M23 Appendix A

NZTA M23:2023

Appendix A: permanent road safety hardware & devices

27 July 2023

Version 15

More information

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This document is available on the Waka Kotahi NZ Transport Agency website at www.nzta.govt.nz

Document references

- AS/NZS 3845 Part 1:2015
- AS/NZS 3845 Part 2:2017
- AUSTROADS Part 6: Roadside Design, Safety and Barriers
- AUSTROADS Part 3: Geometric Design
- American Association of Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware (MASH)
- System Suppliers' documentation
- Waka Kotahi NZTA M23
- Waka Kotahi NZTA M23 Interim acceptance notices
- Waka Kotahi Bridge Manual
- Waka Kotahi Traffic Control Devices Manual

Revision record

Date	Notes
March 2012	
October 2017	
December 2018	
January 2019	
February 2020	
March 2020	
May 2020	
October 2020	
August 2021	
September 2021	
October 2021	
December 2021	Product updates
May 2022	Product updates, rigid barriers moved to Appendix B and new format
December 2022	Product updates and additions based on latest ASBAP TCUs
July 2023	Product updates, additions and corrections based on latest ASBAP TCUs

Contents

Glossary

(Refer also to AS/NZS 3845 Part 1 2015 and Part 2 2017)

Aesthetic Barrier	A road safety barrier with improved aesthetics compared to other barrier types but reduced safety performance and/or lacking a crashworthy end terminal
Anchorage	The component used to restrain the end of the barrier system and to transmit impact forces to the ground. A permanent barrier system must be anchored to the ground
Bi-directional application	Two-way traffic. Eg Barrier hardware that can be hit by both adjacent and opposing traffic
Clear Area	An area, behind or in front of a road safety barrier system, which should be kept free of hazards for the proper operation of the road safety barrier system or combination of systems. Also referred to as run out area
Clear Zone	An outdated safety concept which has been replaced by a risk assessment of the Design Envelope in accordance with Safe System principles. Clear Zones were defined as the roadside area bordering the travel lanes which should be free of hazards and traversable
Crashworthy	A feature that has been proven acceptable for use under specified conditions either through crash testing or in-service performance
Crossfall	The transverse sloping of the road surface toward the shoulder or gutter
Deflection	The horizontal displacement of the barrier when impacted
Delegated Authority role	For state highway projects, this is the Waka Kotahi Lead Safety Advisor. For other RCAs, the appropriate person may be someone with equivalent delegated authority to make decisions on the acceptability of proposed safety hardware.
Design Envelope	The roadside area of interest, the scale of which is based on a risk assessment in accordance with Safe System principles, within which hazards should be treated or protected
End Terminal	A crashworthy end treatment must be provided when the end of a barrier is exposed to head-on impacts
Energy Absorbing Unit	The individual units in a crash cushion that absorb impact energy
FHWA	USA Federal Highways Administration
Flare Rate	The curvature applied near the end of a road safety barrier installation. Expressed as the ratio of the longitudinal distance to the transverse offset, by which a road safety barrier flares away from the road
Flexible Barrier	Barrier systems which dissipate crash impact energy largely by deflection of the barrier system. Lower impact forces are imposed on the vehicle and occupants
F-Shape Barrier	Concrete barrier of the current accepted F-shape cross-section
Gating	A road safety barrier terminal designed to allow an impacting vehicle to pass through the device, when impacted at an angle, upstream from the point of redirection
Impact angle	For a longitudinal barrier, it is the angle between the face of the barrier and the vehicle's impact direction.
Installation Designer	The entity that designs the length, location and types of components of a system to be installed on a section of the road network. The Installation Designer designs the system to suit the particular conditions of the section of road network
Length of need	The required length of barrier system that is redirective, to shield the hazard
MASH	Manual for Assessing Safety Hardware (MASH) is a Manual for Assessing Highway Safety Features. This is the current Waka Kotahi test protocol for road safety hardware
Minimum Length	Minimum standalone length of safety barrier system, excluding end terminals
NCHRP 350	National Co-operative Highway Research Program (report) 350
New Jersey Barrier	Generally a concrete barrier of the New Jersey Barrier profile. Superseded by the F-shape
Pinning	Either connecting adjacent transportable barrier sections or fastening of barrier sections to the pavement or ground
Point of Redirection	That point on a barrier system downstream of which will be redirective. Previously referred to as "point of need"
Proprietary	A road safety barrier system that is the subject of patent or other intellectual property rights
Public Domain	A road safety barrier system that is not the subject of patent or other intellectual property rights within Australia and New Zealand. Note: These systems are also referred to as non-proprietary road safety barrier systems

RCA	Road Controlling Authority that has control of the road, sometimes referred to as Road Authority
Redirective	The ability of a barrier system to redirect an impacting vehicle away from the barrier without barrier pocketing or rupture
Ribbon Strength	The longitudinal strength of a barrier system to provide crash energy containment and redirection
Rigid Barrier	Barrier system that has no deflection under impact. Higher impact energy transmitted to vehicle and occupants
Semi-Rigid Barrier	Barrier systems which deflect during re-direction. Impact energy to vehicle and occupants is less than for a rigid system but greater than a flexible system
Shy Line	The distance from the edge of the travelled way outside of which the start of a roadside object (eg barrier) will not cause a driver to change their vehicles lateral placement or speed
Sight/ Anti-Gawk Screens	Screens to shield visual distractions from passing drivers
Site Specific Risk Assessment	An assessment which is specific to the site that considers risk based on parameters such as road user exposure, crash likelihood and crash severity
Slope	The relative steepness of the terrain expressed as a ratio or percentage
System Installer	The entity that installs the system
System Owner	The entity that has the property rights to the road safety hardware system through their ownership of the patent
System Supplier	The entity that supplies the system or device
Test Level (TL)	A set of prescribed test conditions, defined in terms of vehicular mass, impact speed and angle that defines the crash energy
Uni-directional application	One-way traffic eg barrier hardware that cannot be hit by opposing traffic
Vaulting	Abrupt upward movement of an impacting vehicle
Wear and tear	Damage that naturally and inevitably occurs as a result of normal use or aging
Working Width	The minimum width that is required to prevent an impacting design vehicle from colliding with an object behind a road safety barrier system. This includes both the dynamic deflection of the road safety barrier (if any) and the extra width to allow for the roll (vertical rotation) of an impacting vehicle
WRSB	Wire rope safety barrier, a flexible barrier system

Flexible barriers

The following general notes apply to all flexible barriers:

a. The minimum performance level for state highways is MASH TL-3.

b. As per M23 Section 8.3. Ground conditions to be checked and confirmed at least as good as test conditions. Where the ground conditions vary from the standardised soil used in the crash testing of the accepted system under consideration, the Installation Designer shall either amend the foundation design in accordance with the design/installation guidance provided by the System Supplier or consider an alternative protection system.

c. For driven sockets the soil conditions must have been demonstrated to meet or exceed the AASHTO Standard Soil used in the formal crash testing of the parent flexible barrier system. For NZ conditions, this will generally be engineered granular fill, meeting or exceeding Waka Kotahi Specification M4 material compacted to Specification B2 requirements (or better). The engineered granular fill should extend for the full depth of the socket, however a layer of engineered granular fill above natural ground of high strength may be acceptable where post pullover tests demonstrate acceptable performance.

d. The minimum length of flexible barrier is to be as per the tested system length. A minimum installation length in accordance with Austroads technical advice SBTA 21-002 may be acceptable where physical constraints preclude an optimal length of installation and these have been clearly demonstrated and documented by the Installation Designer.

e. The maximum length of flexible barrier between anchors is up to 2500 m where this in accordance with the System Owner's and System Supplier's guidance.

f. For horizontal radii above 600 m a median width less than 4 m and post spacing up to 3 m may be acceptable in constrained situations. For horizontal radii below 600 m, the Installation Designer should consider a wider median and/or closer post spacing to mitigate risk of vehicle intrusion into the opposing lane. Other design factors such as sight distance, available seal width, AADT and maintenance must also be considered.

g. For horizontal radii below 250 m, the Installation Designer should consider mitigation for issues caused by differences in tension, or another barrier type (semi-rigid or rigid).

h. Flexible barrier should not be used where fixed hazards (eg utility poles, trees, sign gantries) are within the tested deflection width. Where non-fixed hazards may be within the deflection width the Installation Designer must use a risk assessment to determine the appropriateness of the selected barrier type. Note that horizontal curvature can complicate deflection concerns especially on convex curves.

i. Flexible barriers should be avoided on popular motorcyclist routes. While no direct evidence of increased injury from the horizontal elements has been found, safety barrier posts present the greatest risk for motorcyclist injury and in these situations, a barrier system with crash tested under-run is advised over flexible barriers with post cushions.

j. Flexible barrier cables or straps that are under tension must be de-tensioned prior to cutting.

k. Drive-by system inspections are recommended at least monthly, and hands-on inspections are recommended at least yearly.

l. All flexible barrier systems must be checked after impacts to ensure that the tension is maintained.

m. For new installations, lighting columns shall be installed so that there is at least 1.5 m clearance between the closest parts of the barrier system and the lighting column. In retrofit situations only, the clearance may be reduced to 1.0 m with application to, and acceptance by, the Lead Safety Advisor. Lighting columns within the working width of barriers must be passively safe and should not be on a frangible 'slip base' (for retrofit installations these should be modified to reduce the risk of being activated by a deflecting barrier).

Brifen MASH wire rope safety barrier

Summary	
Test level / conditions:	TL-3
For use with	Brifen MASH end terminal
Status	Accepted
Technical information	
Dimensions	• Cable heights (to centre of cable): 890 mm, 710 mm, 530 mm and 355 mm • Cable: Pre-stretched 19 mm 3 x 7 strand • Post spacing: 2.1 m
Tested length	164.5 m between points of redirection
Working width	2.4 m (deflection 2.4 m)
Footings	• Default footing: Concrete footings 300 mm diameter, 900 mm deep • Alternate footing: Concrete footings as per Waka Kotahi TAN #16-18
Clear area	6 m wide by 18.5 m long from point of redirection

Grade or placement restrictions	• A maximum side slope of 10H:1V (10%)
	• Offset to batter hinge point:
	  ○ Working width (preferred)
	  ○ 1 m (minimum - refer Waka Kotahi TAN #16-18)

Other restrictions / considerations	• Point of redirection is 11.25 m from the anchor • Minimum horizontal radius is 200 m • Minimum sag vertical curve (K value) is ≥ 30 • Refer also to general notes for flexible barriers

MASHFlex wire rope safety barrier

Summary	
Test level / conditions:	TL-3 and TL-4
For use with	MashFlex end terminal
Status	Accepted
Technical information	
Dimensions	• Cable heights (to centre of cable): 800 mm, 780 mm, 670 mm and 570 mm • Cable: Pre-stretched 19 mm 3 x 7 strand • Post spacing: 2.5 m or 3.0 m
Tested length	188 m between points of redirection
Working width	• TL-3 2.19 m (2.5 m post spacing) (deflection 2.19 m) • TL-3: 2.73 m (3.0 m post spacing) (deflection 2.68 m) • TL-4: 3.80 m (3.0 m post spacing) (deflection 2.80 m)

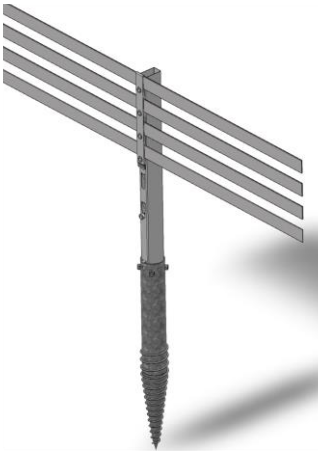
Footings	• Default footing: Concrete footings 300 mm diameter, 600 mm deep
	• Alternate footing:
	  ○ Concrete footings as per Waka Kotahi TAN #16-18
	  ○ Driven socket as per General Notes above
	  ○ Base plated post as per System Supplier's guidance

Clear area	6 m wide by 18.5 m long from point of redirection

Grade or placement restrictions	• A maximum side slope of 10H:1V (10%)
	• Offset to batter hinge point:
	  ○ Working width (preferred)
	  ○ 1 m (minimum - refer Waka Kotahi TAN #16-18)

Other restrictions / considerations	• Point of redirection is 11.73 m from the anchor • Minimum horizontal radius is 200 m • Minimum sag vertical curve (K value) is ≥30 • Refer also to general notes for flexible barriers

ROBOS safety barrier system



Summary	
Test level / conditions:	TL-3 and TL-4
For use with	ROBOS end terminal
Status	Accepted
Technical information	
Dimensions	• Strap heights (to top of strap): 960 mm, 840 mm, 720 mm and 600 mm • Strap: high tensile galvanized flat steel strap 53 mm x 2.95 mm (single-sided variant has four straps, double-sided variant has eight straps) • Post spacing: 3.0 m
Tested length	180 m between points of redirection
Working width	• single sided variant: i. TL-3: 2.25 m (deflection 2.16 m) ii. TL-4: 3.09 m (deflection 2.88 m) • Double sided variant i. TL-3: 1.96 m (deflection 1.96 m) ii. TL-4: 3.09 m (deflection 2.88 m)
Footings	Ground screw 1000 mm long
Clear area	6 m wide by 18.5 m long from point of redirection
Grade or placement restrictions	• A maximum side slope of 10H:1V (10%) • Offset to batter hinge point: ○ Working width (preferred) ○ 1 m (minimum - refer Waka Kotahi TAN #16-18)
Other restrictions / considerations	• Point of redirection: ○ TL-3: interface between barrier and end treatment ○ TL-4: 53.8 m (leading) / 93 m (trailing) • Minimum horizontal radius is 250 m • Minimum sag vertical curve (K value) is ≥25 • This system can be installed on the roadside or in the median (double or single sided) • Installation requires specialised automated equipment. Automated installation requires approval from the road authority. • The minimum ground screw installation torque provided in the installation manual must be achieved for every ground screw

