# Road Safety Barriers

# International experiences and new directions for Australia

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## Abstract

Australian road fatalities may have halved since 1990, but all is not well. Australian fatality reduction has plateaued where our international peers see continued decline (BITRE, 2014-1). Serious injuries from road traffic accidents have been suggested to be on the rise (ITF, 2014). And if you're a crash statistic in Australia – you're three times more likely to be a fatality than in the UK, Canada, Germany or Sweden (BITRE, 2014-2). So are there lessons to be learnt from abroad? Australian road safety experts agree better infrastructure, and specifically road safety barriers, are part of the new solution (BITRE, 2014-3). This paper focusses on European (EN1317 compliant) safety barriers, which are lesser known in Australia than NCHRP-MASH compliant barriers. We present European experiences and state-of-the-art development directions that may help Australian road designers, specifiers and authorities make roads safer. We suggest EN1317 compliant barrier systems offer a good direction for greater injury reduction on Australian roads, with economic incentives compared to other options.

## Comparison of international standards

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

- Standard EN1317, valid and obligatory in European countries and accepted by many national authorities worldwide
- Standard MASH, former also NCHRP, valid and obligatory in the United States of America and accepted by many national authorities worldwide

These standards describe requirements and test parameters of vehicle road restraint systems but do not include national parameters of using road safety barriers. Specific National standards and regulation sort out the requirement on specific road sections national-wide.

The EN1317 and MASH standards differ in certain aspects. A short overview of differences and similarities are presented in Table 1 and Figure 1.

*Table 1. Qualitative comparison of MASH and EN1317*

| MASH standard | EN1317 standard |
|---|---|
| Focus on break-through prevention and deformations of occupant compartment | Focus on passenger safety |
| No direct classification of performance levels | Classification of displacement/working width, vehicle intrusion and passenger safety in performance classes |
| Different test vehicle mix | Different test vehicle mix |
| Minimum installation length defined afterwards | Rollover of vehicles is prohibited |
| Focus on Structural adequacy, occupant risk and vehicle trajectory | Test length defines the minimum installation length of restraint system |

To compare different test conditions of each standard the impact energy levels of the test parameters are mostly used.

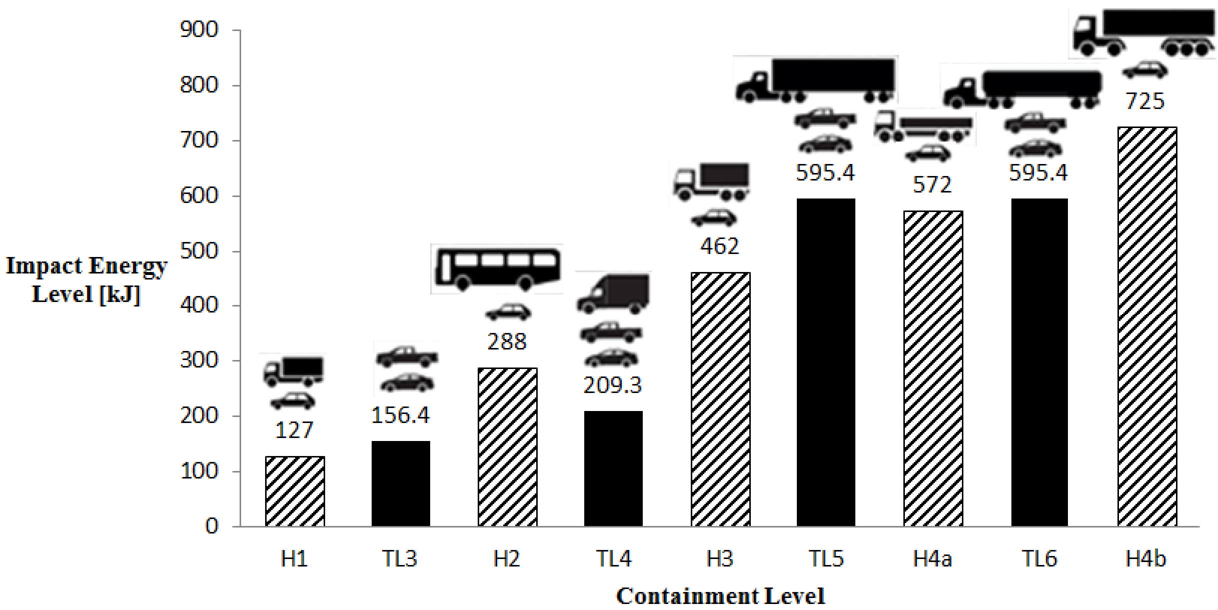


*Figure 1. Containment levels and Impact energy levels of MASH and EN1317*

## Difference in design of safety barriers

Worldwide different design preferences exist. The reason therefore is mostly a historical background of less regulations and standards. Because of strict performance verifications by MASH or EN1317, a limitation of designs should not influence ongoing developments. The following designs are in general most popular:

