barrier continues to protect the object or hazard for which it was considered necessary.

Other roadside objects are typically set back further from the kerb face (e.g. utility poles, trees), have smaller target areas, and therefore are perceived to pose less threat to cyclists than objects such as roadside barriers.

The bicycle design envelope shown in Figure 7.1 [Austroads (4)] gives a desirable minimum clearance of 0.5 metres and an absolute minimum of 0.2 metres between the cyclist's envelope and fixed objects such as walls, fences and barriers.

The 1.0 metre wide envelope allows for a cycle width of about 0.6 metre (handlebars) and 0.2 metre tracking variation either side.

7.2 Wide kerbside lanes

On urban roads with low traffic volumes it is often possible for cyclists and motorists to safely share the available road space.

As speed and traffic volumes increase a cyclist will be passed more often by motorists. Therefore consideration should be given to providing sufficient width in the kerbside lane to allow motorists to safely overtake cyclists without the need to change lanes. Wide kerbside lanes are considered as a cost effective means of providing space for cyclists because signs, pavement markings and bylaw procedures are not required.

A study of kerbside lanes on roads having a 60 km/h speed limit indicated that kerbside lanes should be 3.7 to 4.2 metres wide in order to be satisfactory for cyclists. Other references state that lane widths in excess of 4.5 metres should be avoided because of the potential for motor cars to travel two abreast within a wide lane [Austroads (4)]. Austroads (4) gives the desirable minimum of 4.0 metres and desirable maximum of 4.2 metres.

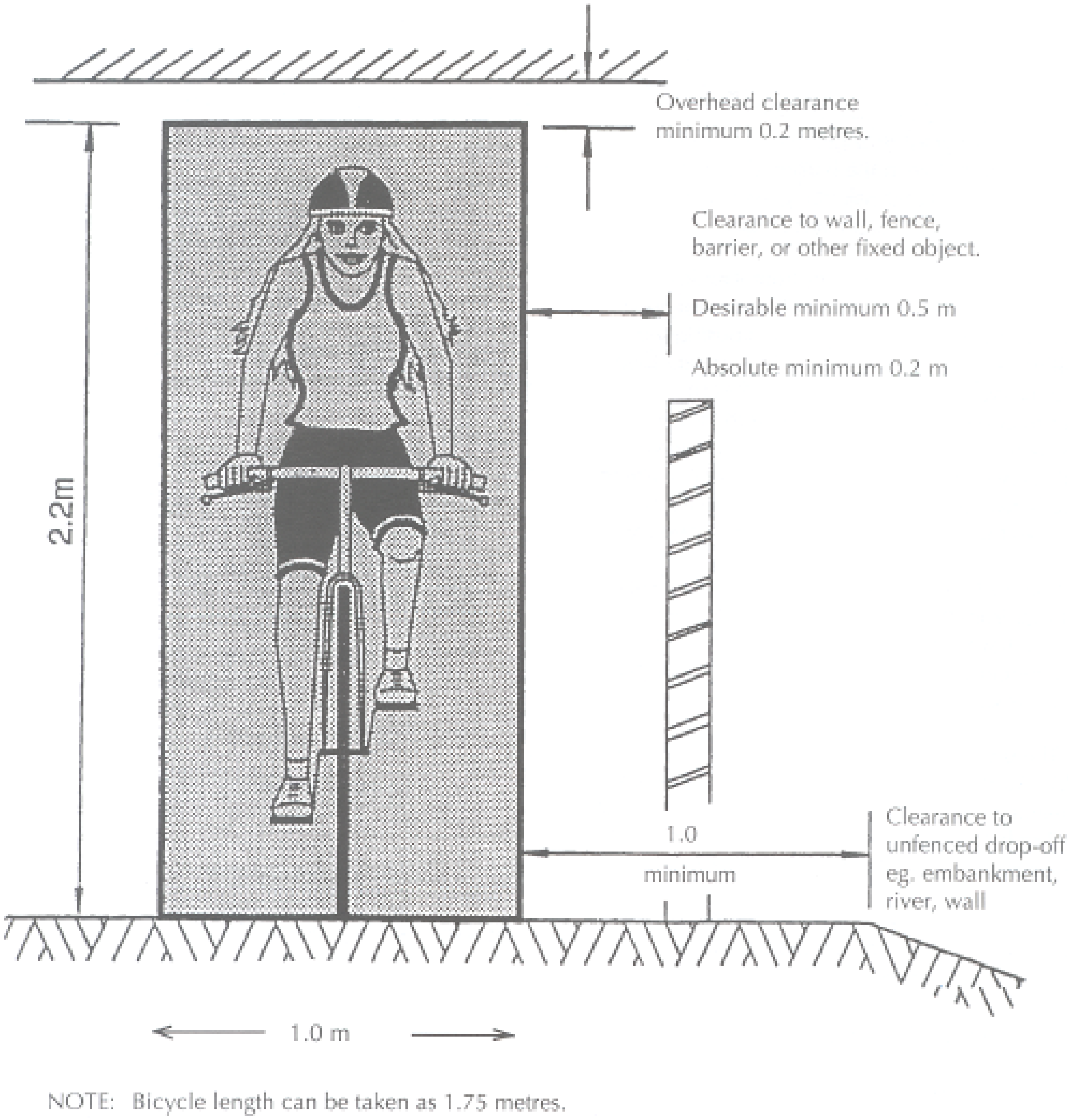
The decision to consider the cyclist design envelope and provide wide kerbside lanes in areas with roadside barriers will depend on the following:

- the demand for cycling as a transport mode (e.g. commuters, recreation)
- the existence of designated cycle networks (e.g. road controlling authority cycle policy)
- traffic speed, volume, and composition (% cycles, % heavy motor vehicles)
- road alignment and width
- the frequency and length of roadside barriers.

7.3 Delineation issues

At some sites (e.g. bends) delineation devices such as RRPMs (reflective raised pavement markers) may be considered as part of an appropriate road edge treatment to prevent crashes. This type of device has the potential to "throw" a cyclist or force them further out into the traffic lane (for example, where edge line RRPMs are used). Therefore, consideration of RRPM placement relative to cycle passage is required. See Section 3.6 regarding RRPMs.

Figure 7.1: Bicycle design envelope



8. Roadside barrier types, performance and layout

8.1 Performance of roadside barriers

This document does not discuss the technical performance of the various roadside barrier products available.

Standards New Zealand and Standards Australia are developing a joint standard for road barrier systems. This standard is expected to be in four parts covering issues such as general requirements, metal and cable barriers, concrete barriers, and composite material barriers. The standard is likely to draw upon the large amount of field and laboratory testing undertaken by overseas roading agencies, particularly in Australia and the United States.

8.2 Types of roadside barriers and layout requirements

Roadside barriers are typically classified as flexible, semi-rigid or rigid. Some of the barrier systems commonly used in New Zealand include:

Flexible barriers:	W Beam (weak post system)
	Wire rope
Semi-rigid barriers:	W Beam (strong post system)
	Tric Bloc
	Thrie Beam
Rigid barriers:	New Jersey

It is beyond the scope of this guideline to detail specific layouts for the many barrier systems and situations in which they may be used in the urban speed environment. The requirements for barrier systems on State Highways should be sought from Transit New Zealand.

The document "Road Design Guide: Section 6; Safety Barriers for Roads and Bridges (October 1993)" by the Roads and Traffic Authority, Australia (5) is a comprehensive guideline that discusses many roadside barrier types and layouts for various speed environments. With some engineering judgement applied it is likely that the material presented in the Australian guideline would be applicable to the New Zealand urban speed environment.

9. Roadside barrier selection checklist

9.1 Selection criteria

The most favourable barrier system is one that will reduce the severity of all potential crashes at reasonable cost.