	• Refer also to general notes for flexible barriers

Sentryline-M wire rope safety barrier

Summary	
Test level / conditions:	TL-3 and TL-4
For use with	Sentryline-M end terminal
Status	Accepted
Technical information	
Dimensions	• Cable heights (to centre of cable): 900 mm, 800 mm, 700 mm and 590 mm • Cable: Pre-stretched 19 mm 3 x 7 strand • Post spacing: 3.0 m
Tested length	185 m between points of redirection
Working width	• TL-3: 3.02 m (deflection 3.02 m) • TL-4: 3.05 m (deflection 3.02 m)

Footings	• Default footing: Concrete footings 300 mm diameter, 750 mm deep
	• Alternate footing:
	  ○ Concrete footings as per Waka Kotahi TAN #16-18
	  ○ Driven socket as per General Notes above
	  ○ Base plated post as per System Supplier's guidance
	  ○ Alternate anchor blocks (3.4 m x 1.5 m x 0.74 m or 3.4 m x 1.0 m x 1.0 m (LxWxD))

Clear area	6 m wide by 18.5 m long from point of redirection

Grade or placement restrictions	• A maximum side slope of 10H:1V (10%)
	• Offset to batter hinge point:
	  ○ Working width (preferred)
	  ○ 1 m (minimum - refer Waka Kotahi TAN #16-18)

Other restrictions / considerations	• Point of redirection is 5.5 m from the anchor • Minimum horizontal radius is 200 m • Minimum sag vertical curve (K value) is ≥30 • Refer also to general notes for flexible barriers

Semi-rigid barriers

The following general notes apply to all semi-rigid barriers:

a. The minimum performance level for state highways is MASH TL-3.

b. ‘Weak post’ W-beam systems have occupant risk values similar to flexible cable/strap barriers and may therefore be considered 'flexible' in an Austroads design context.

c. Ground conditions to be checked and confirmed to meet or exceed test conditions. Where the ground conditions fall below those used in the crash testing of the accepted system under consideration, the Installation Designer shall either amend the foundation design in accordance with the design/installation guidance provided by the System Supplier or consider an alternative protection system.

d. When upgrading an existing barrier from timber posts to steel posts the ground conditions must be checked as in item b. The timber post must be removed, and the cavity backfilled with suitable material and compacted. Where the cavity is behind a new post location material finer than AP40 mixed with a small percentage of cement (eg 0.5%) may be an acceptable solution.

e. Accepted M23-compliant W-beam end terminals must be used to terminate and anchor W-beam barriers, except where the W-beam is transitioned to a rigid barrier using an accepted transition.

f. A minimum installation length in accordance with Austroads technical advice SBTA 21-002 may be acceptable where physical constraints preclude an optimal length of installation and these have been clearly demonstrated and documented by the Installation Designer.

g. All shop-curved W-beams must be weld marked (or similar) with the nominal radius prior to galvanising to assist with maintenance activities.

h. W-beam guardrail element may be considered serviceable after localised damage to a single rib, but non-serviceable if there is damage to two ribs within 2 m. Thrie-beam guardrail element may be considered serviceable after localised damage to a single rib, but non-serviceable if there is damage to two or more ribs within 2 m.

i. May be used for long term or temporary work area protection.

j. Where the barrier posts damage the ground surface, creating potential for water ingress, this must be rectified eg by sealing with a granular and bitumen mixture.

k. For new installations, lighting columns shall be installed so that there is at least 1.5 m clearance between the closest parts of the barrier system and the lighting column. In retrofit situations only, this may be reduced to 1.0 m with application to, and acceptance by, the Lead Safety Advisor. Lighting columns within the working width of barriers must be passively safe and should not be on a frangible ‘slip base’ (for retrofit installations these should be modified to reduce the risk of being activated by a deflecting barrier).

l. In constrained locations, the barrier posts may be installed at reduced post spacing to slightly reduce the barrier working width and deflection, where this is warranted by the System Supplier. Decreased post spacing may an adverse effect on barrier performance with light vehicles. Decreased post spacing should not be used as a substitute for removal or relocation of a hazard or installation of a higher-performing barrier system. Irrespective of approach, working width clearance must be maintained or a departure sought.

m. In constrained locations where driven posts cannot be installed, the barrier may be installed on system specific base plated posts on a ground beam or structure, as detailed in the System Supplier’s installation guidance and/or as per Waka Kotahi TM-2012.

Ezy-Guard 4 W-beam barrier

Summary	
Test level / conditions:	TL-3
For use with	M23-compliant W-beam end terminals (e.g. SoftStop W-beam terminal), appropriate transition to Thrie-beam, QuadGuard M10 (via QUAD-BEAM transition) and Ingal RBT or RSB-5M transition
Status	Accepted

Technical information	
Dimensions	• Post Length: 1.650 m (embedment depth 873 mm) • System Width: 200 mm • Rail Height: 790 mm • Post spacing: 1.905 m
Minimum length	As per Austroads technical advice SBTA 21-002
Working width	1.65 m (deflection 1.65 m)
Weight	• Post mass: 12.5 kg (2 posts required per guardrail panel) • W-beam guardrail: 47 kg (per panel)
Grade or placement restrictions	A maximum approach and cross slope of 1V:10H is preferable. On slopes greater than this, acceptance is required from the RCA
Other restrictions / considerations	• Ezy-Guard 4 can be used for curves with radius ranging from 5 m to 45 m. Curves in excess of 45 m do not require shop curving as the rail can be field installed to suit. If the curve is less than 25 m, refer to Waka Kotahi technical note TM-2008 • This system can be installed on the roadside or in the median (double or single sided) • The Ezy-Lift carriage may be used with this system where the road surface has been overlaid • Posts may be spaced at 0.95 m in constrained locations where this is accepted by the road controlling authority • In constrained locations where driven posts cannot be installed, the barrier may be installed with a single 5.7 metre clear span as detailed in the System Supplier's installation guidance, providing that the barrier is no closer than the system dynamic deflection from the shoulder hinge point • May be installed in socketed concrete foundation as per System Supplier's drawing EZY-SM-143 Rev 0. Ground supporting the sockets must include >100 mm dense asphaltic concrete surface • Refer also to general notes for semi-rigid barriers

Nu-Guard 31 W-beam barrier

Summary	
Test level / conditions:	TL-3
For use with	M23-compliant W-beam end terminals (e.g. MAX-Tension W-beam terminal), appropriate transition to Thrie-beam and RSB-5M transition
Status	Accepted
Technical information	
Dimensions	• Post Length: 1.980 m • System Width: 0.61 mm • System Height: 787 mm • Post spacing: 1.905 m
Minimum length	As per Austroads technical advice SBTA 21-002
Working width	1.33 m (deflection 1.30 m)
Weight	• Post: 14.78 kg (2 posts required per guardrail panel) • W-beam guardrail: 47 kg
Grade or placement restrictions	A maximum approach and cross slope of 1V:10H is preferable. On slopes greater than this, acceptance is required from the RCA
Other restrictions / considerations	• For radii below 25 m, refer to Waka Kotahi technical note TM-2008 • Transitions to other barrier types available • From December 2017, all Nu-Guard 31 installations must have top of post 10mm below top edge of W-beam element. Existing installations with the posts above the W-beam may be retrospectively adjusted to new configuration. Top of W-beam element unchanged at 790mm • This system can be installed on the roadside or in the median (double or single sided) • Refer also to general notes for semi-rigid barriers

RamShield W-beam barrier

Summary	
Test level / conditions:	TL-3
For use with	M23-compliant W-beam end terminals (e.g. MSKT W-beam terminal), appropriate transition to Thrie-beam, RamShield Transition (Drawing SD-RB-04000) and RSB-5M transition
Status	Accepted
Technical information	
Dimensions	• Post Length: 1.560 m • System Width: 183 mm • System Height: 800 mm • Post spacing: 1.905 m
Minimum length	As per Austroads technical advice SBTA 21-002
Working width	1.63 m (deflection 1.56 m)
Weight	• Post: 15 kg (2 posts required per guardrail panel) • W-beam guardrail: 47 kg
Grade or placement restrictions	A maximum approach and cross slope of 1V:10H is preferable. On slopes greater than this, acceptance is required from the road controlling authority
Other restrictions / considerations	• Any increase in height to match W-beam terminal end must occur over a minimum of 2 lengths (7.62 m) • For radii below 25 m, refer to Waka Kotahi technical note TM-2008 • Transitions to other barrier types available • This system can be installed on the roadside or in the median (single sided - not suitable for impact on the post side) • An isolated 5.7 m span between posts may be provided where posts cannot be driven or founded on a ground beam and the resultant change barrier performance is acceptable to the road controlling authority • Posts may be spaced at 0.95 m in constrained locations where this is accepted by the road controlling authority • Refer also to general notes for semi-rigid barriers

Sentry W-beam barrier

Summary	
Test level / conditions:	TL-3
For use with	M23-compliant W-beam end terminals (e.g. MAX-Tension W-beam terminal), appropriate transition to Thrie-beam and RSB-5M transition
Status	Accepted
Technical information	
Dimensions	• Post Length: 1.640 m • System Width: 201 mm • System Height: 800 mm • Post spacing: 1.905 m
Minimum length	As per Austroads technical advice SBTA 21-002
Working width	1.59 m (deflection 1.59 m)
Weight	• Post: 13.7 kg (2 posts required per guardrail panel) • W-beam guardrail: 47 kg
Grade or placement restrictions	A maximum approach and cross slope of 1V:10H is preferable. On slopes greater than this, acceptance is required from the road controlling authority
Other restrictions / considerations	• Any increase in height to match W-beam terminal end must occur over a minimum of 2 lengths (7.62 m) • For radii below 25 m, refer to Waka Kotahi technical note TM-2008 • Transitions to other barrier types available, including MASH tested RSB-5M transition • This system can be installed on the roadside or in the median (double or single sided) • Refer also to general notes for semi-rigid barriers

Ezy-Guard Thrie-beam barrier (HC and LDS)

Summary	
Test level / conditions:	TL-3 and TL-4
For use with	An appropriate transition to W-beam, concrete (Ingal RBT or RSB-5M transition) or QuadGuard M10 to provide a crashworthy terminal and anchorage
Status	Accepted
Technical information	
Dimensions	• Z-Post length: 2.0 m (The Z-post embedment depth is 1.030 m) • System Width: 245 mm • Rail Height: 980 mm • Post spacing: 2.0 m
Minimum length	Ezy-Guard HC: MASH TL-4 system 82 m (excluding transitions and terminals/crash cushions) Ezy-Guard LDS: MASH TL-4 system 63 m (excluding transitions and terminals/crash cushions)

Working width	• Ezy-Guard HC
	  ○ TL-3: 1.16 m (deflection 1.16 m)
	  ○ TL-4: 1.80 m (deflection 1.20 m)
	• Ezy-Guard LDS
	  ○ TL-3: 1.20 m (deflection 1.10 m)
	  ○ TL-4: 2.50 m (deflection 1.10 m)

Weight	• Post mass: 19.5 kg (2 posts required per guardrail panel) • Thrie-beam guardrail: 72 kg (per panel)
Grade or placement restrictions	A maximum approach and cross slope of 1V:10H is preferable. On slopes greater than this, acceptance is required from the road controlling authority
Other restrictions / considerations	• Accepted transitions must be used to connect the Ezy-Guard Thrie-beam barrier system to adjoining W-beam barrier and/or terminals • Ezy-Guard HC can be installed on the roadside or in the median (double or single sided) • LDS variant does not currently have an accepted base plate option • LDS 1:1 (slope) batter hinge point variant (TL-3 only) requires demonstration of site-specific factors including but not limited to suitable ground conditions, whole of life costs and maintenance regime, as well as site specific acceptance from the Waka Kotahi Lead Safety Advisor • Refer also to general notes for semi-rigid barriers

RamShield High Containment HC

Summary	
Test level / conditions:	TL-3 and TL-4
For use with	An appropriate transition to W-beam or concrete (RamShield Transition – Drawing SD-RB-04001 or RSB-5M transition).
Status	Accepted
Technical information	
Dimensions	• Post Length: 1.860 m • System Width: 230 mm • System Height: 1.0 m • Post spacing: 2.0 m
Minimum length	MASH TL-4 system 82 m (excluding transitions and terminals/crash cushions)
Working width	• TL-3: 1.00 m (deflection 1.00 m) • TL-4: 2.20 m (deflection 1.10 m)
Weight	• Post mass: not provided • Thrie-beam guardrail: 72 kg (per panel)
Grade or placement restrictions	A maximum approach and cross slope of 1V:10H is preferable. On slopes greater than this, acceptance is required from the road controlling authority
Other restrictions / considerations	• Accepted transitions must be used to connect the RamShield HC barrier system to adjoining W-beam barrier and/or terminals • This system can be installed on the roadside or in the median (single sided - not suitable for impact on the post side) • RamShield EDGE variant requires demonstration of site-specific factors including but not limited to suitable ground conditions, whole of life costs and maintenance regime, as well as site specific acceptance from the Waka Kotahi Lead Safety Advisor • Refer also to general notes for semi-rigid barriers

Sentry Thrie-beam barrier

Summary	
Test level / conditions:	TL-3 and TL-4
For use with	An appropriate transition to W-beam or concrete (RSB-5M transition)
Status	Accepted

Technical information	
Dimensions	• Post Length: 2.0 m • System Width: 200 mm • System Height: 1.05 m • Post spacing: 2.0 m
Minimum length	MASH TL-4 system 86 m (excluding transitions and terminals/crash cushions)
Working width	• TL-3: 1.53 m (deflection 1.45 m) • TL-4: 2.80 m (deflection 1.53 m)
Weight	• Post: 20.5 kg (2 posts required per guardrail panel) • Thrie-beam guardrail: 72 kg (per panel)
Grade or placement restrictions	A maximum approach and cross slope of 1V:10H is preferable. On slopes greater than this, acceptance is required from the road controlling authority
Other restrictions / considerations	• Accepted transitions must be used to connect the Sentry Thrie-beam barrier system to adjoining W-beam barrier and/or terminals • This system can be installed on the roadside or in the median (double or single sided) • Refer also to general notes for semi-rigid barriers

Rigid roadside and median barriers

The following general notes apply to all rigid barriers:

a. A site-specific risk assessment must be undertaken for every design to ensure residual risks have been considered.

b. For rigid barriers used in roadside applications and bridge barriers refer to M23 Appendix B.

