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W-Beam Guardrail

Semi-Rigid Protection

Product Manual

Ref: PM 003/03

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1.0 Introduction

Providing a forgiving roadside environment reduces the consequences for vehicles leaving the safe, travelled way. Hazards such as trees, utility poles, culverts and embankments are often located adjacent to roadways and relocating them is often impractical. In these instances, shielding with a longitudinal safety barrier is the most appropriate solution.

Roadside safety barrier designs have developed over the years and are used to safely contain and re-direct errant vehicle away from nearby hazards. Safety barriers reduce the severity of run-off-the-road crashes and have made a significant contribution to the safety of our region's roads.

Longitudinal barriers are typically classified into three categories;

- ***Flexible barriers***: designed to move substantially during a vehicle impact. The energy of the impacting vehicle is absorbed by movement of the barrier;
- ***Semi-rigid barriers:*** designed for moderate movement during a vehicle impact. The energy of the impacting vehicle is absorbed by movement of the barrier and deformation of the barrier; and
- ***Rigid barriers:*** designed for no movement during a vehicle impact. The energy of the impacting vehicle is absorbed by the deformation of the vehicle.

2.0 W-Beam Guardrail

W-beam guardrail is the world's most widely specified safety barrier system offering protection from hazards located adjacent to the travelled way. W-beam guardrail provides designers an economical and dependable roadside solution.

W-beam guardrail comprises a rail element, known as w-beam, that is blocked out from specially-engineered supporting posts. Adjacent rails are bolted together forming a splice connection and end terminals are placed at either end to anchor the system.

W-beam systems vary throughout Australia. Whilst the rail element design remains the same, the design of the supporting posts and blocking pieces vary according to state road authority requirements.

The w-beam systems adopted within Australia incorporate the use of C-posts (Queensland, NSW, S.A. & W.A.) or U-posts (Victoria and Tasmania).

W-beam guardrail using C-posts or U-posts is regarded as a semi-rigid barrier. A semi-rigid barrier provides a desirable outcome for both designer and the vehicle occupants. The lateral displacement of the system, also known as deflection, is typically limited to 1m providing protection from nearby roadside hazards. The ability of w-beam guardrail to absorb some of the crash energy reduces occupant risk and limits deformation of the impacting vehicle.

3.0 How W-Beam Guardrail Works

Safe vehicle containment and re-direction is developed through a combination of the flexural resistance of the rail and the bending resistance of the supporting posts.

Upon impact, the posts absorb some of the crash energy through post rotation in the surrounding soil prior to separation from the rail as they fully yield. The blocking pieces, positioned between the rail and posts, minimise vehicle snagging and reduce the potential for the vehicle to vault over the barrier by maintaining rail height during the initial stages of impact.

Once the rail separates from the posts, the rail forms a re-directive ribbon, guiding the vehicle away from the nearby hazard.

The sectional strength of the posts, spaced every 2m or 2.5m (Victoria), combined with the flexural strength of the rail, limits the deflection of the system during impact.