Table 9.1 contains items that should be considered when selecting a barrier system.

Table 9.1: Barrier selection checklist

Item	Considerations
Strength and safety	• System should contain and redirect vehicle at design conditions
	• System should be less hazardous than other alternatives
Deflection	• Is a rigid, semi-rigid or flexible system required?
Maintenance	• Collision maintenance
	• Routine maintenance
	• Environmental conditions
Compatibility	• Can system be transitioned to other barrier systems?
	• Can system be terminated properly?
Costs	• Initial costs
	• Maintenance costs
	• Crash costs to motorist and society
Field experience	• Documented evidence of barrier's performance in the field
Aesthetics	• Barrier should have a pleasing appearance

10. Maintenance of barrier systems

Typical maintenance considerations that should be evaluated when installing a roadside barrier are shown in Table 10.1.

Table 10.1: Maintenance of roadside barriers

Maintenance item	Considerations
Collision maintenance	• Labour requirements
	• Typical hours to repair (exposure)
	• Typical barrier damage
	• Special equipment
	• Ability of rail to be repaired or straightened
	• Salvage value (if not repairable)
Routine maintenance	• Level of working knowledge required
	• Cleaning and painting
	• Mowing and clearing vegetation
Environmental conditions	• Checking and tightening blocks and fasteners
	• Snow or sand drifting
	• Snow or sand removal
	• Weathering or corrosion due to environment or chemical effects
Material and storage requirements	• Dependence on a number of parts
	• Availability of parts
	• Storage facilities required

Source = AAHSTO (6)

In addition to maintenance items, surveys of existing barriers should be undertaken and the following considered:

- unnecessary barriers that should be removed
- substandard barriers that should be upgraded or replaced with acceptable systems
- poorly located barriers that should be relocated.

References

1. Land Transport Safety Authority/Transit New Zealand (1994) *Manual of Traffic Signs and Markings - Part I: Traffic Signs, Part 11: Markings.*
2. Land Transport (1992) RTS 5 *Guidelines for Rural Road Marking and Delineation.*
3. NAASRA (1987) *Safety Barriers: Considerations for the Provision of Safety Barriers on Rural Roads*, Sydney.
4. Austroads (1993) *Guide to Traffic Engineering Practice, Part 14: Bicycles*, Sydney.
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Acknowledgements

This guideline was compiled by a working group comprised of:

Graeme Bean	Land Transport Safety Authority (Convenor)
Todd Langwell	Auckland City Council

Appendix 1: National crash data

1.1 Analysis of object struck crash data

An analysis of the Land Transport Safety Authority crash database for all New Zealand was undertaken using the following criteria:

- single vehicle vs single object injury crashes only
- urban speed limit only (0 - 70 km/h)
- five years data (1989 - 1993)

Single vehicle vs single object only crashes were selected to enable the severity of crashes with specific objects to be identified. The Land Transport Safety Authority document "Accident Printout Interpretation" (7) lists 24 object categories that can be used to code crashes with objects. From this list the 14 object types chosen for analysis were:

B	bridge abutment, handrail or approach, includes tunnels	C	upright cliff/bank, retaining walls
E	over bank	F	fence, letterbox, hoarding
G	guardrail	H	house or building
I	traffic island or median	J	public furniture
K	kerb	P	pole (utility)
S	traffic signs/bollards	T	trees
V	ditch	Z	into water, river, sea

The object types not included in the analysis include:

A	driven or accompanied animals	D	debris, boulder or object from vehicles
L	landslide, washout, floodwater	M	parked motor vehicle
N	train	Q	broken down vehicles, taxi pick-up etc.
R	roadworks, signs or drums	W	wild animals
X	other	Y	objects thrown/dropped onto vehicles

Table 1.1 shows the number of single vehicle vs single object injury crashes in New Zealand over the five year period, 1989 - 1993. Crashes with guardrails comprise 3.5 percent of the data.

