Austroads Safety Barrier Assessment Panel – Technical Advice

Run-out Areas for Barrier Terminals

SBTA 21-003

Preamble

Since the development of the Modified Eccentric Loader Treatment (MELT) and the associated run-out area, the design of safety barrier terminals has changed significantly. Modern crash test protocols, including National Cooperative Highway Research Program Report 350 (Ross et al., 1993) and American Association of State Highway and Transportation Officials (AASHTO, 2016) *Manual for Assessing Safety Hardware* (MASH), require all terminals to undergo a suite of crash tests, therefore the Austroads Safety Barrier Assessment Panel (ASBAP) has a collection of crash test results for various terminal types, that report the final resting position of the test vehicle.

This Technical Advice provides guidance on the run-out area for barrier terminals, to supplement the information provided in Austroads *Guide to Road Design Part 6: Roadside Design, Safety and Barriers* (Austroads, 2022), Section 5.3.21 – Terminal Treatments.

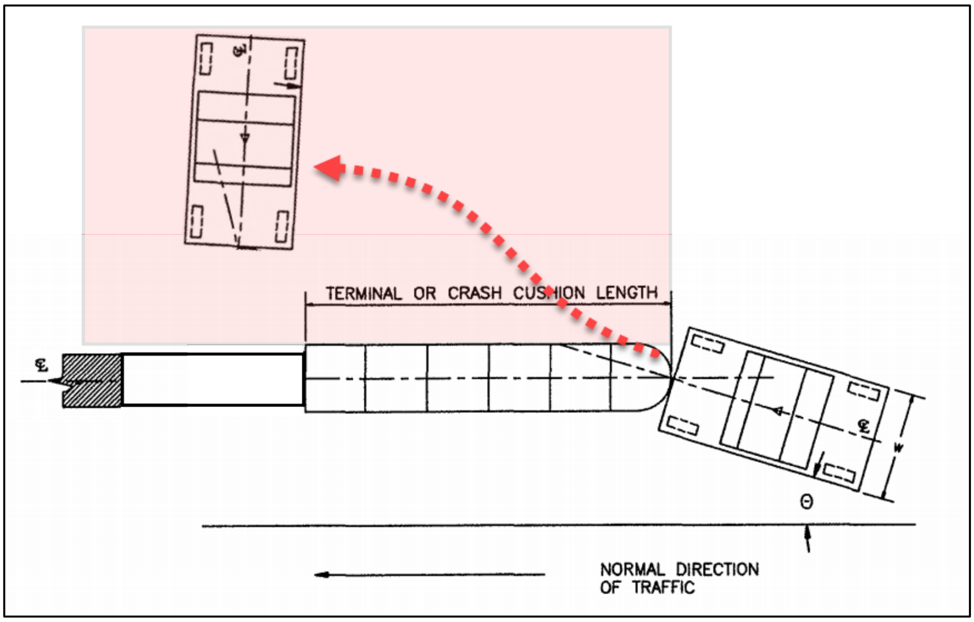
Audience

- Road agencies
- Road designers.

Background

Gating terminal systems are designed to allow a vehicle impacting the nose, or the side of the terminal at an angle near the nose, to pass through the terminal and come to rest behind the barrier (i.e. on the side of the road safety barrier opposite the travelled lane). This area is referred to as the 'run-out area'.

Figure 1: Post impact trajectory



The run-out area, according to Austroads (2022), must contain no fixed hazards, must be traversable, must extend 18.5 m beyond the point of redirection and be at least 6 m wide. This area is measured from the point of redirection (PoR) of any gating terminal and is based on the 22.5 m long by 6 m wide hazard-free area required for the MELT as shown in AS/NZS 3845:1999.

However, since the development of the MELT, the design and performance of barrier terminals has changed significantly and ASBAP has received over 230 terminal crash test reports; over 90 of which demonstrated gating behaviours.

While each product will perform differently, this Technical Advice groups the performance of similar terminal types, including guardrail terminals, crash cushions, plastic water-filled terminals and wire rope barrier terminals.