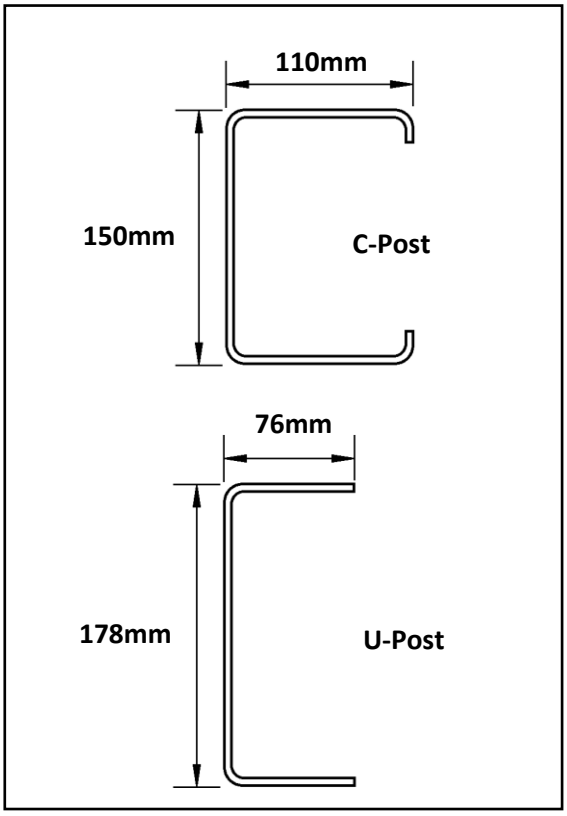

Figure 1: Post Profiles

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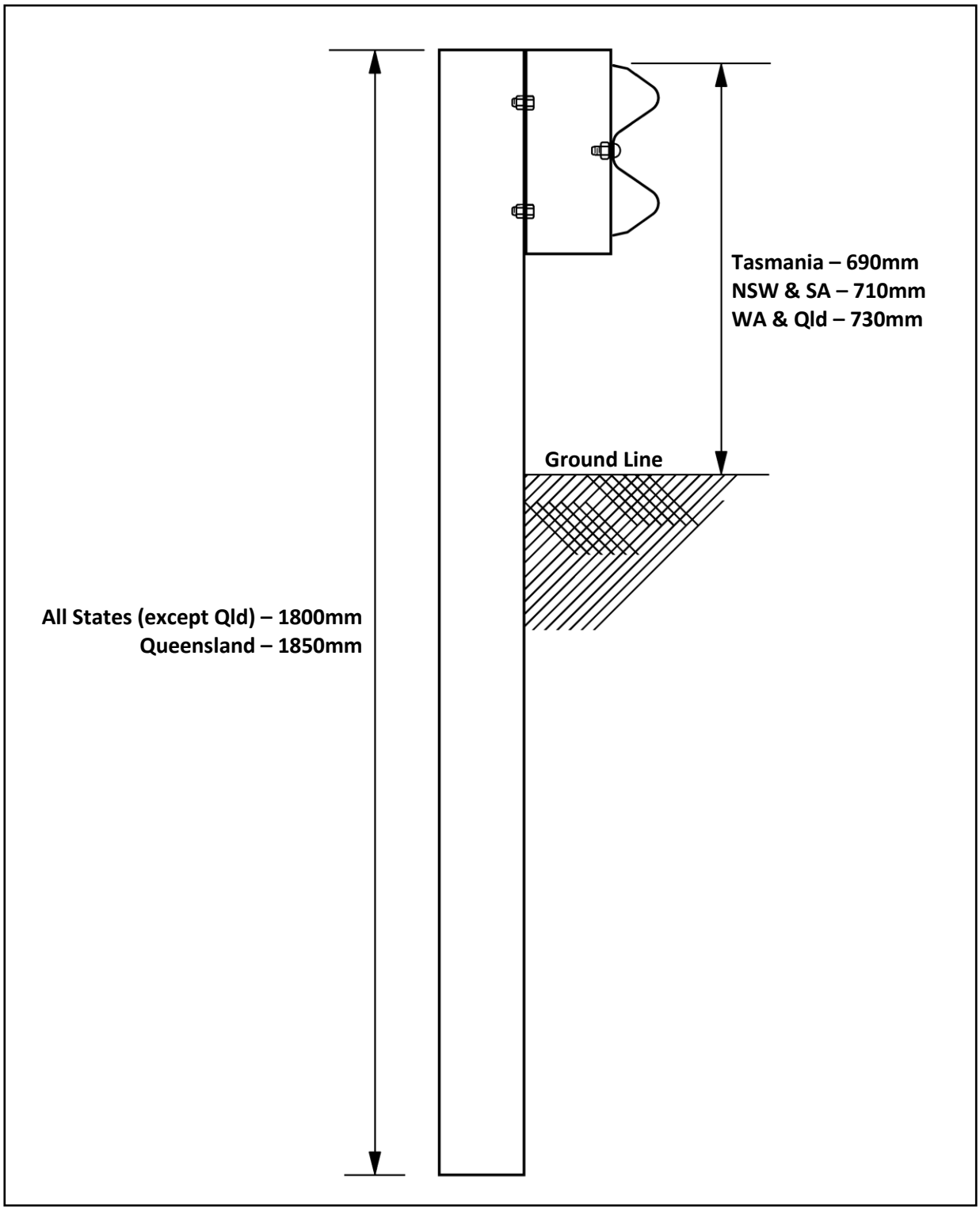


Figure 2: W-Beam Assembly Detail

4.0 Design Considerations

4.1 End Terminals

End terminals are the specially designed end pieces located at the leading and trailing end of the w-beam guardrail system.

End terminals are designed to anchor the w-beam guardrail system and introduce the necessary tensile and flexural strength required for safe vehicle containment and re-direction throughout the length-of-need section.