Aesthetic barriers

Aesthetic barrier systems comprise timber facings over steel rails and steel posts. The timber facings may result in more visually appealing systems than those using steel components.

The following general notes apply to all aesthetic barriers:

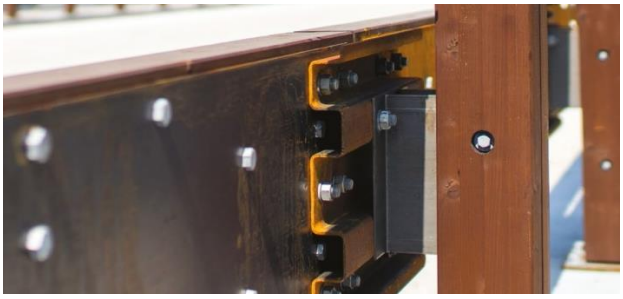
a. Aesthetic barrier systems are considered suitable for use on local road networks with vehicle operating speeds up to 70 km/h at the discretion of the road controlling authority.

b. Currently no MASH or NCHRP 350 crash tested end terminal is available for aesthetic barrier systems.

c. Aesthetic barrier systems are not for use on the state highway network without site specific acceptance from the Waka Kotahi Lead Safety Advisor.

d. Aesthetic barrier systems are terminated using a proprietary sloping end which should be flared away from traffic, wherever possible, to mitigate risk of end-on impact. The terminal end must be flared away from the road at least 500 mm (flare rate to comply with Austroads GTRD Part 6). Whenever practical consider extending the rail and terminal end to achieve a greater offset.

Margaritelli aesthetic barrier H1BL-01 and H2BL-01



Summary	
Test level / conditions:	• H1BL-01 - Tested to EN1317 Part 1 and 2 Test Level H1 (approximately equivalent to MASH TL-2) • H2BL-01 - Tested to EN1317 H1 (approximately equivalent to MASH TL-3)
For use with	Tested with a proprietary end anchored to the ground
Status	• Not for use on state highways without site specific acceptance from the Waka Kotahi Lead Safety Advisor • Maximum 70 km/h posted speed limit
Technical information	
Dimensions	• Post Spacing: 3 m (H1BL-01) • Post length: 1.77 m • Rail Height: 830 mm
Minimum length	81 m (H1BL-01) or 90 m (H2BL-01) (excluding terminals)
Deflection	• 1.5 m (H1BL-01 TB42 test) • 1.59 m (H2BL-01 TB51 test)
Weight	Post weight: 15.83 kg
Grade or placement restrictions	A maximum approach and cross slope of 1V:10H is preferable. On slopes greater than this, acceptance is required from the road controlling authority
Other restrictions / considerations	• The H1BL-01 and H2BL-01 systems are terminated using proprietary sloping end or curved terminal ends which are not energy absorbing. The barrier end should be flared away from traffic to mitigate risk of end-on impact • Refer also to general notes for aesthetic barriers

Timber Faced Guardrail GRP

Summary	
Test level / conditions:	• Tested to EN1317 N2 – 1500 kg car at 110 km/h and 20° with 1.5, 2, 3, 4 & 6 m post spacing (approximately equivalent to MASH TL-1) • Tested to EN1317 H1 – 10 000 kg truck at 70 km/h and 15° with 1.5 m post spacing (approximately equivalent to MASH TL-2)
For use with	Tested with a proprietary end anchored to the ground
Status	• Not for use on state highways without site specific acceptance from the Waka Kotahi Lead Safety Advisor • Maximum 70 km/h posted speed limit
Technical information	
Dimensions	• Post Spacing: 1.5, 2, 3 or 6 m • Rail Height: 781 mm ± 20 mm above ground level height
Minimum length	84 m (excluding terminals)
Other restrictions / considerations	Refer to general notes for aesthetic barriers

Timber Faced Guardrail G4M and G2M

Summary	
Test level / conditions:	Tested to EN1317 N2 – 1500 kg car at 110 km/h and 20° with 1.5, 2, 3, 4 & 6 m post spacing (approximately equivalent to MASH TL-1)
For use with	Attaches to C100 anchor with terminal end rail
Status	• Not for use on state highways without site specific acceptance from the Waka Kotahi Lead Safety Advisor • Maximum 60 km/h posted speed limit
Technical information	
Dimensions	• Post Spacing: 4 m (radii >29 m) or 2 m (radii <29m) • Rail Height: 700 mm ± 20 mm above ground level height
Minimum length	60 m (excluding terminals)
Other restrictions / considerations	• Posts can be moved along the rail without affecting the rail integrity, if required to avoid underground services, boulders or tree roots, on installation • The Timber Faced Guardrail G4m & G2m is terminated using a proprietary sloping end which should be flared away from traffic, wherever possible, to mitigate risk of end-on impact • Recommended installation is that the terminal end should be flared away from the road at least 300 mm. Whenever practical consider extending the rail and terminal end to achieve a greater flare • Handrail systems can be added at any height required for cyclists and pedestrians at discretion of road controlling authority • Back masks for the rail and posts are available to cover steel components at the rear of the Timber Faced Guardrail • Refer also to general notes for aesthetic barriers

T-MASH 18

Summary	
Test level / conditions:	TL-2
For use with	Tested with a proprietary 4 m sloping end anchored to the ground
Status	• Not for use on state highways without site specific acceptance from the Waka Kotahi Lead Safety Advisor • Maximum 70 km/h posted speed limit
Technical information	
Dimensions	• Post Spacing: 4 m (4M) or 2 m (4MS2) • Rail Height: 700 mm + 0/- 50 mm above ground level
Deflection	1.0 m
Minimum length	80 m (excluding terminals)
Other restrictions / considerations	• T-MASH 18 is terminated using a proprietary 4 m sloping end which should be flared away from traffic, wherever possible, to mitigate risk of end-on impact. Recommended installation is that the terminal end should be flared away from the road at least 300 mm. Whenever practical consider extending the rail and terminal end to achieve a greater flare • Refer also to general notes for aesthetic barriers

Continuous motorcyclist protection systems (CMPS)

The following general notes apply to all continuous motorcyclist protection systems:

a. EN1317-8 Impact Severity Level 1 is the minimum standard for use on state highways.

b. Length of installation should be chosen based on the length of the associated semi-rigid barrier system and the requirement for CMPS based on a site-specific risk assessment. Risk assessment should include factors such as traffic volumes, operating speed and road geometry. Indicative horizontal curve radii thresholds for a treatment are 250 m or 400 m, depending on other risk factors and funding (refer M23 main document).

c. Kerbs and other drainage features may affect performance and should not be present.

d. It is recommended that CMPS not be installed within the W-beam end terminal section.

Biker-shield Motorcyclist Protection Rail

Summary	
Test level / conditions:	Continuous motorcyclist protection system (CMPS) under AS/NZS3845.1:2015
For use with	Ramshield W-beam and High Containment Thrie-beam barrier systems and strong post timber W-beam (SGR04B). May also be fitted to Nu-Guard 31 W-beam barrier
Status	Accepted

Technical information	
Dimensions	• Splice joint spacing: 3.81 m • Bracket spacing: 1.905 m (midspan) • Rail height above ground: 60 mm clearance underneath (maximum)
Weight	5.90 kg per metre
Performance	Dummy tested to EN1317-8 Impact Severity Level 2 for following tests: • TM 1.60: Dummy to post, 60 km/h 30° angle of impact • TM 3.60: Dummy to point on barrier midway between posts, 60 km/h 30° angle of impact Tested to MASH TL3: 1,100 kg car at 100 km/h and 25° angle of impact
Other restrictions / considerations	• A BIKER-SHIELD™ bullnose must be installed on the leading and trailing end of the system • May be retrofitted to Strong Post and Nu-Guard 31 W-beam barrier systems. Where installation requires on site drilling, any holes shall be formed using a step bit or auger bit to ensure a clean hole. The hole shall be cleaned of any swarf and the surrounding area cleaned and wire brushed. The cut edges and surrounding area including any damaged galvanising shall then be treated with 2 coats of a suitable un-thinned zinc-rich primer paint applied to the cleaned and dried surface in accordance with AS/NZS 2312:2014

Ingal Motorcyclist Protection Rail

Summary	
Test level / conditions:	Continuous motorcyclist protection system (CMPS) under AS/NZS3845.1:2015
For use with	Ingal Ezy-Guard W-beam barrier systems, Ezy-Guard HC & LDS Thrie-beam barriers and strong post timber W-beam (SGR04B). May also be fitted to Nu-Guard 31 W-beam barrier
Status	Accepted

Technical information	
Dimensions	• Splice joint spacing: 3.81 m • Bracket spacing: 1.905 m (midspan) • Rail height above ground: 60 mm clearance underneath (+20 mm)
Weight	4.65 kg per metre
Performance	Tested to EN1317-8 Impact Severity Level 1 for following tests: • TM 1.60: Dummy to post, 60 km/h 30° angle of impact • TM 3.60: Dummy to point on barrier midway between posts, 60 km/h 30° angle of impact. TB11: 900 kg car at 100 km/h and 20° angle of impact • TB32: 1,500 kg car at 110 km/h and 20° angle of impact
Other restrictions / considerations	• Can be applied to curved W-beam with radii down to 26 m. For lower radii pre-curved rail is available • Each end of the run must be terminated with an MPR Terminal End • May be retrofitted to Strong Post and Nu-Guard 31 W-beam barrier systems. Where installation requires modifications to the bracket connecting MPR to the barrier post any such modification shall be accepted by the System Owner

Rider Pro MPR

Summary	
Test level / conditions:	Continuous motorcyclist protection system (CMPS) under AS/NZS3845.1:2015
For use with	Sentry W-beam and Sentry Thrie-beam
Status	Accepted
Technical information	
Dimensions	• Splice joint spacing: 3.81 m • Bracket spacing: 1.905 m • Rail height above ground: 30 mm clearance underneath (+10/-0 mm)
Weight	5.8 kg per metre
Performance	Tested to MASH 3-10 and 3-11and EN1317-8 Impact Severity Level 1 for following tests: • TM 1.60: Dummy to post, 60 km/h 30° angle of impact • TM 3.60: Dummy to point on barrier midway between posts, 60 km/h 30° angle of impact.
Other restrictions / considerations	• Can be applied to curved W-beam with radii down to 25 m • The rail height ensures a uniform distance from the ground throughout the run and compensating for uneven terrain and height differences in the existing barriers • Each end of the run must be terminated with a RiderPro MPR Terminal End

Discontinuous motorcyclist protection systems (DMPS)

Stack Cushion

Summary	
Test level / conditions:	Discontinuous motorcyclist protection system (DMPS) under AS/NZS3845.1:2015
For use with	Compatible safety barrier posts with a maximum post size of 100 x 50 mm
Status	Accepted
Technical information	
Dimensions	• Height: 490 mm • Diameter: 200 mm • Recess: 100 x 50 mm
Other restrictions / considerations	• Headform Drop Test achieved acceptable HIC values at an impact speed of 30 km/h – ie performance at higher impact speeds is unknown • Can be retrofitted to existing barrier installations • For median use orientate towards direction with greater risk or alternate orientation, as appropriate

W-Beam end terminals

The following general notes apply to all W-beam end terminals:

a. Ground conditions to be checked and confirmed at least as good as test conditions. Where the ground conditions vary from the standardised soil used in the crash testing of the accepted system under consideration, the Installation Designer shall either amend the foundation design in accordance with the design/installation guidance provided by the System Supplier or consider an alternative protection system.

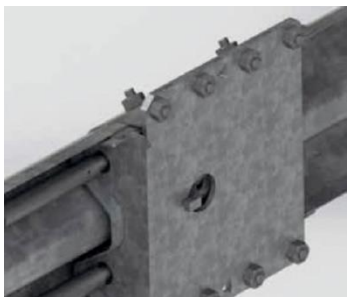
b. MASH surface mounted end terminals are not currently available. NCHRP350 surface mounted terminals may be an option where there is no better alternative, however site-specific acceptance is required from the Waka Kotahi Lead Safety Advisor prior to specification or installation.