Commentary

Over 230 crash test reports have been reviewed and approximately 90 of these resulted in the vehicle coming to rest behind the barrier. This behaviour is a primary objective of the crash testing protocol, therefore this ratio of redirective to non-redirective outcomes is normal.

The range of products analysed included eight guardrail terminals, nine crash cushions, five temporary plastic water-filled terminals and three wire rope barrier terminals. The review included both NCHRP 350 and MASH compliant crash test results.

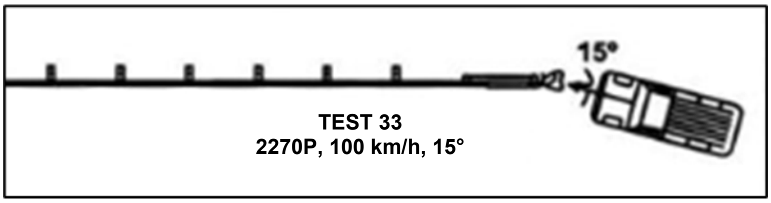
Guardrail Terminals

From 83 guardrail terminal tests, 27 vehicles came to rest behind the barrier.

While most test vehicles came to rest within the recommended 22.5 m x 6 m run-out area, there were several results in which the vehicle stopped over 30 m from the terminal head. These were identified as Test 32 and Test 33 outcomes, which involves a 15° impact at the barrier nose. The primary objective of Tests 32 and 33 is to evaluate occupant risk and vehicle trajectory criteria, therefore most guardrail terminals are designed to allow a vehicle to pass through unimpeded and without penetration of the vehicle.

As such, it is considered inappropriate to include these results in the run-out area. Rather, these test results should act as a reminder of the consequence of not extending the barrier far enough.

Figure 2: Impact conditions for Test 3-33



Source – based on AASHTO (2016)

Test Level 2 (70 km/h) crash test data was limited; however, it was noted that one product was subjected to both the 3-33 and 2-33 tests which provided a useful comparison. At 100 km/h (Test 3-33), the terminal gated and the vehicle came to rest behind the barrier approximately 9 m downstream of the terminal. However, at 70 km/h (Test 2-33), the same terminal demonstrated negligible gating behaviour and the vehicle came to rest in front of the terminal. While this highlights the depreciating run-out area value when impact speeds are low, it is insufficient to conclude a TL-2 run-out area.