Table 1.2 expresses the crashes in Table 1.1 as a percentage severity for the single vehicle vs single object crashes.

Table 1.3 shows the cost to the nation of the single vehicle vs single object injury crashes using July 1994 injury crash costs from the Transit New Zealand "Project Evaluation Manual Volume II" (8). The average cost of an injury guardrail crash is $90,000. It should be noted that additional costs exist for those crashes categorised as multiple vehicles and/or multiple objects struck.

Table 1.4 shows single vehicle vs guardrail injury crashes by vehicle type and movement code for speeds 0 - 70 km/h. Cars, vans and utes comprise 84 percent of the vehicle types involved in guardrail crashes. Loss of control on left hand corner or right hand corner (DB or DA) movements comprise 80 percent of the data (DA = 60 percent, DB = 20 percent).

Crash movement codes (DA, DB and so on) are shown in Appendix 2.

Table 1.1: Number of single vehicle vs single object crashes (1989-1993 <=70 km/h) (f = fatal, s = serious, m = minor)

Object code	Object			Severity	
		F	S	M	Total
B	Bridges, tunnels, abutments	4	28	65	97
C	Upright cliff/bank, retaining walls	5	73	195	273
E	Over bank	13	36	65	114
F	Fence, letterbox, hoarding, hedge	19	120	381	520
G	Guardrail	2	34	113	149
H	House, building	1	38	111	150
I	Traffic island, median	4	43	125	172
J	Phone box, bus shelter, signal box	3	11	24	38
K	Kerb	8	40	113	161
P	Light, power, telephone poles	71	491	1,329	1,891
S	Traffic signs, delineators, bollards	4	12	64	80
T	Tree	22	135	281	438
V	Ditch, watertable, drainage channel	6	39	106	151
Z	Water, river, sea, lake, estuary	8	5	20	33
Total		**170**	**1105**	**2992**	**4267**

Table 1.2: Single vehicle vs single object crashes: percent severity (1989-1993 <=70 km/h) (f = fatal, s = serious, m = minor)

Object code	Object			Severity	
		F	S	M	Total
B	Bridges, tunnels, abutments	4.1	28.9	67.0	100.0
C	Upright cliff/bank, retaining walls	1.8	26.7	71.4	100.0
E	Over bank	11.4	31.6	57.0	100.0
F	Fence, letterbox, hoarding, hedge	3.7	23.1	73.3	100.0
G	Guardrail	1.3	22.8	75.8	100.0
H	House, building	0.7	25.3	74.0	100.0
I	Traffic island, median	2.3	25.0	72.7	100.0
J	Phone box, bus shelter, signal box	7.9	28.9	63.2	100.0
K	Kerb	5.0	24.8	70.2	100.0
P	Light, power, telephone poles	3.8	26.0	70.3	100.0
S	Traffic signs, delineators, bollards	5.0	15.0	80.0	100.0
T	Tree	5.0	30.8	64.2	100.0
V	Ditch, watertable, drainage channel	4.0	25.8	70.2	100.0

Table 1.3: Single vehicle vs single object crashes: total cost ($000) of NZ injury crashes (1989-1993) (f = fatal, s = serious, m = minor)

Object		<70 km/h			70 km/h		Av cost	Total
	F	S	M	F	S	M	/crash	cost
Bridges, tunnels, abutments	6840	3857	876	2410	1989	146	166	16117
Upright cliff/bank, retaining walls	11400	13398	2552	0	1547	541	108	29438
Over bank	25080	6496	831	4820	884	208	336	38319
Fence, letterbox, hoarding, hedge	31920	22127	5391	12050	2431	499	143	74418
Guardrail	4560	5684	1268	0	1326	603	90	13442
House, building	2280	7511	1570	0	221	146	78	11728
Traffic island, median	9120	8120	1706	0	663	250	115	19859
Phone box, bus shelter, signal box	6840	2233	332	0	0	42	249	9447
Kerb	15960	7917	1616	2410	221	125	175	28249
Light, power, telephone poles	136800	91147	19026	26510	9282	1435	150	284200
Traffic signs, delineators, bollards	6840	2030	921	2410	442	62	159	12706
Tree	43320	25781	3971	7230	1768	374	188	82445
Ditch, watertable, drainage channel	6840	5481	1057	7230	2652	749	159	24009
Water, river, sea, estuary	15960	1015	257	2410	0	62	597	19704
Total cost	323760	202797	41374	67480	23426	5242	156	664079