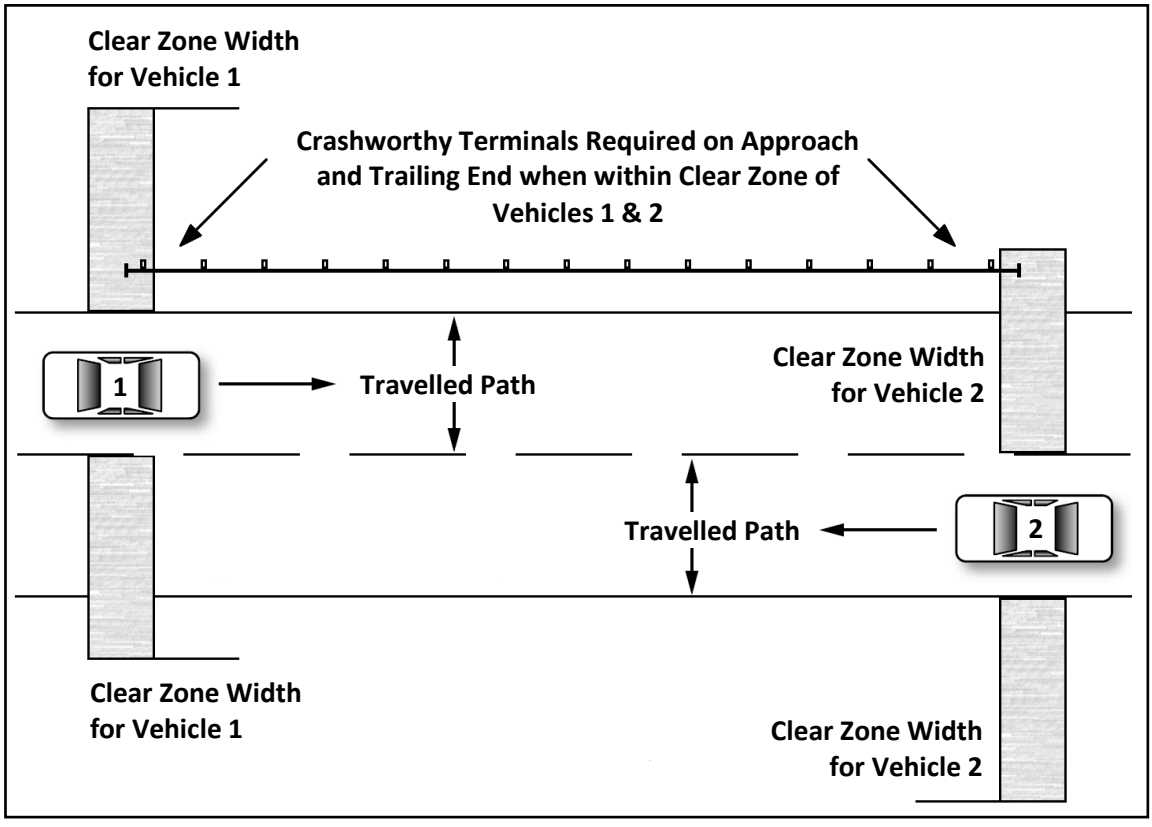
Some guardrail end terminals also provide the additional feature of reducing the severity of an impact near or at the end of the system.

It is a requirement that all w-beam guardrail systems be appropriately anchored at the leading and trailing end of the installation. It is necessary that the leading end of the system be anchored with a crashworthy end terminal such as the SKT-SP or FLEAT-SP.

4.1.1 Trailing End Protection

In some instances it is necessary to install a crashworthy terminal on the trailing end. This occurs when the trailing end of a guardrail barrier is located within the clear zone of approaching traffic.

The clear zone is the horizontal width of space available for the safe use of an errant vehicle. This distance is dependent upon the posted speed and road geometry. Guidelines for determining the clear zone width are contained within state road authority publications.



4.2 The Point-of-Need

W-beam guardrail is designed to safely contain and re-direct errant vehicles away from roadside hazards. The point-of-need is the location where the barrier becomes re-directive.

The point-of-need is typically dependent upon the terminal selected to anchor the w-beam system. For terminals such as the SKT-SP and FLEAT-SP the point-of-need location is terminal post 3, a distance of 3.81m downstream from the start of the system.

It is necessary that the point-of-need location is appropriately aligned with the hazard that is being shielded. Figure 4 provides an example.

Whilst the point-of-need location may vary between terminal types, provided the terminal point-of-need and the site beginning-length-of-need are horizontally aligned, the road safety barrier system will provide the same re-directive capabilities, regardless of the terminal selected.

4.3 Recommended Minimum Length

The recommended minimum length of w-beam guardrail on high speed roads to effectively contain and re-direct an errant vehicle is 30m between terminals.

4.4 Double-Sided Configuration

When installed in a central median, w-beam guardrail can be installed with blocking pieces mounted to either side of a single post.