Crash Cushions

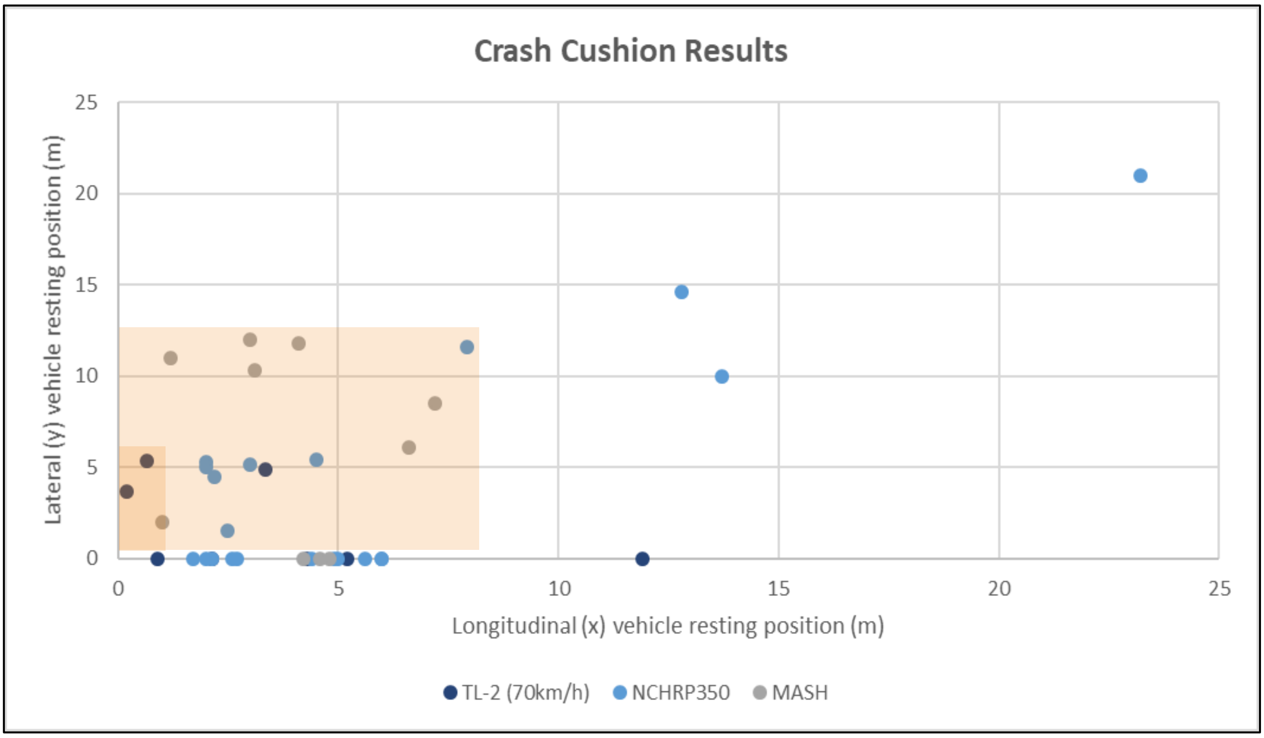
Crash Cushions at 100 km/h

From 99 crash cushion tests, 37 vehicles came to rest behind the barrier. It was evident from the TL-3 results (Figure 3) that many vehicles came to rest more than 6 m (laterally) behind the terminal, but less than 22.5 m downstream of the nose. The impacting vehicles have a significant amount of longitudinal and lateral momentum, and although the crash cushion can absorb longitudinal energy, the vehicle continues to move/rotate laterally after the impact.

While crash cushions have not traditionally warranted a run-out area, these 37 tests suggest that a run-out area of 8 m (long) x 12 m (lateral) from the crash cushion nose is necessary.

Where crash cushions are located in a gore area, the offset to traffic lane should be maximised, although it often not practical to locate the traffic lanes outside the run-out area.

Figure 3: Final vehicle resting positions for TL-3 crash cushions tests



Crash Cushions at 70 km/h

From 23 crash cushion tests, eight vehicles came to rest behind the barrier. Impacts at 70 km/h had significantly less impact energy, therefore the lateral momentum and vehicle position after an impact was negligible. While the furthest resting position was 3.35 m x 4.88 m, this was not consistent in all 3-32 crash tests, therefore a run-out area is not essential for impact speeds of 70 km/h and less.

Temporary Plastic Water-Filled Terminals

From 25 plastic water-filled terminal tests, 15 vehicles came to rest behind the barrier.

Temporary plastic water-filled terminals had the most varied behaviour, with several vehicles coming to rest beyond the recommended 22.5 m x 6 m run-out area. This finding is concerning, given that temporary plastic water-filled terminals are commonly used near worksites where space is limited and is a reminder that speed reductions should be implemented when sufficient run-out area is not provided.

At 70 km/h (TL-2) and 50 km/h (TL-1), the impact energy is significantly less and similarly, the vehicle came to rest closer to the barrier nose. As such, a smaller run-out area of 10 m (long) by 6 m (lateral) is recommended for impact speeds of 70 km/h and less.

Wire Rope Barrier Terminals

From 16 wire rope barrier terminal tests, 13 vehicles came to rest behind the barrier. During these impacts, the wire rope barrier terminal absorbed very little kinetic energy and the vehicle was able to travel a significant distance before coming to a rest. While this is not an evaluation criterion (pass/fail) of the crash test protocol, it highlights the importance of wire rope barrier terminal placement.

Limitations of the Review

There were multiple crash test reports which did not adequately display the final resting position of the crash tested vehicles. In these cases, the associated photographs and videos were consulted to provide an estimate of the final position. This estimate was based on known information such as post spacings and vehicle dimensions.