- Single slope design – preferred in the USA
- Step profile design – preferred European wide
- F-shape design – preferred in the USA
- New Jersey design – preferred European wide

**Verifiable passenger safety by ASI value classification**

The standard EN1317 includes certain parameters for classifying the injury risk potential of passengers. The Acceleration Severity Index characterizes the intensity of the impact, and is regarded as the most important rate of impact on occupants. MASH acknowledges that measurement and/or calculation of ASI is preferable, but it is only prescriptive in EN1317.
The ASI value is an interaction and Correlation of different values:

- HIC – the Head Injury Criterion, measures the acceleration acting on the head of the occupants
- AIS – the Abbreviated Injury Scale, especially describes the injuries in head and neck area of occupants involved in collisions. Table 2 details the scale.

***Table 2. Abbreviated Injury Scale***

| Injury Scale | Category | Injuries |
|---|---|---|
| 0 | None | No injury |
| 1 | Minor | Light brain injuries with headache, vertigo, no loss of consciousness, light cervical injuries, whiplash, abrasion, contusion |
| 2 | Moderate | Concussion with or without skull fracture, less than 15 minutes unconsciousness, corneal tiny cracks, detachment of retina, face or nose fracture without shifting |
| 3 | Serious | Concussion with or without skull fracture, more than 15 minutes unconsciousness without severe neurological damages, closed and shifted or impressed skull fracture without unconsciousness or other injury indications in skull, loss of vision, shifted and/or open face bone fracture with antral or orbital implications, cervical fracture without damage of spinal cord |
| 4 | Severe | Closed and shifted or impressed skull fracture with severe neurological injuries |
| 5 | Critical | Concussion with or without skull fracture with more than 12 hours unconsciousness with haemorrhage in skull and/or critical neurological indications |
| 6 | Fatal | Death, partial or full damage of brainstem or upper part of cervical due to pressure or disruption, fracture and/or wrench of upper part of cervical with injuries of spinal cord. |

There is a correlation between AIS and the Injury Scale as Figure’s 2 and 3 demonstrate.

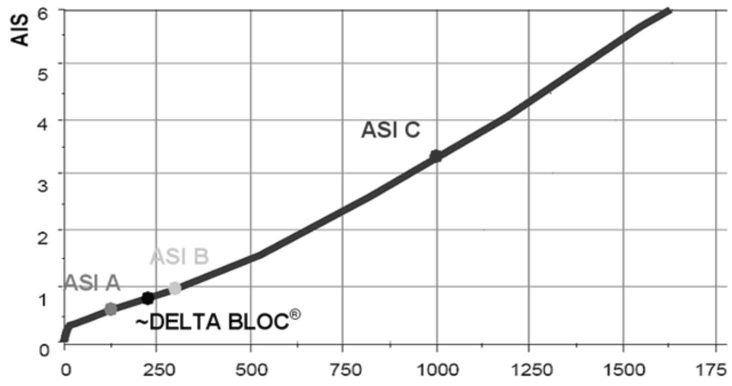


*Figure 2. Correlation between AIS and HIC*

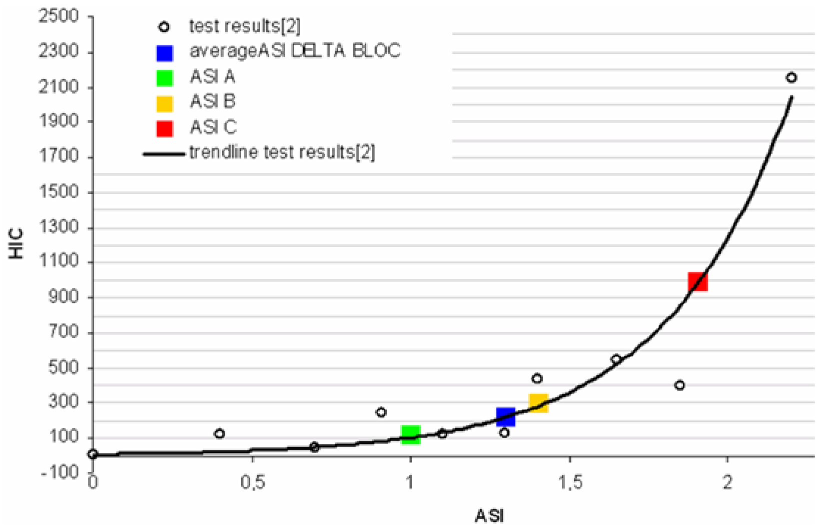


*Figure 3. Correlation between AIS and HIC*

As a result of the correlation between these values the performance classes ASI A and AIS B can be classified as providing high passenger safety with minor influences for occupants. Performance class AIS C in the contrary is classified as area of serious injury potential and is not approved in most countries.

## State of the art technology

In recent years, the demands on traffic restraint systems have changed dramatically. The higher volume of traffic, the increased use of traffic management systems as well as the claims in the area of occupant protection and system space requirement flow strongly to development of new traffic restraint systems excessively.