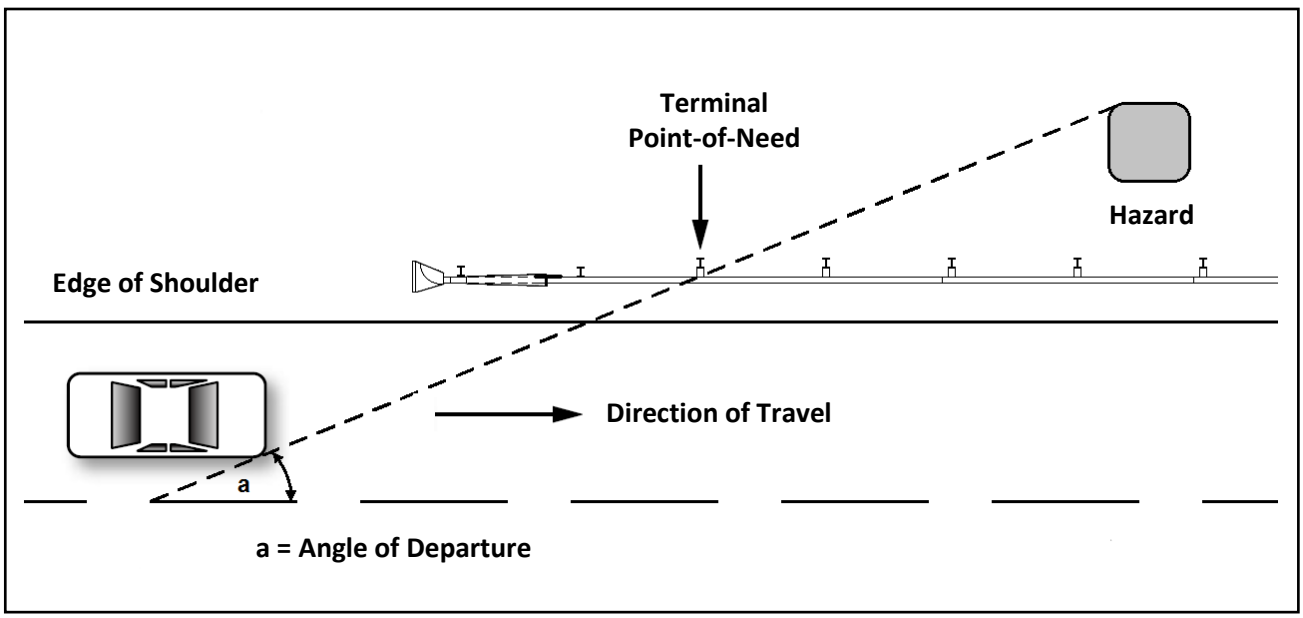


Figure 4: Positioning of Terminal Point-of-Need to Adequately Shield a Roadside Hazard

4.5 Site Grading Requirements

Grading around the area of a road safety barrier is an important consideration. The site grading should be considered from three perspectives; advance grading, adjacent grading and run-out grading.

Under crash test conditions, the surfaces immediately in front of and behind w-beam guardrail barriers are reasonably flat and unobstructed. In the field, conditions vary from site to site and obstructions such as kerbs, services and embankments are encountered.

4.5.1 Advance Grading

It is recommended that the area in advance of the w-beam guardrail barrier be limited to a grading of 10H:1V to ensure that the vehicle's suspension is neither extended nor compressed at the moment of impact. The selection of a tangential end terminal such as the SKT-SP may reduce the requirement for earthworks normally associated with the use of a traditional parabolic flared terminal such as the MELT.

4.5.2 Adjacent Grading

Adjacent grading refers to the surface on which the w-beam guardrail is installed and the area immediately behind. It is recommended that this area be relatively flat (10H:1V) so that the terrain does not contribute to vehicle behaviour. The supporting posts of the w-beam guardrail barrier should have 600mm of fill material behind them, providing sufficient lateral support.

On existing roads with limited formation, positioning posts on the hinge point may be the only option. It is recommended that the post embedment depth be increased to provide sufficient lateral support. Guidelines for calculating the increased post embedment are detailed in Figure 7.

4.5.3 Run-Out Grading

It is a requirement that all w-beam guardrail barriers be appropriately anchored with an end terminal. When there exists an opportunity for an errant vehicle to strike the end of the w-beam system, consideration must be given to the area parallel to and behind the system. When struck at or near the nose at an angle of 15° or greater, w-beam guardrail end terminals will yield, allowing a vehicle to continue into the area immediately behind and beyond the terminal.

AS/NZS 3845 nominates an area measuring 22.5m long x 6.0m wide measured from the nose of the terminal to be reasonably traversable and free from fixed object hazards. This may be difficult to address, particularly on existing roadways. This is recognised by AS/NZS 3845 which also states that 'if a clear run-out area is not possible, this area should at least be similar in character to adjacent unshielded roadside areas'.

When the desirable run-out area is not available or when there is a high likelihood of a head-on impact with the terminal, the use of an energy-absorbing terminal such as the SKT-SP or FLEAT-SP should be the preferred option over a non energy-absorbing terminal such as the MELT.

The ability of energy-absorbing terminals to dissipate energy during head-on impacts and bring an errant vehicle travelling at high-speed to a controlled stop over a short distance reduces the opportunity for an errant vehicle to pass behind the system.