Cost per crash ($000) by speed limit and severity (all movements/vehicles): TNZ PEM ($1994)

Crash severity	F	S	M	F	S	M
Cost per crash by speed limit	2280.0	203.0	15.1	2410.0	221.0	20.8

Table 1.4: Single vehicle vs guardrail crashes (1989-1993 <=70 km/h), number of NZ injury crashes by movement and vehicle type

Crash Movement codes	Fatal Motor-cycle	Fatal Bus	Serious Car	Serious Van /ute	Serious Motor-cycle	Minor Car	Minor Van /ute	Minor Motor-cycle	Minor Truck	Mvmt Moped	Totals
AD											0
CA						4		1		1	6
CB					3	5					8
CC						2	1		1		4
DA	1	1	16	1	5	55	4	4	2		89
DB			5	1	1	19	1	3			30
DC				1	1	8					10
EC						2					2
FF											0
LB											0
M											0
Q											0
Crashes	**1**	**1**	**21**	**3**	**10**	**95**	**6**	**8**	**3**	**1**	**149**

1.2 Comparing single vehicle, single object crashes

In order to establish any points of interest regarding single vehicle guardrail crashes, two data sets were compared as follows:

1. Single vehicle vs guardrail crashes: object type = G
2. Single vehicle vs single object crashes: object types = B, C, E, F, H, I, J, K, P, S, T, V and Z (i.e. excludes guardrail)

Points of interest from comparison are summarised in Table 1.5.

Table 1.5: Urban crash percentages by contributing factors

Crash factors	Guardrail crashes	Other objects	All New Zealand urban crashes
Darkness	58	65	36
Wet road	46	32	25
Speed	46	38	15
Alcohol	44	53	21
At intersection	34	29	49
Road factors	11	9	7
Vehicle factors	7	6	4
Straight road - loss control/head on	12	38	9
Curved road - loss control/head on	87	57	16