MSKT end terminal

Summary	
Test level / conditions:	TL-2 and TL-3
For use with	W-beam guardrail
Status	Accepted (TL-2 version not accepted for state highway use)

Technical information	
Dimensions	• TL-3 Length: 14.29 m • TL-2 length: 9.50 m (not for state highway use) • Rail height: 790 mm • Post spacing: 1905 mm centres
Point of redirection	Length of need measured from point of redirection at post #3
Clear area	6 m wide by 18.5 m long from point of redirection
Grade or placement restrictions	• Maximum approach and cross slope of 10H:1V • Terminal grading in accordance with Waka Kotahi RSB-3
Other restrictions / considerations	• The primary mechanism for dissipation of end impact energy is through extrusion of the W-beam element. Extruded rail is flattened and spools out the back of the barrier, away from the road • First rail used must be a special kinking rail with slotted holes • 600 mm maximum flare at impact head • Any reduction in height to match W-beam barrier must occur over a minimum of 2 lengths (7.62 m) • W-beam splices at mid-span of the posts • Drive-by system inspections are recommended at least monthly, and hands-on inspections are recommended at least yearly

MAX-Tension end terminal system



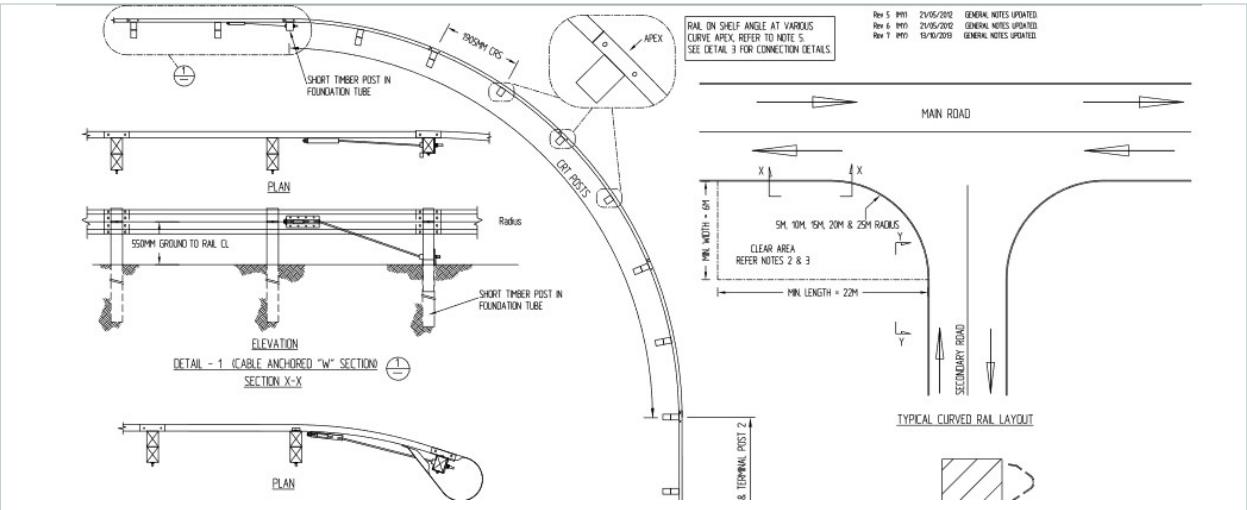
Summary	
Test level / conditions:	TL-2 and TL-3
For use with	W-beam guardrail
Status	Accepted (TL-2 version not accepted for state highway use)

Technical information	
Dimensions	• TL-3 length: 16.77 m • TL-2 length: 7.89 m (not for state highway use) • System width: 180 mm • System height: 787 mm • Post Spacing: Generally, 1905 mm centres except posts 0-1 (1619 mm), posts 1-2 (953 mm) and posts 5-6 (1848 mm)
Point of redirection	Length of need measured from point of redirection at post #3 (TL-3)
Clear area	6 m wide by 18.5 m long from point of redirection
Grade or placement restrictions	• Maximum approach and cross slope of 10H:1V • Flared or tangential terminal layouts acceptable • Terminal grading in accordance with Waka Kotahi RSB-3
Other restrictions / considerations	• 610 mm maximum flare at impact head • W-beam splices at mid-span of the posts • The frequency of drive-by inspections is dependent on the traffic volume and the impact history of the system. Drive-by inspections are recommended at least monthly. Hands-on inspections are recommended at least yearly

SoftStop end terminal system

Summary	
Test level / conditions:	TL-2 and TL-3
For use with	W-beam guardrail
Status	Accepted (TL-2 version not accepted for state highway use)
Technical information	
Dimensions	• TL-3 length: 15.48 m • TL-2 length: 7.89 m • System width: 180 mm System height: 787 mm • Post Spacing: 1905 mm centres
Point of redirection	Length of need measured from point of redirection at post #3 (TL-3)
Clear area	6 m wide by 18.5 m long from point of redirection
Grade or placement restrictions	• Maximum approach and cross slope of 10H:1V • Flared or tangential terminal layouts acceptable • Terminal grading in accordance with Waka Kotahi RSB-3
Other restrictions / considerations	• The primary mechanism for dissipation of end impact energy is through anchorage and extrusion of the W-beam element. Extruded rail is flattened and maintains connection to unit • The frequency of drive-by inspections is dependent on the traffic volume and the impact history of the system. Drive-by inspections are recommended at least monthly. Hands-on inspections are recommended at least yearly • W-beam splices at mid-span of the posts • The SoftStop End Terminal can be assembled with a flare to offset the head 600 mm for the TL-3 system (300 mm for the TL-2 system). The flare must be over the length of the system. The maximum flare rate is 1:25 • Alternative anchor post concrete foundation is limited to constrained locations where a driven post cannot be installed. Must be accompanied by site specific ground investigation. Site specific acceptance is required from the Waka Kotahi Lead Safety Advisor • Baseplated variant on concrete foundation is limited to constrained locations where a driven post cannot be installed

Curved W-beam guardrail terminal (RSB-2, RSB-2A)



Summary	
Test level / conditions:	NCHRP 350 TL-3
For use with	Public domain or proprietary W-beam barrier systems in curved installations or as termination into low-risk side road or access
Status	Accepted

Side roads or driveways commonly intersect a highway close to the end of a bridge or other immovable, restrictive feature which prevent barrier length of need being achieved. In many of these situations, it is not practical to change the site conditions by relocating the intersecting roadway further away from the bridge end in order to allow room for a standard approach guardrail. Therefore, a curved guardrail installation which would substantially improve the safety at these sites is required. Research undertaken by Washington State Department of Transportation and the Federal Highway Administration (FHWA) has resulted in improved curved guardrail designs from which the Waka Kotahi Curved Guardrail Terminal has been developed.

The RSB-2A curved W-beam guardrail is a continuous guardrail variation of RSB-2.

Technical information	
Dimensions	• Curved W-beam radii: 5 m, 10 m, 15 m, 20 m, 25 m • Post Spacing: 1905 mm centres
Point of redirection	A minimum clear area of 22 m X 6 m with a maximum slope of 6H:1V is to be provided behind the curved rail
Grade or placement restrictions	The approach grading is 10H:1V or flatter and is to be maintained free of obstructions
Other restrictions / considerations	• A substandard clear area requires the acceptance of the RCA • Factory (or “shop”) curved W-beam guardrail is to be used for all curved guardrail elements • Sight distances must be maintained in accordance with the Austroads Guide to Road Design • These designs are most appropriate for use on low volume highways • Where the approach speed on the side road is exceeds 70 km/h, accepted Test Level 3 end terminals should be installed where practicable • The location of the apex posts depends on the most likely directions of impact • The rail at the apex posts is not bolted through but sits on shelf angles to maintain the correct height • At least one intermediate anchor will be required, with two required for the continuous variation • The standard detail given for RSB-2/ RSB-2A is applicable to non-proprietary timber post semi-rigid W-beam barrier systems only. For proprietary semi-rigid guardrail systems, refer to the System Supplier to confirm if equivalent Waka Kotahi accepted details are available

Trailing terminal

Summary	
Test level / conditions:	N/A (non-crashworthy; anchorage only)
For use with	Only to be used to anchor the end of a semi-rigid W-beam barrier system
Status	Accepted

Technical information	
Dimensions	• Length of terminal: 3.81 m • System Height: 706 mm for public domain or 787 mm for proprietary variants • Post Depth: varies • Post Spacing: 1905 mm
Other restrictions / considerations	• The purpose of the Trailing Terminal is to anchor the end of a flexible rail system to keep the tensile strength in the rail • Trailing Terminals are not crashworthy terminals when struck head-on since they are not designed to absorb energy or break away. They must not be installed where there is a likelihood they could be impacted head-on by an errant vehicle except in special cases for low volume, low speed situations where this has been accepted by the RCA • Minor site grading may be necessary for guardrail installations beyond the edge of the shoulder to prevent the anchor points from extending more than 100 mm above the ground • The curved trailing end terminal (CTT) should be used as the default. The straight trailing end terminal (STT) should only be used where space constraints prevent use of a CTT • A bullnose end is required on CTT and STT; a rolled end fitting or fishtail is not allowed • The CTT has an offset at the bullnose of 335 mm

TREND median end terminal

Summary	
Test level / conditions:	TL-3
For use with	Double-sided W-beam median guardrail
Status	Accepted (only for use with double-sided W-beam guardrail)
Technical information	
Dimensions	• Length: 11.1 m • Rail height: 787 mm • Post spacing: 1905 mm centres
Point of redirection	Length of need measured from point of redirection at post #3
Clear area	6 m wide by 18.5 m long from point of redirection
Grade or placement restrictions	• Maximum approach and cross slope of 10H:1V • Terminal grading in accordance with Waka Kotahi RSB-3
Other restrictions / considerations	• The primary mechanism for dissipation of end impact energy is through distortion and rupture of the W-beam and other components. Debris and damaged components can be expected in the vicinity of the terminal during and following a crash. • Must not be curved or flared. • Drive-by system inspections are recommended at least monthly, and hands-on inspections are recommended at least yearly

Crash cushions

The following general notes apply to all crash cushions:

a. Connecting hardware must be kept in good condition and the hardware replaced if it is damaged, including the barrier unit(s) where these are integral. Modification of any kind, including cutting or welding is not acceptable.

b. Bi-directional applications must utilize an accepted bi-directional transition configuration. The barrier system will be considered non-compliant if an appropriate end treatment or transition component is not fitted.

c. Reverse impacts into the transition section can produce unacceptably high occupant severity values. Where reverse impacts are possible (eg bidirectional traffic) a risk assessment must be completed and steps to mitigate the likelihood of reverse impact should be implemented.

d. Site specific grading may be necessary to ensure that there are no “humps” or “hollows” that may significantly alter the impacting vehicle’s stability, reduce surface friction between the barrier and the ground or substantially alter the barrier height in relation to the ground.

e. Crash cushions must be attached to a reinforced concrete base.

f. End treatments should not be installed immediately in front of or behind kerbs.

g. End treatments must be checked frequently for damage and connection condition with any faults corrected in a timely manner.

h. Provide delineation as per TCD Rule requirements.

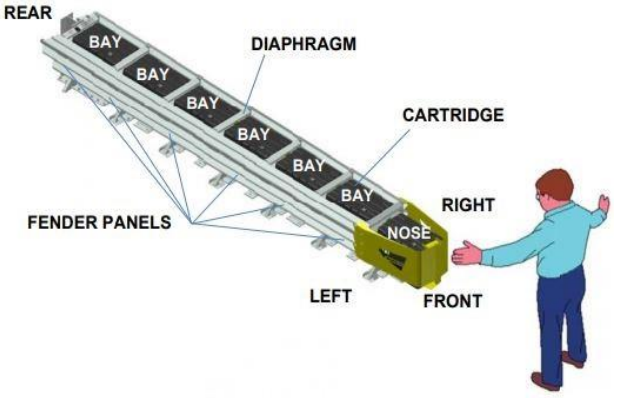
i. The end treatment must be inspected after each impact and where appropriate pulled out to its original length. Depending on the impact and type of end treatment, components may get damaged and need replacement.

Hercules

Summary	
Test level / conditions:	MASH TL-3
For use with	Permanent F-shape rigid concrete barriers
Status	Accepted

Technical information	
Dimensions	• Width: 590 mm • Length: 5.9 m • Height: 890 mm
Weight	1051 kg
Grade or placement restrictions	• 6.0 m x 800 mm x 190 mm depth reinforced concrete • Hazard free area 3 metres downstream of the crash cushion and 12 metres laterally must be provided • Side slope shall not exceed 8%
Other restrictions / considerations	• Requires an anchoring system approved by the System Owner • A transition to adjacent rigid F-shape barriers is required if a reverse-angle impact is possible. Transition hardware is available from the System Supplier

QuadGuard M10, M Wide



Summary	
Test level / conditions:	MASH TL-3 and TL-2
For use with	Permanent F-shape concrete barriers, Thrie-beam guardrail and EzyGuard HC semi-rigid barrier with the appropriate transition (may only be connected to Thrie-beam guardrail or EzyGuard HC where reverse impacts are highly improbable, and a risk assessment has been completed and steps undertaken to mitigate any risks identified)
Status	Accepted (TL-2 version not accepted for permanent state highway use)

Technical information	
Dimensions	• Width: 610 mm (QuadGuard M10) or 1.755 m (QuadGuard M Wide) • Length: 6.71 m (TL-3) or 4.0 m (TL-2) • Height: 817 mm
Weight	Not supplied
Grade or placement restrictions	• Should be assembled on an existing or freshly placed and cured concrete base (Min 28 MPa and 150 mm min depth). The foundation surface shall have a light broom finish • Hazard free area 3.1 m downstream and 11 m laterally to be provided • Cross-slope shall not exceed 8% and should not twist more than 2% over the length of the system
Other restrictions / considerations	• Requires an anchoring system approved by the System Owner • Transitions to adjacent barriers are available from the System Supplier • Visual drive-by inspections are recommended at least once a month. Walk-up inspections are recommended at least once a year

SCI-100 Smart Cushion

Summary	
Test level / conditions:	MASH TL-3 and TL-2
For use with	Permanent F-shape concrete barriers and Thrie-beam guardrail
Status	Accepted (TL-2 version not accepted for permanent state highway use)

Technical information	
Dimensions	• TL-3: 6.55 m long, 609.6 mm wide, 840 mm high • TL-2: 4.12 m long, 609.6 mm wide, 840 mm high
Weight	• TL-3: 1570 kg • TL-2: 1120 kg
Grade or placement restrictions	• Foundations must be a flat surface with longitudinal and cross slopes of 10:1 or less • Smart Cushion impact units should not be located over drainage basins or expansion joints • Portland cement concrete foundation pads are preferred for permanent installations. Asphaltic concrete foundation pads of appropriate thickness may be used for temporary installations
Other restrictions / considerations	• Requires an anchoring system approved by the System Owner • The Smart Cushion side panels can move rearward beyond the end of the attenuator up to 760 mm upon impact. This area is known as the travel zone and must not be obstructed • Barriers that are wider than 610 mm (excepting F-Shape barriers with base widths up to 700 mm) and/or have reverse direction traffic require a transition as per the supplier's recommendations

Universal TAU-M

Summary	
Test level / conditions:	MASH TL-3 and TL-2
For use with	Permanent F-shape concrete barriers and Thrie-beam guardrail
Status	Accepted (TL-2 version not accepted for permanent state highway use)