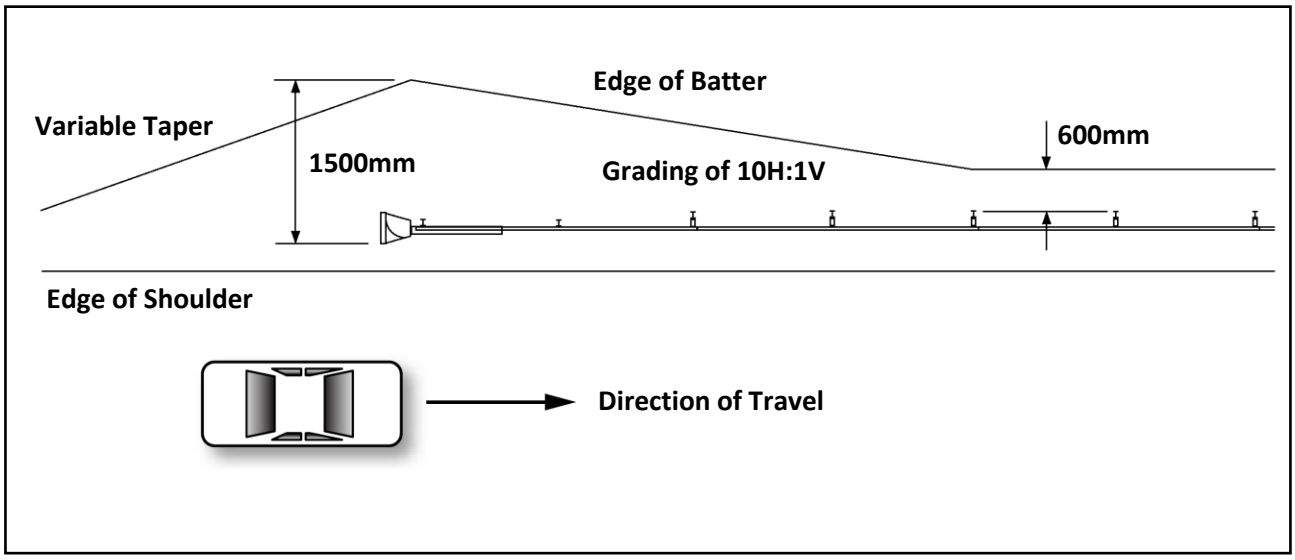


Figure 5: Recommended Advance Grading for W-Beam Guardrail with Tangential End Terminal