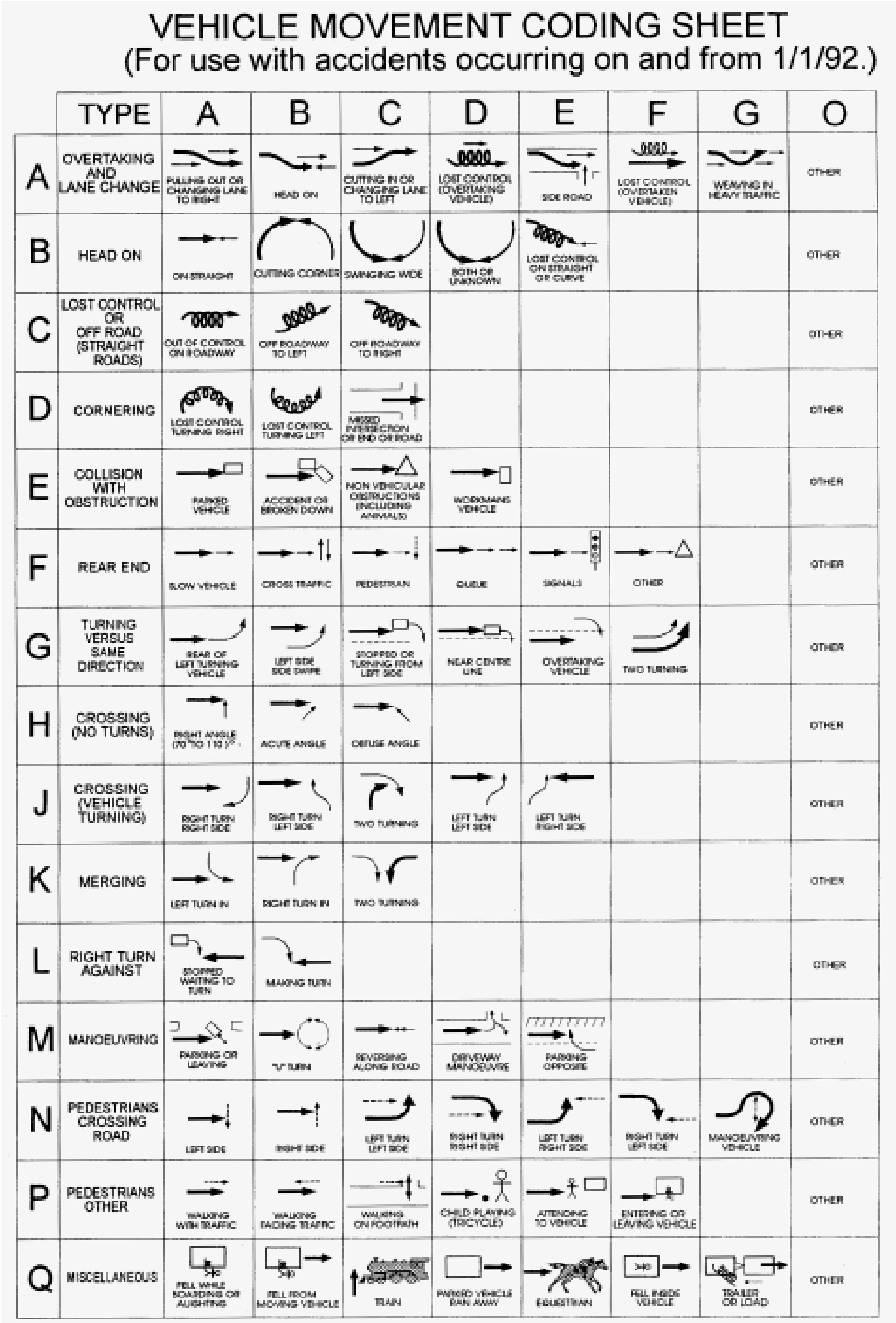
Guardrail crashes have the following over-represented factors when compared with all New Zealand urban crashes:

- darkness
- wet road
- speed
- alcohol
- road factors
- vehicle factors
- loss of control on straight road
- loss of control on curved road.

When compared with 'single vehicle versus single object' crashes, guardrail crashes are over-represented with the following factors:

- wet road
- speed
- at intersection
- road factors
- vehicle factors
- loss of control on curved road.

Appendix 2: Crash movement codes



VEHICLE MOVEMENT CODING SHEET
(For use with accidents occurring on and from 1/1/92.)