Technical information	
Dimensions	• TL-2: length: 4 bays, 4.33 m • TL-3: length: 7 bays, 6.93 m • 762 mm width • 830 mm height
Weight	Varies with configuration
Grade or placement restrictions	Side slope limit: Vertical (7%)
Other restrictions / considerations	• Requires an anchoring system approved by the System Owner • All kerbs, islands and elevated objects greater than 100 mm high that would be beneath, beside or less than 15 m in front of a TAU-M crash cushion should be removed prior to installation • Design speed: 100 km/h maximum • For cycleway and pedestrian area use consider potential for snagging and deflection

Median gate systems

Armorguard gate steel median gate system

Summary	
Test level / conditions:	NCHRP 350 TL-3
For use with	Attaches to permanent concrete barrier
Status	Accepted

Technical information	
Dimensions	• Unit Length: 8, 12 and 16 m • Width: 700 mm • Height: 830 mm
Minimum length	8 m
Deflection	Minimum in-service impact deflection of up to 0.6 m should be allowed for irrespective of configuration
Grade or placement restrictions	Maximum site gradient limits of 3% (1V:33H) apply to both side slope and longitudinal slopes at the proposed installation location which must be within a straight alignment
Other restrictions / considerations	• Suitable as a permanent or temporary work area barrier where emergency vehicles, maintenance crews and emergency evacuation access may be needed • Assembled at installation point or offsite • Hinges from either end, can be unpinned for complete removal • Must be within a straight alignment of both carriageway and safety barrier • The maximum clear opening is 16 m • Transitions available to most rigid barrier systems • Manually operated opening system • Both ends of the F-shape concrete median barrier (attached to the gate system) must have base thickening and additional end reinforcement to tolerate the anchorage loads imposed by an impact with the gate system • The installation designer (not the system supplier) must write a standard operating procedure (SOP) for each installation to ensure safe operation of the gate. The SOP must include clear indication of the site gradients and require opening of the gate at the upslope end only, with a suitable restraint system detailed

BG800 gate

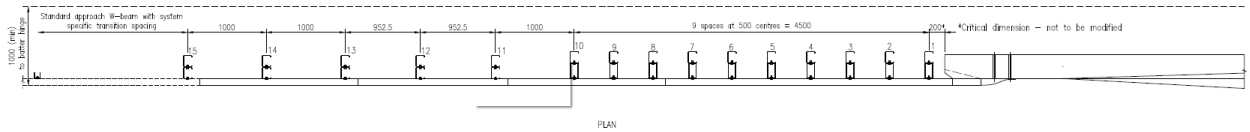
Summary	
Test level / conditions:	NCHRP 350 TL-3
For use with	The BG800 Gate Steel Median Gate System installation may only be installed between anchored BG800 “gate post” connecting sections transitioning to anchored lengths of BG800 steel median barrier or F-shape concrete median barrier.
Status	Accepted
Technical information	
Dimensions	• Unit Length: 3 and 6 m modular units • Width: 540 mm • Height: 915 mm
Minimum length	6 m (minimum opening 4.7 m, maximum opening 28.7 m)
Weight	135 kg per metre
Deflection	1.16 m (NCHRP 350 TL-3: 2000 kg at 100 km/h and 25°)
Grade or placement restrictions	• BG800 Gate should not be installed where there are ditches or kerbs that may affect operation of the gate. It is recommended that the gate is installed on straight sections, but slight curves can be accommodated • The BG800 Gate works on slopes, but it is recommended that the cross fall does not exceed 5% (1V:20H) to allow controlled manual operation • The BG800 Gate requires anchoring with sufficient strength from the supporting ground conditions, to allow the gate to perform as tested. A foundation that conforms with the system supplier’s guidance is required.
Other restrictions / considerations	• Suitable as a permanent or temporary work area barrier where emergency vehicles, maintenance crews and emergency evacuation access may be needed • Assembled at installation point or offsite • Hinges from either end, can be unpinned for complete removal • Must be within a straight alignment of both carriageway and safety barrier • The maximum clear opening is 30 m • Transitions available to most rigid barrier systems • Manually operated opening system • Both ends of the F-shape concrete median barrier (attached to the gate system) must have base thickening and additional end reinforcement to tolerate the anchorage loads imposed by an impact with the gate system • The installation designer (not the system supplier) must write a standard operating procedure (SOP) for each installation to ensure safe operation of the gate. The SOP must include clear indication of the site gradients and require opening of the gate at the upslope end only, with a suitable restraint system detailed

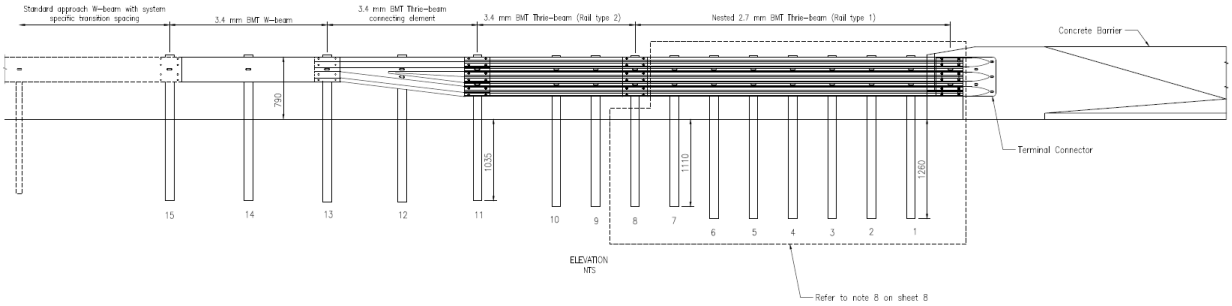
Ironman median gate steel median gate system

Summary	
Test level / conditions:	NCHRP 350 TL-2 and TL-3
For use with	The Ironman Median Gate System may only be installed between anchored lengths of F-shape concrete median barrier
Status	Accepted (TL-2 version not accepted for permanent state highway use)
Technical information	
Dimensions	• Unit Length: 4 m, 8 m or 12 m • Width: 530 mm • Height: 820 mm
Minimum length	4 m
Weight	400 kg (4 m Length) 800kg (8 m Length) 1200 kg (12 m Length)
Deflection	Impact deflection of up to 0.6m
Grade or placement restrictions	Maximum site gradient limits of 3% (1V:33H) apply to both side slope and longitudinal slopes at the proposed installation location which must be within a straight alignment
Other restrictions / considerations	• Provides a method for emergency access or construction access in rigid barriers • The maximum length of any Ironman Median Gate System installation is 25.31 m with a clear opening of 20.57 m (5-unit configuration) • The Ironman can be deployed as a free-standing system or used with a range of end treatments • All installations require site specific acceptance on a case-by-case basis from the Waka Kotahi Lead Safety Advisor to ensure safe operation • Both ends of the F-shape concrete median barrier must have base thickening and additional end reinforcement to tolerate the anchorage loads imposed by an impact with the gate system • The F-shape barrier installation must be integral with, or structurally connected to, the concrete anchor foundations for the Ironman Median Gate steel transition sections • The installation designer (not the system supplier) must write a standard operating procedure (SOP) written for each installation to ensure safe operation of the gate. The SOP must include clear indication of the site gradients and require opening of the gate at the upslope end only, with a suitable restraint system detailed

Transitions

RSB-5M semi-rigid to rigid Thrie-beam transition



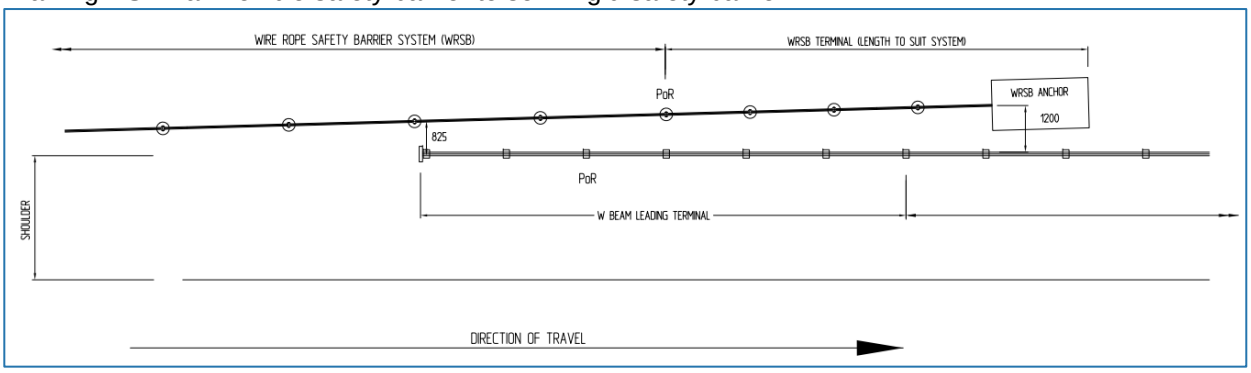


Summary	
Test level / conditions:	MASH TL-3
For use with	Transition from semi-rigid barrier (W-beam or Thrie-beam) to rigid (concrete) barrier
Status	Accepted

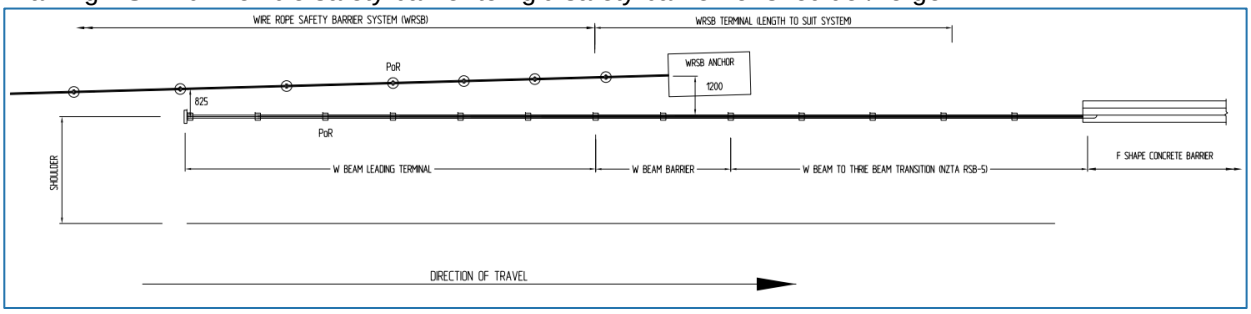
Technical information	
Other restrictions / considerations	• The transition shall be in accordance with the RSB-5M drawings • The rigid barrier for a median system must extend beyond the hazard (e.g. bridge pier or gantry leg) by a minimum of 18m in both directions • The minimum transition length for semi-rigid barrier to concrete barrier is as per the System Supplier's guidance

Flexible safety barrier transitions

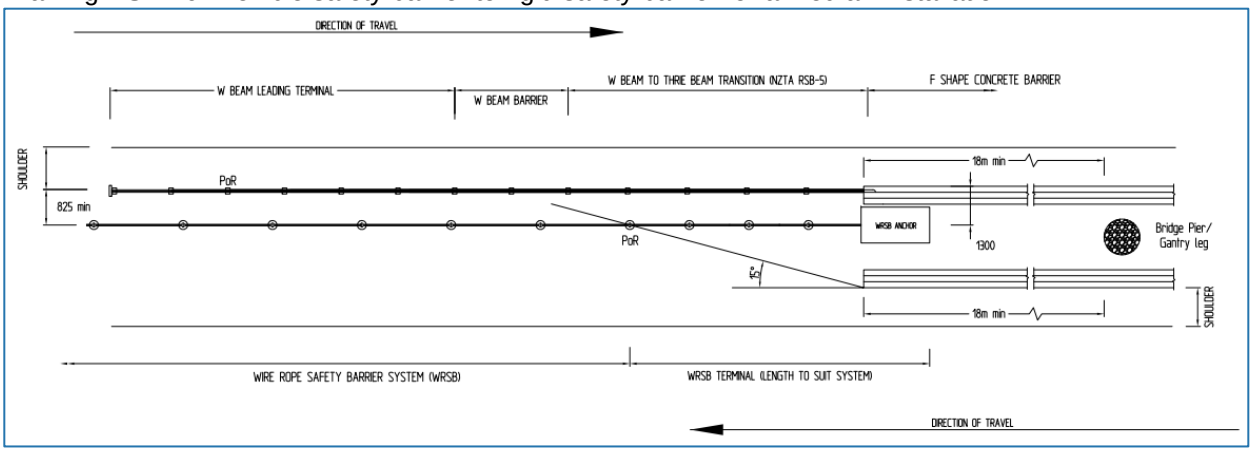
Drawing RSB-7a: Flexible safety barrier to semi-rigid safety barrier



Drawing RSB-7b: Flexible safety barrier to rigid safety barrier for shoulder/verge



Drawing RSB-7c: Flexible safety barrier to rigid safety barrier for a median installation



Summary	
Test level / conditions:	As per system specific details
For use with	Transition from a flexible safety barrier to a semi-rigid or rigid barrier
Status	Accepted
Technical information	
Other restrictions / considerations	• The flexible safety barrier transition provides transition from a flexible safety barrier to a W-beam (semi-rigid) or Concrete F-shape (rigid) barrier in median and side protection situations, such as approaching a bridge structure or sign gantry • The problem of transitioning from flexible to rigid barrier systems is commonly encountered where structural elements, such as bridge parapets/piers or gantry supports, are placed in close proximity to the travelled way, either in a median or shoulder/verge situation • The recommended practice for the following situations is given below: Shoulder/Verge: ○ Flexible barrier to W-beam (Drawing RSB-7a) ○ Flexible barrier to Concrete F-shape (Drawing RSB-7b) Median: ○ Flexible barrier to Concrete F-shape (Drawing RSB-7c) • The transition advice (above) should be followed unless acceptance of any alternative solution has been given by the Waka Kotahi Lead Safety Advisor or warranted design supplied by System Supplier(s) • The point of redirection of the flexible barrier median system must be positioned to provide protection for an errant vehicle departure angle of 15° • The rigid barrier for a median system must extend beyond the hazard (eg bridge pier or gantry leg) by a minimum of 18m in both directions • Initial 825mm offset from the semi-rigid barrier system to the flexible barrier system • On state highway projects where the design guidance given above cannot be applied, the proposed solution and supporting rationale should be referred to Waka Kotahi

Single point safety hardware

The following general notes apply to all single point safety hardware:

a. Hardware designed to protect single point hazards often have limitations that reduce their ability to increase safety and reduce risk. These limitations include the amount of energy that can be absorbed and the limited testing that has been undertaken and therefore understanding of performance.