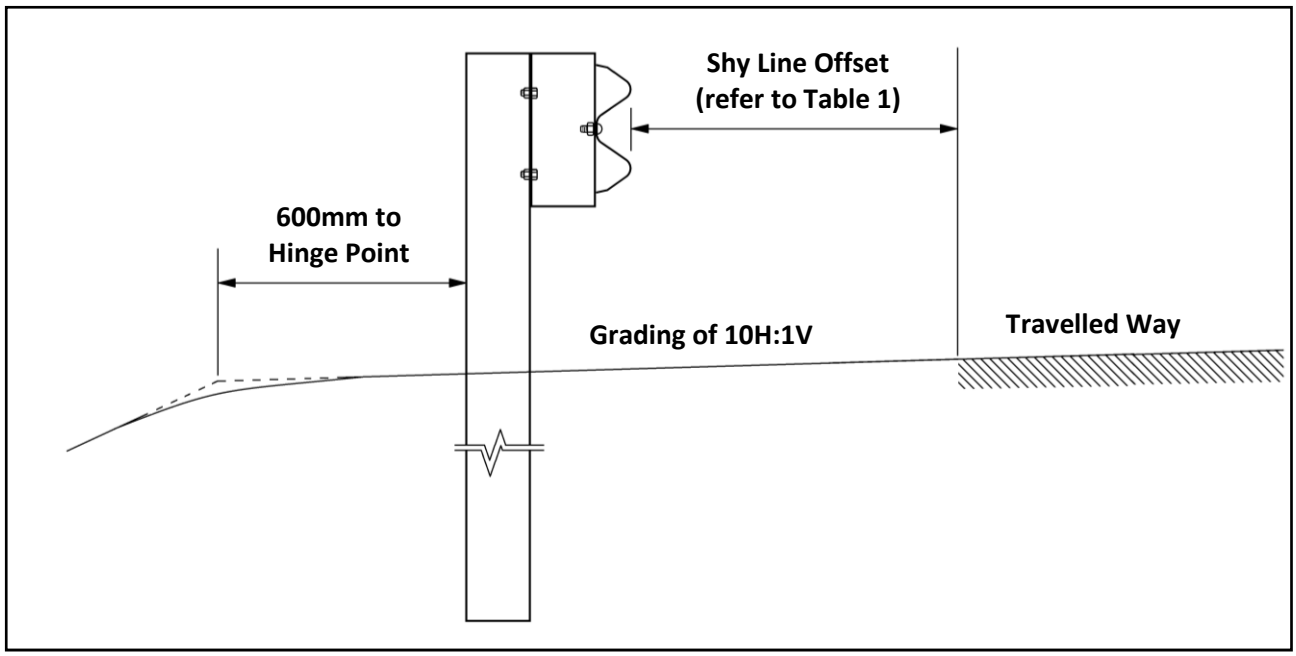


Figure 6: Recommended Adjacent Grading for W-Beam Guardrail

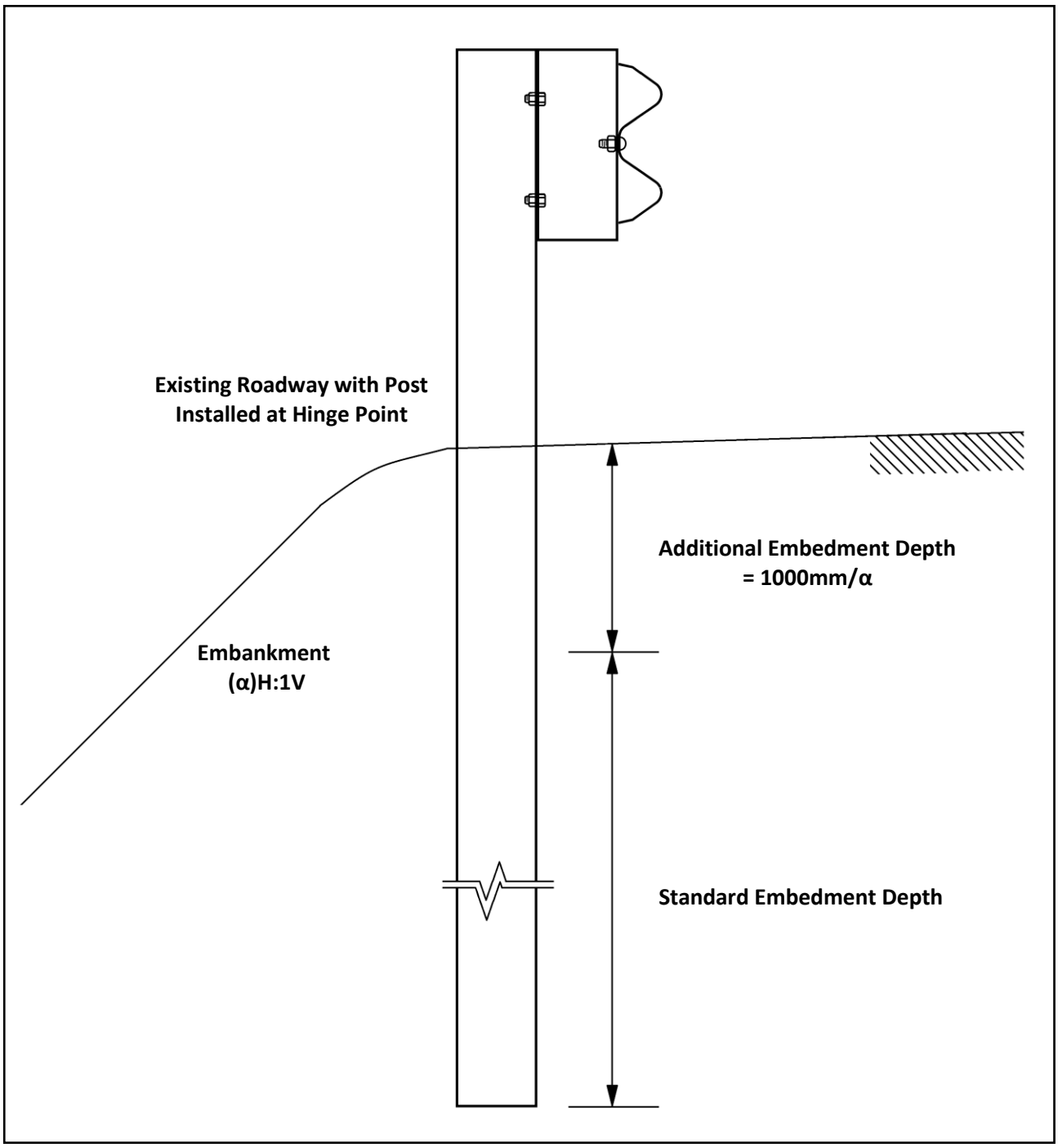


Figure 7: Guidelines for Increasing Post Embedment Depth (Source: Qld Main Roads Drawing 1474)

4.6 Kerbs

Placing kerbs in front of w-beam guardrail on high-speed roads is not recommended. As an alternative, a shallow gutter in front of the barrier or subsurface grated drainage should be considered.