	TYPE	A	B	C	D	E	F	G	O
A	OVERTAKING AND LANE CHANGE	PULLING OUT OR CHANGING LANE TO RIGHT	HEAD ON	CUTTING IN OR CHANGING LANE TO LEFT	LOST CONTROL (OVERTAKING VEHICLE)	SIDE ROAD	LOST CONTROL (OVERTAKEN VEHICLE)	WEAVING IN HEAVY TRAFFIC	OTHER
B	HEAD ON	ON STRAIGHT	CUTTING CORNER	SWINGING WIDE	BOTH OR UNKNOWN	LOST CONTROL ON STRAIGHT OR CURVE			OTHER
C	LOST CONTROL OR OFF ROAD (STRAIGHT ROADS)	OUT OF CONTROL ON ROADWAY	OFF ROADWAY TO LEFT	OFF ROADWAY TO RIGHT					OTHER
D	CORNERING	LOST CONTROL TURNING RIGHT	LOST CONTROL TURNING LEFT	MISSED INTERSECTION OR END OF ROAD					OTHER
E	COLLISION WITH OBSTRUCTION	PARKED VEHICLE	ACCIDENT OR BROKEN DOWN	NON VEHICULAR OBSTRUCTIONS (INCLUDING ANIMALS)	WORKMANS VEHICLE				OTHER
F	REAR END	SLOW VEHICLE	CROSS TRAFFIC	PEDESTRIAN	QUEUE	SIGNALS	OTHER		OTHER
G	TURNING VERSUS SAME DIRECTION	REAR OF LEFT TURNING VEHICLE	LEFT SIDE SIDE SWIPE	STOPPED OR TURNING FROM LEFT SIDE	NEAR CENTRE LINE	OVERTAKING VEHICLE	TWO TURNING		OTHER
H	CROSSING (NO TURNS)	RIGHT ANGLE (70° TO 110°)	ACUTE ANGLE	OBTUSE ANGLE					OTHER
J	CROSSING (VEHICLE TURNING)	RIGHT TURN RIGHT SIDE	RIGHT TURN LEFT SIDE	TWO TURNING	LEFT TURN LEFT SIDE	LEFT TURN RIGHT SIDE			OTHER
K	MERGING	LEFT TURN IN	RIGHT TURN IN	TWO TURNING					OTHER
L	RIGHT TURN AGAINST	STOPPED WAITING TO TURN	MAKING TURN						OTHER
M	MANOEUVRING	PARKING OR LEAVING	"U" TURN	REVERSING ALONG ROAD	DRIVEWAY MANOEUVRE	PARKING OPPOSITE			OTHER
N	PEDESTRIANS CROSSING ROAD	LEFT SIDE	RIGHT SIDE	LEFT TURN LEFT SIDE	RIGHT TURN RIGHT SIDE	LEFT TURN RIGHT SIDE	RIGHT TURN LEFT SIDE	MANOEUVRING VEHICLE	OTHER
P	PEDESTRIANS OTHER	WALKING WITH TRAFFIC	WALKING FACING TRAFFIC	WALKING ON FOOTPATH	CHILD PLAYING (TRICYCLE)	ATTENDING TO VEHICLE	ENTERING OR LEAVING VEHICLE		OTHER
Q	MISCELLANEOUS	FELL WHILE BOARDING OR ALIGHTING	FELL FROM MOVING VEHICLE	TRAIN	PARKED VEHICLE RAN AWAY	EQUESTRIAN	FELL INSIDE VEHICLE	TRAILER OR LOAD	OTHER

July 1995

Road and Traffic Guideline publications

The following Road and Traffic Guidelines are available:

RTS 1	Guidelines for the implementation of traffic control at crossroads (1990)
RTS 2	Guidelines for street name signs (1990)
RTS 3	Guidelines for establishing rural selling places (1992)
RTS 4	Guidelines for flush medians (1991)
RTS 5	Guidelines for rural road marking and delineation (1992)
RTS 6	Guidelines for visibility at driveways (1993)
RTS 7	Advertising signs and road safety: design and location guidelines (1993)
RTS 8	Guidelines for safe kerbline protection (1993)
RTS 9	Guidelines for the signing and layout of slip lanes (1994)
RTS 11	Urban roadside barriers and alternative treatments (1995)
RTS 13	Guidelines for service stations (1995)
RTS 14	Guidelines for installing pedestrian facilities for people with visual impairment (1997)
RTS 17	Guidelines for setting speed limits (1995)

The Guidelines may be purchased from:

Land Transport Safety Authority, Head Office (PO Box 2840, Wellington) or Regional Offices in: Auckland, (Private Bag 106 602), Wellington (PO Box 27 249) and Christchurch (PO Box 13 364).