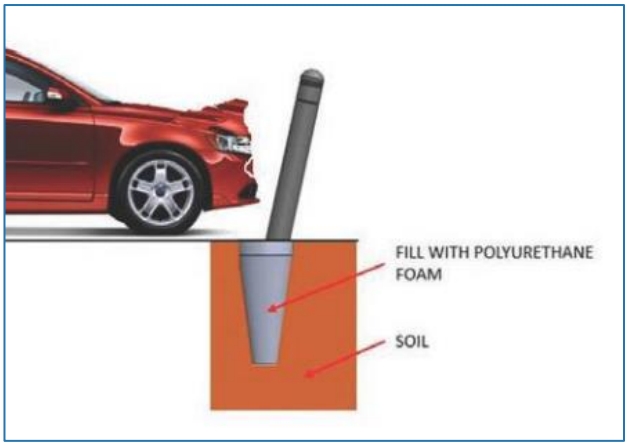
b. Single point safety hardware may only be used where site specific analysis shows that a better option (eg removal of hazard or continuous barrier) is not feasible.

c. Single point safety hardware may only be used on state highways where site specific acceptance has been granted by the Waka Kotahi Lead Safety Advisor.

d. Single point safety hardware must have an energy absorbing function, to reduce risk to vehicle occupants. Hardware that does not have an energy absorbing function, such as security bollards designed to prevent hostile vehicle intrusion into pedestrian areas are not covered by this document.

e. Installation of single point safety hardware shall be recorded on the RCA's asset management database and records of field performance must be kept and uploaded to the asset database to allow for efficacy to be assessed.

Energy absorbing steel bollards



Summary	
Test level / conditions:	Test Level 0; 1600 kg at 50 km/h (AS3845:1999 - superseded)
For use with	Used as an attenuator to shield hazards such as poles and trees or protect vulnerable users from motor vehicle traffic
Status	Site specific acceptance required from the Waka Kotahi Lead Safety Advisor Maximum 50 km/h posted speed limit

Technical information	
Dimensions	• Height: 1450 mm • Diameter: 165 mm • Foundation: 1000 mm deep x 600 mm diameter
Other restrictions / considerations	• Non-energy absorbing variants are not accepted • Colour and retroreflective elements to be as per RCA requirements

Raptor single point protector

Summary	
Test level / conditions:	MASH TL-1
For use with	Used as an attenuator to shield hazards such as poles and trees
Status	Site specific acceptance required from the Waka Kotahi Lead Safety Advisor Maximum 50 km/h posted speed limit

Technical information	
Dimensions	• Raptor 300 length: 2460 m • Raptor 600 length: 2760 mm • System Widths: 1150 mm • System Heights: 1050 mm
Weight	Weight per shell: 110 kg
Other restrictions / considerations	• Two cavity sizes available; Raptor 300 and Raptor 600 • Ensure adequate sightlines at driver's eye height before installation • The foundation shall be firm and level • The device may rotate during impacts. The area within a radius of 1.5 metres must be level without any hindrances to this free rotation • The Raptor must always be parallel to the direction of travel

Legacy hardware

In this section
Legacy flexible barriers
Armorwire WRSB - including Armorwire terminal end (A.T.E)
Brifen 4 cable wire rope safety barrier (WRSB)
Safence TL-4 WRSB
Safence slope WRSB
Legacy semi-rigid roadside & median barriers
Strong-post W-beam guardrail (SGR04B)
Steel post Thrie-beam guardrail (modified blockout) (SGR09B)
Strongpost W-beam double-sided guardrail (SGM04B)
Steel post Thrie-beam double-sided guardrail (modified blockout) (SGM09B)
Legacy aesthetic barriers
Lograil T18 4M/4MS2
Legacy w-beam end terminals
ET2000 plus end terminal system
FLEAT-350 & SKT-350 end terminals
X-350 end terminal system
Buried in backslope anchor
Legacy crash cushions
CAT 350 crash cushion
QUADGUARD II
TRACC crash attenuation cushion
Universal TAU-II
Legacy transitions
RSB-5 semi-rigid to rigid Thrie-beam transition

Legacy flexible barriers

Armorwire WRSB - including Armorwire terminal end (A.T.E)

Summary	
Test level / conditions:	NCHRP 350 TL-4
For use with	Armorwire Terminal End (A.T.E)
Status	Legacy system (repair use only, not for new state highway installations)

Technical information	
Dimensions	• Cable heights (to centre of cable): TL-4: 790 mm, 770 mm, 650 mm and 530 mm (± 25 mm) • Cable: 19 mm 3 x 7 strand, pre-stretched by 35% • Post spacing: 3 m
Minimum length	Minimum barrier length is 114 m and represents the distance between the upstream and downstream Length of Need of the terminal ends. i.e. excludes the 8 m of Armorwire Terminal End (A.T.E) cable at each end
Working width	• 1.54 m (at 3 m post spacing, based on NCHRP 350 TL-3 test) • 2.15 m (at 3 m post spacing, based on NCHRP 350 TL-4 test)
Deflection	• 1.54 m (at 3 m post spacing, based on NCHRP 350 TL-3 test)
Footings	• Default footing: Concrete footings 300 mm diameter, 750 mm deep • Alternate footing #1: Concrete footings as per Waka Kotahi TAN #16-18 • Alternate footing #2: Proprietary driven socket may be used through both barrier and terminal length where the ground conditions have been demonstrated to meet or exceed AASHTO Standard Soil. Site specific acceptance is required from the RCA with the site recorded in RAMM for maintenance purposes
Clear area	6 m x 18.5 m clear area directly behind the A.T.E to enable system to gate if impacted
Grade or placement restrictions	• A maximum slope of 10H:1V is preferable. On slopes greater than this, advice should be followed from the Road Controlling Authority's guidelines • Offset to hinge point = 1 m minimum (refer Waka Kotahi TAN #16-18)
Other restrictions / considerations	• Used in both median and roadside situations in either orientation as long as the slot arrangement is consistent • Maximum flare is 30:1 • The four line posts between the terminal end 'trigger' post and the Armorwire cable barrier must always be at 2 m spacing • Armorwire bolt down post is available (site specific acceptance required from RCA) • Length of need is met at post 5 for the system • Minimum allowable horizontal curve is 200 m radius • Minimum allowable vertical sag is 2400 m radius • Refer to CSP maintenance alert April 2020 for maintenance requirements to address potential corrosion issues at cable grip assemblies • Refer also to general notes for flexible barriers

Brifen 4 cable wire rope safety barrier (WRSB)

Summary	
Test level / conditions:	NCHRP 350 TL-4
For use with	Brifen cast in or surface mounted anchor
Status	Legacy system (repair use only, not for new state highway installations)

Technical information	
Dimensions	• Cable heights (to centre of cable): 930 mm, 780 mm, 630 mm and 480 mm • Cable: Pre-stretched 19 mm 3 x 7 strand • Post spacing: 3.2 m
Minimum length	60 m between points of redirection
Working width	Not available
Deflection	2.21 m at 3.2 m post spacing (based on NCHRP 350 TL-4 test)
Footings	• Default footing: Concrete footings 250 mm diameter, 750 mm deep • Alternate footing #1: Concrete footings as per Waka Kothai TAN #16-18
Clear area	6 m wide by 18.5 m long from terminal nose
Grade or placement restrictions	• A maximum slope of 10H:1V is preferable. On slopes greater than this, advice should be followed from the RCA's guidelines • Offset to hinge point = 1 m minimum (refer Waka Kotahi TAN #16-18)
Other restrictions / considerations	• For roadside situations use Z shaped posts and in medians use S shaped posts • Point of redirection is 11.2 m from the anchor. • Minimum installation radius is 200 m unless site specific acceptance is sought (and given) by the Waka Kotahi Lead Safety Advisor • Minimum vertical sag curve is 3000 m • For Brifen WRSB systems installed pre-2014: the anchor blocks are required to be upgraded to TL-3 tested specification if impacted, or installation is being upgraded or modified • Refer also to general notes for flexible barriers

Safence TL-4 WRSB

Summary	
Test level / conditions:	NCHRP 350 TL-4
For use with	12 m long NCHRP 350 TL-3 tested anchor system
Status	Legacy system (repair use only, not for new state highway installations)
Technical information	
Dimensions	• Cable heights (to centre of cable): 720 mm, 640 mm, 560 mm and 480 mm • Steel Wire Rope: 19.0 mm Diameter 3 x 7 strands • Post spacing: up to 3.0 m
Minimum length	40 m between points of redirection
Working width	Not available
Deflection	1.60m at 3m post spacing (based on NCHRP 350 TL-3 test)
Footings	• Default footing: Concrete footings 300 mm diameter, 600 mm deep • Alternate footing #1: Concrete footings as per Waka Kotahi TAN #16-18 • Alternate footing #2: Proprietary driven socket may be used through both barrier and terminal length where the ground conditions have been demonstrated to meet or exceed AASHTO Standard Soil. Site specific acceptance is required from the RCA with the site recorded in RAMM for maintenance purposes
Clear area	6 m wide by 18.5 m long from terminal nose
Grade or placement restrictions	• Steepest gradient: 1V:10H • Offset to hinge point = 1 m minimum (refer Waka Kotahi TAN #16-18)
Other restrictions / considerations	• The maximum allowable post spacing for this system is 3.0 m. Closer post spacings are acceptable in order to accommodate installation on curves • The recommended maximum run length of a Safence installation is 1200 m • Minimum allowable sag vertical curve for wire rope barriers is 30 m • Point of redirection is 12.6 m from the anchor • Minimum allowable curve is 150 m radius • Refer also to general notes for flexible barriers

Safence slope WRSB

Summary	
Test level / conditions:	Tested to European Standard EN1317 Parts 1& 2 testing criteria
For use with	Wires anchored using Safence End Terminals
Status	Legacy system (repair use only, not for new state highway installations)

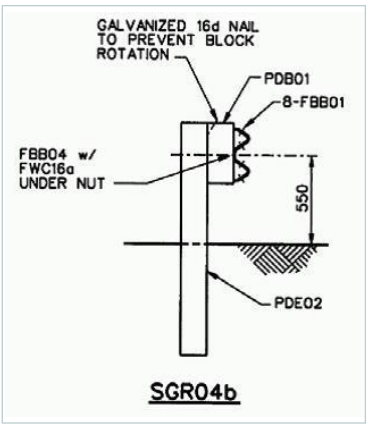
The Safence Slope Barrier is a four-cable wire rope barrier system designed specifically for retrofit installations on sloping shoulders. It has been tested in accordance with European Standard EN1317 Parts 1& 2 testing criteria which are lower than the current Waka Kotahi requirement of MASH TL-3 for side protection.

This system is a non-standard system considered appropriate for retro-fit situations where shoulder widths are limited, but a side protection barrier is desired. A standard wire rope barrier system must be used for all new sites and retrofit sites where shoulder width can reasonably be provided.

Technical information	
Dimensions	• Steel Wire Rope: Right Hand Lay, 19.0 mm Diameter 3x7 strands (1 x 3.15 mm + 6 x 3.0 mm) • Posts: 2100 mm long • Cable Heights: Varies with road geometry
Minimum length	40 m between points of redirection
Working width	1.85 m (containment level EN-1317 N2)
Deflection	TB32: 2m – 1500 kg large car impacting at an angle of 20º and a nominal speed of 110 km/h (Tested under EN-1317)
Footings	Default footing: Driven post
Clear area	6 m x 18.5 m clear area directly behind the A.T.E to enable system to gate if impacted
Grade or placement restrictions	Steepest gradient: 1V:2H
Other restrictions / considerations	• Only to be considered for retro-fit situations where shoulder widths are limited, but a side protection barrier is desired • Designed specifically for installation on sloping shoulders as a side protection system on retrofit projects • Because the European Standard EN1317 Parts 1& 2 testing criteria is lower than those of NCHRP 350 Test Level 3, site specific acceptance is required from the Waka Kotahi Lead Safety Advisor prior to specification or installation • Used for constrained environments only • The minimum allowable curve is 200 m radius • Refer also to general notes for flexible barriers

Legacy semi-rigid roadside & median barriers

Strong-post W-beam guardrail (SGR04B)



Summary	
Test level / conditions:	NCHRP 350 TL-3
For use with	Attaches to compatible end terminals or transition barriers (generally transitioning into a Thrie-beam)
Status	Legacy system (repair use only, not for new state highway installations)

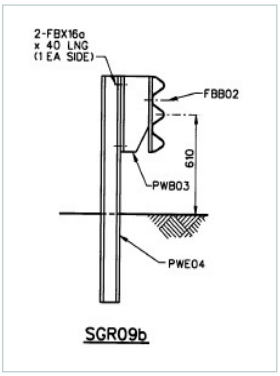
Strong Post Timber W-beam guardrail is a common type of longitudinal barrier in use along local roads and state highways. It is a public domain (non-proprietary) system.

The wood or plastic blockouts reduce or minimise a vehicle snagging on the posts upon impact. In addition, a blockout may be used to increase the offset of guardrail with an obstacle such as a kerb. The posts' primary purpose is to maintain the height of the guardrail during the initial stages of post deflection.

Strong Post Timber W-beam guardrail is a legacy system and may not be installed on new state highway projects. Existing installations may be repaired/maintained until replacement with a higher performing barrier system is viable or necessary.