Some of the crash tests, particularly the early NCHRP 350 tests, used a containment wall which affected the final resting position. Any vehicle impacting the containment wall would have likely cleared the run-out area unless braking was applied.

Recommendation

Based on this review, the recommended run-out area should be based on terminal type and impact speed.

When an errant vehicle impacts a gating or non-gating terminal, it may come to rest within an area behind the end treatment (i.e. on the side of the road safety barrier opposite the travelled lane). As such, a run-out area should be provided at all terminals.

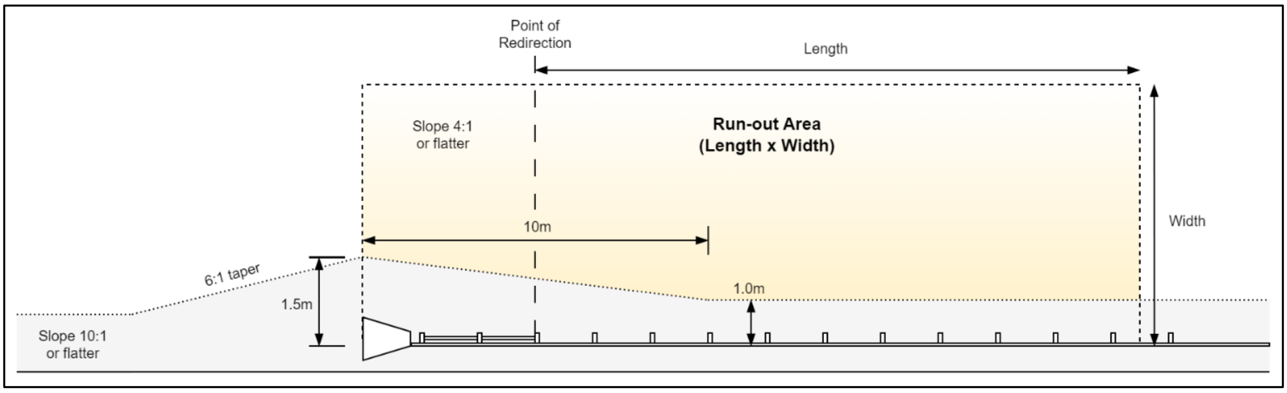
The run-out area should:

- contain no fixed hazards (e.g. poles and trees).
- have a lateral slope of 10:1 or flatter (desirable), or a lateral slope that aligns with Figure 4 (minimum) which is based on AASHTO *Roadside Design Guide* (2011) Figure 8-3.
- measure in accordance with the dimensions in Table 1.

Table 1: Recommended run-out area by terminal type

Terminal type	Run-out area at 100 km/h	Run-out area at 70 km/h
Guardrail terminal	18.5 m x 6 m from PoR	
Crash cushion	8 m x 12 m from nose	Not required
Wire Rope Safety Barrier	18.5 m x 6 m from PoR	
Plastic water filled terminal	18.5 m x 6 m from nose	10 m x 6m from PoR

Figure 4: Run-out area and grading for barrier terminals



Although the recommended dimensions in Table 1 will not cover all possible outcomes, these values are considered a reasonable and practical update to AGRD Part 6 (2020), based on 230 crash test results. This table may be reviewed by ASBAP following further product submissions and new crash test information.

References

AASHTO (2016) *Manual for assessing safety hardware*, 2nd edn, American Association of State Highway and Transportation Officials, Washington, DC, USA

Austroads (2022) *Guide to road design part 6: roadside design, safety and barriers*, AGRD06-22, Austroads, Sydney, NSW

Ross, HE, Sicking, DL, Zimmer, RA & Michie, JD (1993) *Recommended procedures for the safety performance evaluation of highway features,* Report 350, National Cooperative Highway Research Program, Transportation Research Board, Washington, DC, USA.

AS/NZS 3845.1:2015, Road safety barrier systems and devices: part 1: road safety barrier systems

AS/NZS 3845.2:2017, Road safety barrier systems and devices: part 2: road safety devices

Amendment Record

Amendment no.	Amendment	Date
-	New Technical Advice Note	February 2021
1	Wording, Figure 2 and Figure 4 updated	December 2023