On lower speed roads that often require a kerb, it is recommended that the location of the barrier be 200mm from the face of kerb. This reduces nuisance impacts and minimises the potential for vehicle launching.

4.7 Culverts

When culverts are encountered the use of a post mounted on a base plate may be considered. Where a base plate post cannot be accommodated, a span of up to 6m is generally permitted without a supporting post provided the rail is nested (i.e. double layer) throughout this location.

When providing a barrier system over a culvert, the area behind the safety barrier system should be sufficient to accommodate the expected dynamic deflection of the barrier.

4.8 Transition to Rigid Barrier

Since the stiffness properties vary between a semi-rigid and rigid barrier, a specially designed transition is required when connecting w-beam guardrail to a rigid barrier such as concrete.

A transition gradually increases the lateral stiffness of the w-beam guardrail barrier and reduces the potential for vehicle pocketing at the connection with the rigid barrier. Transition designs are contained within state road authority specifications.

Typically transition designs incorporate the use of thrie-beam (triple corrugation rail) and a reduction in post spacing.

4.9 Pedestrians and Cyclists

Pedestrians or cyclists may require shielding by a road safety barrier in situations where they are considered to be exposed to a higher than normal risk of being struck by an errant vehicle. Where a pedestrian/cyclist facility either exists or is proposed for an existing site that has a run-off-road crash history, an assessment of pedestrian, cyclist and bystander exposure should be undertaken so that crash reductions for alternative treatments can be considered.

Cyclists and pedestrians may require a barrier to prevent them inadvertently running onto a traffic lane from an adjacent shared path (e.g. footpath on a bridge with high numbers of young pedestrians/cyclists). In cases where there is no need to protect path users from errant vehicles, or errant vehicles from roadside hazards, a pedestrian fence of a suitable height for cyclists should be adequate.

Where there is a need to provide a road safety barrier between a path and road traffic it is important that the rear of the road safety barrier is not a hazard for pedestrians and cyclists. Where sufficient clearance cannot be provided, cyclists are protected from ‘snagging’ on posts by the provision of suitably designed rub rails.

Designers should ensure that any modification or attachments to the barrier would not be detrimental to its performance under vehicle impact or result in components being hazardous to motorists or path users in the event of a crash with the barrier (e.g. horizontal rails spearing vehicles).

4.10 Shy Line Offset

Drivers tend to reduce speed or laterally move their vehicles away from a road safety barrier if it is within close proximity to the edge of the travelled way.

The distance from the edge of the travelled way beyond which a safety barrier will not be perceived as an immediate hazard by the typical driver is known as the shy line offset. Recommendations for the shy line offset are contained in Table 1.

Table 1: Shy Line Offset

Design Speed (km/h)	Shy Line Offset (m)
50	1.1
60	1.4
70	1.7
80	2.0
90	2.2
100	2.4
110	2.8

Source: Austroads Design Guide

4.11 Flaring

Motorists are less likely to perceive roadside barriers to be a hazard if the barrier is introduced gradually to the roadside environment through the use of a 'flare'. Consequently, some end treatments for w-beam guardrail barriers such as the FLEAT-SP are designed to be flared away from the approaching traffic. The flare rate is the ratio of the length of the flared part of the barrier (measured parallel to the road) to the barrier offset.

Flaring the safety barrier system provides the following benefits;

- The end terminals can be positioned further from the travelled path reducing the potential for a head-on impact;
- The shy line effects where a hazard is close to the travelled path is minimised; and
- Flaring provides a gradual transition to a major hazard close to the roadway (such as a bridge parapet or railing).

The maximum flare rates that should be used on an approach to a road safety barrier are shown in Table 2. Following the guidelines of Table 2 ensures that the flare does not significantly increase the opportunity for high-angle impacts with the barrier.

Table 2: Flare Rate

Design Speed (km/h)	Flare Rate (within Shy Line Offset)	Flare Rate (outside Shy Line Offset)
50	13:1	7:1
60	16:1	8:1
70	18:1	10:1
80	21:1	11:1
90	24:1	12:1
100	26:1	14:1
110	30:1	15:1

Source: Austroads Design Guide

The flare rate for end terminals such as the FLEAT-SP vary from those contained in Table 2. Please refer to specific Product Guides for allowable flare rates for end terminals.

5.0 Curving

W-beam guardrail performs well on the outside of curves, even those of relatively small radius, as the concave shape (in plan view) supports the development of tension in the w-beam rail.

In the field, straight sections of w-beam can be used to form a radius of 45m or greater. When a radius of less than 45m is required, the w-beam rails are required to be factory curved. For ordering purposes, the orientation of curvature and radius is required by the manufacturer.

Table 3 details the chord length (C), height offset (H), and angle (Ø) for various curved rails.