Technical information	
Dimensions	• 1905 mm post spacing • 550 mm height (to centre of W-beam)
Minimum length	30.48 m (8 lengths) (excluding end treatments):
Deflection	800 mm
Other restrictions / considerations	• W-beam guardrails must be anchored and terminated using a suitable end treatment • 2 x 16d nails per blockout to prevent rotation • Barrier post offset to hinge point = 1 m (600 mm minimum) • W-beam guardrail element may be considered serviceable after damage to a single rib, but non-serviceable if there is damage to 2 ribs within 2 m • Limited ability of the system to contain and redirect modern vehicles that have a higher centre of gravity, along with the increased weight of those vehicles • Refer to AASHTO 2-Space W-beam Guardrail (RWM02a-b) for details of W-beam element

Steel post Thrie-beam guardrail (modified blockout) (SGR09B)



Summary

Test level / conditions:	NCHRP 350 TL-4
For use with	A suitable W-beam terminal can be used in conjunction with an appropriate transition to provide a crashworthy terminal and anchorage
Status	Legacy system (repair use only, not for new state highway installations - except as part of RSB-5 transition) Site specific acceptance required for use on structures – refer M23 Appendix B for details

"Modified Thrie-beam" (SGR09B) is a modified version of the standard SGR09C Thrie-beam with modified (notched) blockouts. It is a public domain (non-proprietary) system.

The SGR09B uses steel I-section posts with steel I-section blockouts and is a NCHRP 350 TL-4 barrier.

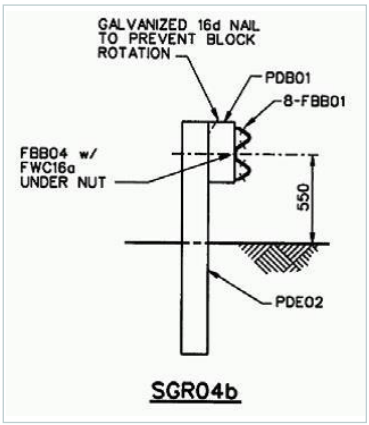
Strong post Thrie-beam guard rails should be used in locations where there is at least 600 mm of available deflection space.

Technical information

Dimensions	• 2000 mm post spacing • 4000 mm rail length • 610 mm height (to centre of Thrie-beam)
Minimum length	32 m (8 lengths) (excluding transitions and terminals/crash cushions)
Deflection	900 mm (NCHRP 350 TL4)

Other restrictions / considerations	• Increased level of performance compared to W-beam, especially for vehicles up to 8 tonne gross
	• Barrier post offset to hinge point = 1 m (600 mm minimum)
	• Thrie-beam guardrail element may be considered serviceable after damage to a single rib, but non-serviceable if there is damage to 2 ribs within 2m
	• Modified Thrie-beam on baseplate mounted posts is the minimum system acceptable for use on state highway structures. Refer M23 Appendix B for details
	• Modified Thrie-beam blockouts must be compliant with the AASHTO PWB03 detail and fabricated from either:
	  ○ rolled steel section conforming to either W360x32.9 or M360x25.6 section profiles defined in AASHTO M160M, or
	  ○ welded steel plate to the same dimensions and strengths (continuous fillet welds with minimum 6 mm leg length, Cat SP to AS/NZS1554.1)
	• The "notch" must be correctly formed with no rib or residual web material remaining behind the traffic face flange, to ensure the system operates as tested
	• Modified Thrie-beam blockouts of reduced depth (< 350 mm) may be used if accepted by the RCA, however the full "notch" must be present
	• Refer to AASHTO Strong Post Thrie-beam Guardrail (SGR09B) for details of Thrie-beam system

Strong-post W-beam double-sided guardrail (SGM04B)



Summary	
Test level / conditions:	NCHRP 350 TL-3
For use with	Attaches to compatible end terminals or transition barriers (generally transitioning into a Thrie-beam)
Status	Legacy system (repair use only, not for new state highway installations)

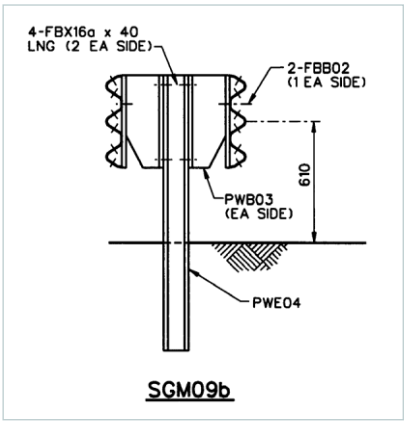
Strong Post Timber W-beam median barriers were generally used in locations where a maximum dynamic deflection of 600 mm or less was acceptable. It is a public domain (non-proprietary) system.

The SGM04B uses timber posts with wooden blockouts and is a NCHRP 350 TL-3 barrier.

Strong Post Timber W-beam median barrier is a legacy system and may not be installed on new state highway projects. Existing installations may be repaired/maintained until replacement with a higher performing barrier system is viable or necessary.

Technical information	
Dimensions	• 1905 mm post spacing • 550 mm height (to centre of W-beam)
Minimum length	30.48 m (8 lengths) (excluding end treatments):
Deflection	800 mm
Other restrictions / considerations	• W-beam barriers must be anchored and terminated using a suitable end treatment • 2 x 16d nails used on each side to prevent block rotation • W-beam guardrail element may be considered serviceable after damage to a single rib, but non-serviceable if there is damage to 2 ribs within 2 m • Limited ability of the system to contain and redirect modern vehicles that have a higher centre of gravity, along with the increased weight of those vehicles. • Refer to AASHTO 2-Space W-beam Guardrail (RWM02a-b) for details of W-beam element

Steel post Thrie-beam double-sided guardrail (modified blockout) (SGM09B)



Summary

Test level / conditions:	NCHRP 350 TL-4
For use with	A suitable W-beam terminal can be used in conjunction with an appropriate transition to provide a crashworthy terminal and anchorage
Status	Legacy system (repair use only, not for new state highway installations)

“Modified Thrie-beam” (SGM09B) is a modified version of the standard SGR09C Thrie-beam with modified (notched) blockouts. It is a public domain (non-proprietary) system.

The SGM09B uses steel I-section posts with steel I-section blockouts and is a NCHRP 350 TL-4 barrier.

Strong post Thrie-beam guard rails should be used in locations where there is at least 500 mm of available deflection space.

Technical information

Dimensions	• 2000 mm post spacing • 4000 mm rail length • 610 mm height (to centre of Thrie-beam)
Minimum length	30.48 m (8 lengths) (excluding end treatments)
Deflection	900 mm

Other restrictions / considerations	• Increased level of performance compared to W-beam, especially for vehicles up to 8 tonne gross
	• Thrie-beam guardrail element may be considered serviceable after damage to a single rib, but non-serviceable if there is damage to 2 ribs within 2m
	• Modified Thrie-beam on baseplate mounted posts is the minimum system acceptable for use on state highway structures. Refer M23 Appendix B for details
	• Modified Thrie-beam blockouts must be compliant with the AASHTO PWB03 detail and fabricated from either:
	  ○ rolled steel section conforming to either W360x32.9 or M360x25.6 section profiles defined in AASHTO M160M, or
	  ○ welded steel plate to the same dimensions and strengths (continuous fillet welds with minimum 6 mm leg length, Cat SP to AS/NZS1554.1)
	• The “notch” must be correctly formed with no rib or residual web material remaining behind the traffic face flange, to ensure the system operates as tested
	• Modified Thrie-beam blockouts of reduced depth (< 350 mm) may be used if accepted by the RCA, however the full “notch” must be present.Refer to AASHTO Strong Post Thrie-beam Guardrail (SGR09b) for details of Thrie-beam system
	• Refer to AASHTO Strong Post Thrie-beam Guardrail (SGR09B) for details of Thrie-beam system

Legacy aesthetic barriers

Lograil T18 4M/4MS2

Summary	
Test level / conditions:	NCHRP 350 TL-2 (Tested to EN1317 N2 – 1500 kg car at 110 km/h and 20°)
For use with	Tested with a proprietary 4 m sloping end anchored to the ground
Status	Not for use on state highways without site specific acceptance from the Waka Kotahi Lead Safety Advisor Maximum 50 km/h posted speed limit

Technical information	
Dimensions	• Post Spacing: 4 m (4M) or 2 m (4MS2) • Rail Height: 700 mm ± 20 mm above ground level height
Minimum length	60 m (excluding terminals)
Other restrictions / considerations	• The Lograil 4M and 4MS2 systems are terminated using a proprietary 4 m sloping end which should be flared away from traffic, wherever possible, to mitigate risk of end-on impact. Recommended installation is that the terminal end should be flared away from the road at least 300 mm. Whenever practical consider extending the rail and terminal end to achieve a greater flare • Handrail systems can be added at any height required for cyclists and pedestrians at discretion of road controlling authority • Back masks for the rail and posts are available to cover steel components at the rear of the Lograil • Refer also to general notes for aesthetic barriers

Legacy w-beam end terminals

ET2000 plus end terminal system

Summary	
Test level / conditions:	NCHRP 350 TL3
For use with	W-beam guardrail
Status	Legacy system (repair use only, not for new state highway installations)

The ET-2000 PLUS guardrail end terminal is used to absorb the kinetic energy of an impacting vehicle at a controlled rate. Upon impact, the extruder head travels horizontally along the guardrail beams, flattening the W-profile of the beam and extruding the flattened section away from the traffic face. The system was used in New Zealand as an end terminal for permanent road safety barrier systems for over 10 years. The ET-2000 PLUS End Terminal system, comprising of SYT Posts, was tested in accordance with NCHRP Report 350 TL-3.

The ET-2000 PLUS guardrail end terminal is a legacy system and may not be installed on new state highway projects. Existing installations may be repaired/maintained until replacement with a higher performing terminal is viable or necessary.

Technical information	
Dimensions	• Length: 15.24 m (TL-3) • Length: 7.62 m (TL-2) • Post Height: 730 mm +/- 20 mm above ground level • SYT Post Spacing: 1905 mm centres
Weight	• TL3 Package Mass: 540 kg • TL2 Package Mass: 330 kg
Point of redirection	Length of need measured from point of redirection at Post #3
Clear area	6 m x 18.5 m clear area to enable the system to gate if impacted downstream from head
Grade or placement restrictions	• Maximum approach and cross slope of 10H:1V • When installed at the end of guardrail following a curved alignment (offsets measured to the face of the rail): <u>Outside of Curve:</u> ○ maximum offset 610 mm from the curve <u>Inside of Curve:</u> ○ maximum offset 305 mm (curve radius of 300 m or less) ○ maximum offset 610 mm (curve radius greater than 300 m) • Must not be installed in front, on top of or behind a kerb • Terminal grading in accordance with Waka Kotahi RSB-3
Other restrictions / considerations	The first two posts from the end of the terminal have no blockout

FLEAT-350 & SKT-350 end terminals

Summary	
Test level / conditions:	NCHRP 350 TL3
For use with	W-beam guardrail
Status	Legacy system (repair use only, not for new state highway installations)

The FLEAT-350 is a flared-only, energy absorbing end terminal that meets NCHRP 350 TL-3. When impacted, the extruded guardrail curls toward the traffic face.

The SKT-350 is a tangential-only, sequential kinking end terminal that meets NCHRP 350 TL-3. When impacted, the extruded guardrail curls behind the barrier line.

The SKT-SP and FLEAT-SP were accepted variants of the SKT/ FLEAT 350 end terminals, using steel breakaway posts rather than timber posts. The FLEAT-MT was a median terminal variation of the FLEAT 350 end terminal. It was available with wood or steel post options.

The FLEAT-350/SP/MT and SKT-350/SP guardrail end terminals are legacy systems and may not be installed on new state highway projects. Existing installations may be repaired/maintained until replacement with a higher performing terminal is viable or necessary.

Technical information	
Dimensions	• TL3: 11.43 m • TL2: 7.6 m • Post Spacing: 1905 mm centres
Point of redirection	Length of need measured from point of redirection at Post #3
Clear area	6 m x 18.5 m clear area to enable the system to gate if impacted downstream from head
Grade or placement restrictions	• A maximum approach and cross slope of 10H:1V • Terminal grading in accordance with Waka Kotahi RSB-3
Other restrictions / considerations	• Drive-by system inspections are recommended at least monthly, and hands-on inspections are recommended at least yearly • Breakaway posts may be wood or steel, both are tested to NCHRP 350 FLEAT-350 • First rail used must be a special kinking rail with slotted holes • 760 to 1220 mm offset needed for NCHRP 350 TL-3 • 500 to 820 mm offset needed for NCHRP 350 TL-2 SKT-350 • First rail used must be a special kinking rail with slotted holes

X-350 end terminal system

Summary	
Test level / conditions:	NCHRP 350 TL3
For use with	W-beam guardrail
Status	Legacy system (repair use only, not for new state highway installations)

The X-350 End Terminal system is a re-directive guardrail terminal end that could be used in tangent or flared (up to 1200 mm) installations. A median variant was also available.

The X-350 End Terminal system could be installed in the following configurations:

- Single-sided, installation height of 705 mm (X-350), breakaway timber or steel posts
- Single-sided, installation height of 790 mm (X-350:31), breakaway steel posts only
- Median (double-sided), installation height of 705 mm (X-350 Median), breakaway timber or steel posts
- Median (double-sided), installation height of 790 mm (X-350:31 Median) breakaway steel posts only.

The X-350 is considered redirective from post #1 but is classed as a gating terminal due to presence of ground strut upstream of post #1.

X-350 guardrail end terminals (all variants) are legacy systems and may not be installed on new state highway projects. Existing installations may be repaired/maintained until replacement with a higher performing terminal is viable or necessary.

Technical information	
Dimensions	• Length: 11.43 m (3 rails) • Height (to top of W-beam): 705 mm or 790 mm to suit guardrail system
Weight	Impact Head weight: 25 kg
Point of redirection	Length of need measured from point of redirection at Post #1
Clear area	6 m x 18.5 m clear area to enable the system to gate if impacted downstream from head
Grade or placement restrictions	• Maximum approach and cross slope of 10H:1V • Flared or tangential terminal layouts acceptable • Terminal grading in accordance with Waka Kotahi RSB-3
Other restrictions / considerations	• Site specific grading must be provided in accordance with Waka Kotahi detail RSB-3 to ensure that there are no “humps” or “hollows” that may significantly alter stability of the impacting vehicle • Impact force held in tension • Gating and Re-directive system • 0 – 1200 mm offset for all variations of the end terminal • When a X-350 End Terminal is installed in a trailing/exit location, where the terminal head is facing away from the direction the vehicle is travelling, the splice joins at rails 1, 2 and 3 of the terminal must be lapped against the direction of adjacent traffic so the terminal can operate correctly • Nut protectors are available • Plastic front-end cover is available for both roadside and median terminal ends

Buried in backslope anchor

Summary	
Test level / conditions:	NCHRP 350 TL-3 or TL-4 (depending on rail height)
For use with	Anchor attaches to W-beam barrier using a TL-4 transition (RSB-5)
Status	Site specific acceptance required from the Waka Kotahi Lead Safety Advisor

This non-gating and re-directive end treatment was developed as an end treatment for W-beam barrier where the road is transitioning from cut to fill. The buried in backslope anchor requires a TL-4 transition to connect the anchor block to the guardrail (refer Waka Kotahi Standard Detail RSB-5). In areas of cut sections on the roadway, or where the road is transitioning from cut to fill, it is sometimes possible to terminate a W-beam guardrail installation by burying the anchor block at the end in the backslope. When properly designed and located this system provides full shielding of the identified hazard, eliminates the possibility of any end-on impact with the terminal, and minimises the likelihood of the vehicle passing behind the rail.

Due to the criticality of the ground conditions to the safe performance of the Buried In Backslope anchor, a site specific acceptance is require for its use. Application for use must include geotechnical assessment of the ground conditions at the proposed location, including consideration of the system specific requirements (ability to form the necessary excavation for construction, competency of soil/rock, erosion risk, etc.). The Installation Designer must satisfy themselves that the ground into which the anchor is to be installed is capable of supporting the anchor block under the design impact loads imposed.

Technical information	
Dimensions	• Barrier height (to centre): 610 mm
Minimum length	Minimum transition length: 10 m
Grade or placement restrictions	• The natural backslope needs to be reasonably close to the beginning or end of the semi-rigid barrier system • The approach grading should provide an unobstructed guardrail contact face at the correct height • The grading through the transition length should not ramp the vehicle
Other restrictions / considerations	• This end treatment is only to be considered where the ground conditions are suitable and shoulder width is limited, but a side protection barrier is desired • The steepness of the backslope covers the end of the barrier. The ideal slope is one that is near-vertical; a slope with too little angle could act as a ramp and allow the vehicle to bypass the barrier • The slope effectively becomes an extension of the barrier face so the errant vehicle can't get behind the terminal • Concrete anchor block must have a minimum strength of 28 MPa • The Installation Designer must mitigate erosion of the backslope in the design • The standard transition (RSB-5) should be substantially exposed to at least Post 2 and present the correct barrier height of 610 mm to the centre of the Thrie-beam guardrail • The anchorage of the system must be able to develop the full tensile strength of the W-beam • Ground conditions are critical; anchor block must be embedded in competent natural soil/rock. Backfilling over a concrete block will be considered a non-compliant installation • Do not use where there is a risk of erosion exposing the concrete block over time • Careful consideration needs to be given to foreslope, backslope and ditch configurations. Ideally used at locations where a natural backslope is reasonably close to point where barrier is introduced

Legacy crash cushions

CAT 350 crash cushion

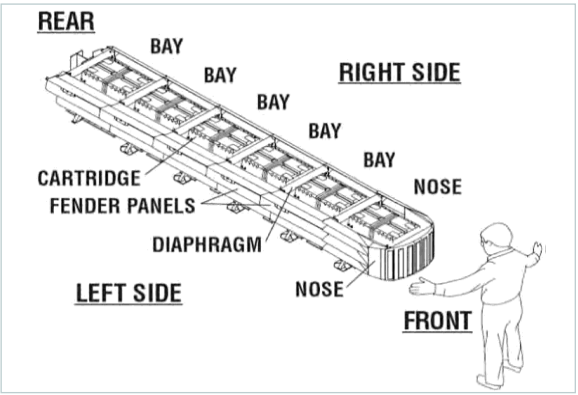
Summary	
Test level / conditions:	NCHRP 350 TL3
For use with	CAT 350™ can be used as a longitudinal barrier end treatment and as a crash cushion either in the median or on the shoulder
Status	Legacy system (repair use only, not for new state highway installations)

CAT 350 crash cushion is an energy absorbing attenuator available for use where blunt ends of rigid barriers and fixed objects are in the median or on the shoulder. This system is a three-stage system using energy absorbing W-beam elements, breakaway wood posts and a cable anchorage system. The W-beam element is a slotted W-beam that telescopes backward during impact. The shearing of the steel rail between the slots as the sections are moved back dissipates the kinetic energy of impact.

The CAT-350 end treatment is a legacy system and may not be installed on new state highway projects. Existing installations may be repaired/maintained until replacement with a higher performing terminal is viable or necessary.

Technical information	
Dimensions	• 9.52 m system length • 610 mm width • 705 mm height (to top of barrier)
Clear area	6 m x 18.5 m clear area to enable the system to gate if impacted downstream from the head
Other restrictions / considerations	• Used as a longitudinal barrier end treatment and as a crash cushion either in the median or on the shoulder • Various post and post/sleeve options are available • Available in weathering steel • Requires no concrete pads, foundations or deadmen anchors • Functions as either a unidirectional and bidirectional device • Length of Need begins at Post #4 from the nose

QuadGuard II



Summary	
Test level / conditions:	Up to NCHRP 350 TL3
For use with	Permanent or temporary concrete barriers
Status	Legacy system (repair use only, not for new state highway installations)

Technical information	
Dimensions	Available in seven widths: 610 mm, 760 mm, 915 mm, 1219 mm, 1755 mm, 2285 mm, 3200 mm
Weight	Varies with configuration
Grade or placement restrictions	• Should be assembled only on an existing or freshly placed and cured concrete base (28 MPa minimum) • Cross-slope shall not exceed 8% and should not twist more than 2% over the length of the system • The foundation surface shall have a light broom finish
Other restrictions / considerations	• The system must be anchored • As a general rule, selection of the narrowest width that adequately shields the hazard is recommended • System length is specified by the number of bays the system includes. The number of bays required is a function of the design speed of the roadway, as specified in the product manual • When there is an existing guardrail or median barrier at the site, the backup (anchor) of the Quad-Guard System should tie into it when possible • Visual drive-by inspections are recommended at least once a month. Walk-up inspections are recommended at least once a year for Quad-Guard systems on asphalt • Some components may be reusable following a crash

TRACC crash attenuation cushion



Summary

Test level / conditions:	NCHRP 350 TL-2 and TL-3
For use with	Concrete, W-beam and Thrie-beam
Status	Legacy system (repair use only, not for new state highway installations)

Technical information

Dimensions

System	Test Level	Width	Length
TRACC	3	610 mm	6.5 m
ShorTRACC	2	610 mm	4.3 m
WideTRACC- B	3	1470 mm**	6.5 m**
WideTRACC - L	3	1040 mm***	6.5 m***
WideTRACC - R	3	1040 mm***	6.5 m***

** The width of the WideTRACC – B can be further increased by adding wing extensions on both sides. The extensions will add 710 mm of length and 175 mm of system width per extension added

*** The width of the WideTRACC – L and – R can be further increased by adding wing extensions on one side. The extensions will add 710 mm of length and 87 mm of system width per extension added

Weight

Varies with configuration

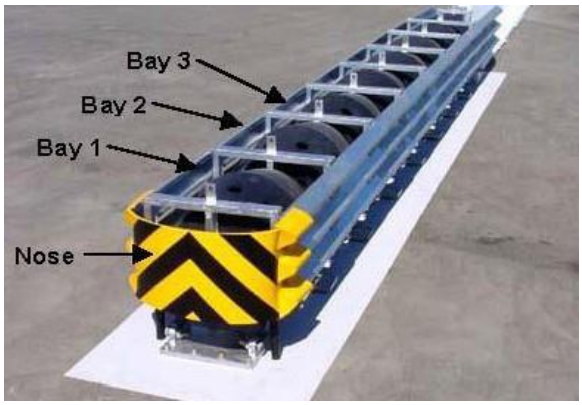
Grade or placement restrictions

It is recommended that the TRACC system should not be placed directly behind a raised kerb. The approach area in front of the system should slope at a rate no greater than 10H:1V in the direction of traffic flow. The cross slope should be no more than 12H:1V

Other restrictions / considerations

- The TRACC can be anchored to a combination of asphalt, concrete and compacted sub base
- A plastic nose cone that is supplied with the system should be attached to the front of the TRACC
- TRACC units are delivered pre-assembled to site to facilitate rapid installation and minimise disruption to traffic flow
- Installation of the TRACC system and its transitions depends on the traffic pattern and the backup structure at the particular location. Unidirectional traffic (one side or both) requires no transition provided opposing traffic cannot impact the unit
- TRACC systems can be lifted as complete units
- Holes should be drilled 40 mm less than the overall length of the anchor studs to ensure proper embedment to the foundation
- Field repair is to be limited to minor end-on impacts that stroke the system less than 1350 mm
- Some components may be reusable following a crash

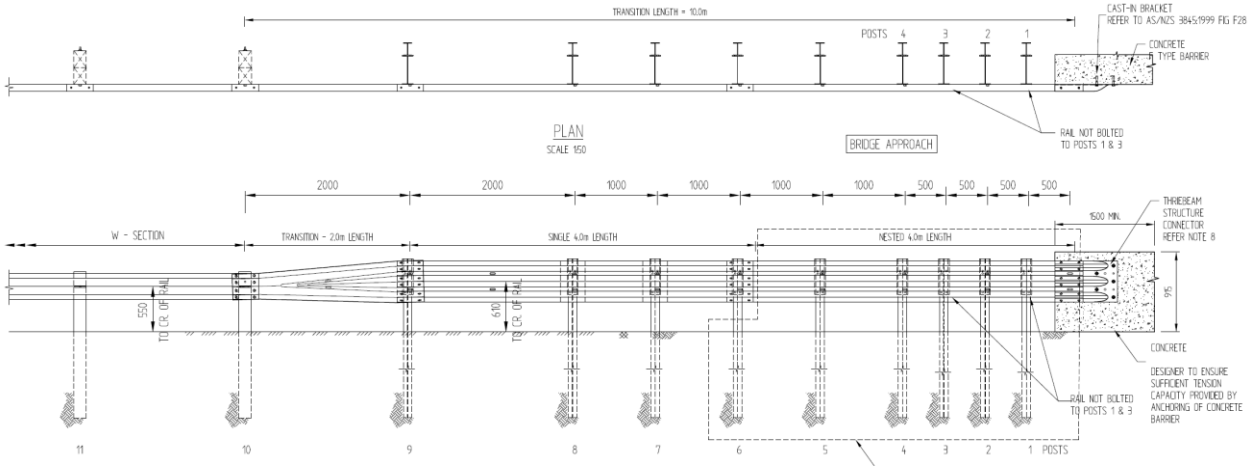
Universal TAU-II



Summary	
Test level / conditions:	NCHRP 350 TL-2 and TL-3
For use with	Concrete, W-beam and Thrie-beam
Status	Legacy system (repair use only, not for new state highway installations)
Technical information	
Dimensions	• TL-3: length: 8 bays. 7.2 5 m (P.C.B Backstop) or 7.75 m (Compact Backstop) • TL-2: length: 4 bays. 3.78 m (P.C.B Backstop) or 4.28 m (Compact Backstop) • 762 mm width • 829 mm height
Weight	Varies with configuration
Grade or placement restrictions	Cross slopes of up to 8% (5 degrees) can be accommodated with the standard hardware and with the instructions provided with the system. If there are cross slopes in excess of 8%, contact CSP Pacific to obtain engineering advice and assistance
Other restrictions / considerations	• The accepted anchoring foundation is a solid concrete pad over the length of the system • The concrete foundation must be a minimum of 150 mm thick, reinforced 28 MPa Portland Cement Concrete (PCC) or 200 mm non-reinforced 28 MPa PCC • All kerbs, islands and elevated objects greater than 100 mm high that would be beneath, beside or less than 15 m in front of a TAU-II crash cushion should be removed prior to installation • Details for transitions to concrete, W-beam and Thrie-beam are available from CSP Pacific • Hazard widths: 1000 mm – 2440 mm max • Design speeds: 50 km/h – 100 km/h • An anchoring package is supplied with the TAU-II system and contains the necessary threaded rods and epoxy needed to install the system • Some components may be reusable following a crash

Legacy transitions

RSB-5 semi-rigid to rigid Thrie-beam transition



Summary	
Test level / conditions:	NCHRP 350 TL-4
For use with	Transition from W-beam (semi-rigid) barrier to Thrie-beam (semi-rigid) or concrete (rigid) barrier
Status	Legacy system (repair use only, not for new state highway installations)

Technical information	
Other restrictions / considerations	• The rigid barrier for a median system must extend beyond the hazard (e.g. bridge pier or gantry leg) by a minimum of 18m in both directions • The minimum transition length for W-beam to concrete is 10.0m • All transition posts to be steel with modified blockouts as per Waka Kotahi drawing B3 • Where proper post embedment cannot be achieved, standard 'I' beam bridge steel posts on steel base plates (as per Appendix B Waka Kotahi Bridge Manual) can be bolted to a concrete beam • Posts 7 & 8 need to have backing pieces • Trailing transitions installed on roads divided by median barrier may have the entire nested Thrie- Beam section with posts 1 thru 6 omitted • Thrie-beam structure connector to be fixed using 6 x grade 8.8/S M24 bolts through 30mm diameter holes in concrete barrier with a full bolt pattern backing plate (16mm thick 250MPa PL) for cast-in bracket, refer to Waka Kotahi standard detail B8-2 • For Thrie-beam across structures refer to Waka Kotahi drawing B3 • On state highway projects where the design guidance given above cannot be applied for any particular reason, the proposed solution and supporting rationale should be referred to Waka Kotahi