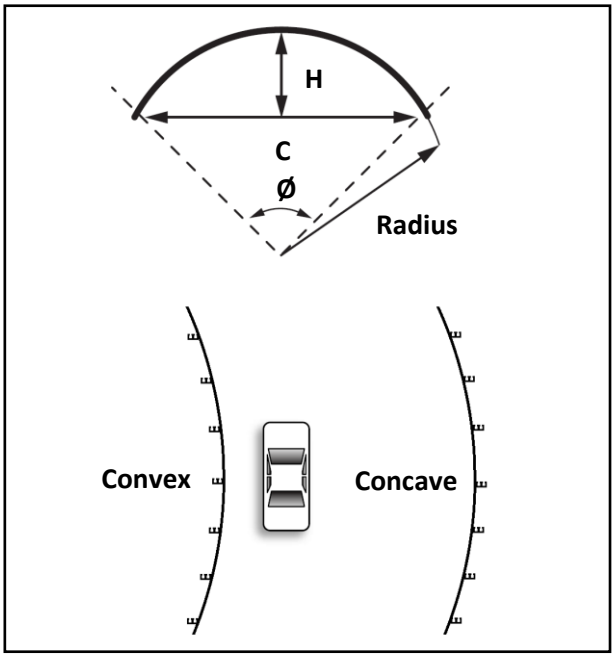


Figure 8: Curving Detail

Table 3: W-Beam Guardrail Curving

	4m W-Beam Guardrail			5m W-Beam Guardrail (Victoria)		
Radius (m)	**Ø (Degrees)**	**C (mm)**	**H (mm)**	**Ø (Degrees)**	**C (mm)**	**H (mm)**
2.4	95.5	3553	786	119.4	4144	1189
3.0	76.4	3710	642	95.5	4441	983
4.0	57.3	3835	490	71.6	4681	756
5.0	45.8	3894	395	57.3	4794	612
6.0	38.2	3926	330	47.8	4857	513
7.0	32.7	3946	284	40.9	4894	442
8.0	28.7	3958	249	35.8	4919	387
9.0	25.5	3967	221	31.8	4936	345
10	22.9	3973	199	28.7	4948	311
12	19.1	3982	166	23.9	4964	259
14	16.4	3986	143	20.5	4973	223
16	14.7	3990	125	17.9	4980	195
20	11.5	3993	100	14.3	4987	156
24	9.6	3995	83	11.9	4991	130
28	8.2	3997	71	10.2	4993	112
32	7.2	3997	62	8.9	4995	98
35	6.6	3998	57	8.2	4996	89
40	5.7	3998	50	7.2	4997	78
45	5.1	3999	44	6.4	4997	69

W-Beam Guardrail

Semi-Rigid Protection

6.0 Summary

- W-beam guardrail is the world's most widely specified safety barrier system.
- The semi-rigid feature of w-beam guardrail provides a desirable outcome for both designer and the vehicle occupants. The lateral displacement of the system is typically limited to 1m providing protection from nearby roadside hazards. The ability of the barrier to absorb some of the crash energy reduces occupant risk and the deformation of the impacting vehicle.
- The semi-rigid feature of w-beam guardrail limits damage during impact, reducing maintenance costs.
- The Australian post and block design has demonstrated excellent in-service performance over many years.
- The blocking pieces, positioned between the rail and posts, minimise vehicle snagging and reduce the potential for the vehicle to vault over the barrier by maintaining rail height during the initial stages of impact.
- Steel components are hot dip galvanised providing a durable solution.
- W-beam guardrail performs well on the outside of curves, even those of relatively small radius, as the concave shape (in plan view) supports the development of tension in the w-beam rail.
- W-beam guardrail can be installed using posts on base plates when passing culverts.
- The high visibility of w-beam guardrail creates driver confidence.

7.0 Designers Checklist

- Calculate the beginning length-of-need required to shield the roadside hazard.
- Calculate the clear zone width and determine whether a crashworthy end terminal such as the SKT-SP or FLEAT-SP is required on the trailing end. Refer to example shown in Figure 3.
- Ensure the end terminal point-of-need is appropriately aligned with the site beginning length-of-need. Refer to example shown in Figure 4.
- Ensure appropriate grading is provided in advance and adjacent to the w-beam guardrail barrier. Refer to examples shown in Figures 5 and 6.
- If the barrier is to be installed on an existing road with limited formation, assess the post embedment depth following the guidelines of Figure 7.
- Consider locating the barrier outside the shy line offset in accordance with Table 1.
- Consider providing a flare throughout the system in accordance with Table 2.
- If the guardrail system follows a curved alignment, determine whether the straight rails can be used or if factory curving will be required.
- Ensure the guideline for minimum length between terminals is observed.
- On high-speed roads, provide a shallow gutter or subsurface grated drainage as an alternative to a kerb.
- Undertake a risk assessment if pedestrians and/or cyclists will be accessing the area behind the barrier.

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