## Modern requirements

- Low space requirement: slim design, small working width, small displacement
- High safety performance: high containment classes H1-H4b / TL4-TL6, high passenger safety
- Economical and simple installation: optional freestanding barrier, over-night installation, short traffic interference
- Connectable system solutions: customised solutions supported by one supplier, transition solutions for existing barriers, wide product range for each application area
- Dual use options
- Reliable safety confirmed by international valid test reports

**Dual use of traffic safety barriers**

A great economic advantage represents mainly so-called dual-use products. Because of extensive tests these products are suitable for temporary protection as well as for permanent protection. This results in great savings potential for the user in the overall consideration. Figure's 4 and 5 demonstrate how the same dual-use barriers can be utilised in both construction and normal service. In normal service, the dual-use barriers are embedded or pinned into the road surface to meet permanent barrier protection requirements.

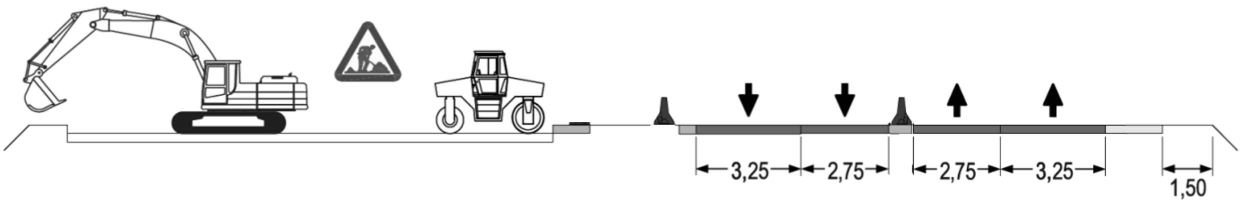


*Figure 4. Example of road work zone during road refurbishment*

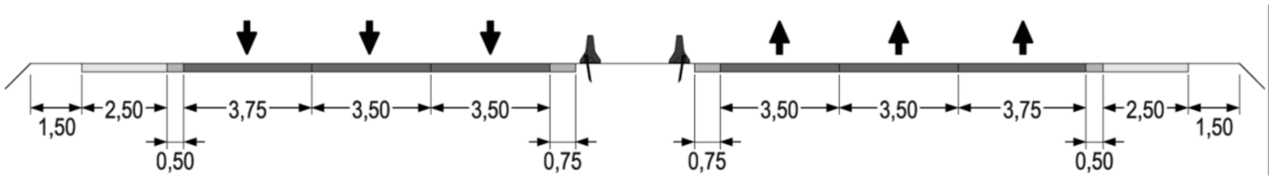


*Figure 5. Final position of road safety barriers after road refurbishment*

**Durability of traffic safety barriers**

The average period of use of restraint systems has changed dramatically through the increased use of high quality materials and technologies in recent years. Systems made of concrete currently have best properties in terms of resistance and durability. Light and medium impact events over the period of use are the greatest burden on restraint systems, and are by far the most common as Figure 6 shows. Most of these light and medium impacts however only marginally affect concrete barrier aesthetics, and not function. High resistance of products and avoiding of impact consequences by bad impact behaviour will be also a benefit directly for road users by low vehicle damage. Furthermore, traffic jams as a result of an impact will be greatly reduced.

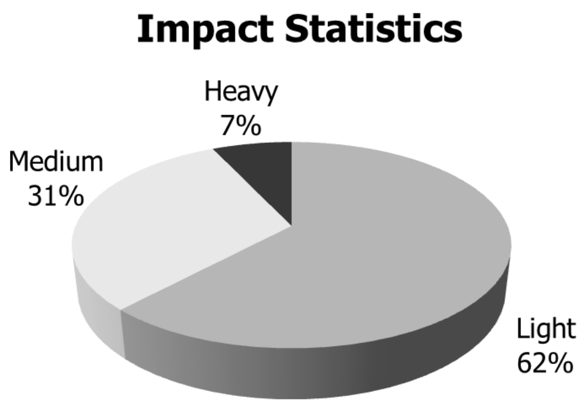


*Figure 6. Impact statistics overview of heavy impact ratio*

**Customised solutions for special application areas**

Standards like the EN1317 and MASH include only test parameters for products installed in a straight line. Therefore even curve radii situations are not supported by separate test parameters. In practice a modern highway section includes a lot of special application areas which requires customized solutions. The planers and authorities are requested to sort out the best provided solution of suppliers and to release them separately by project. Following solutions are well used in European countries.

## Integration of lamp posts

For integration of lamp posts on motorways different options exist but in the case of small space conditions there is only one option: direct connection of the lamp post to the safety barrier as Figure 7 shows. Precast concrete barriers offers flexibility in design of cable releases and fixation plates. The element weight of the barrier supports specific demands on stability without fixation.

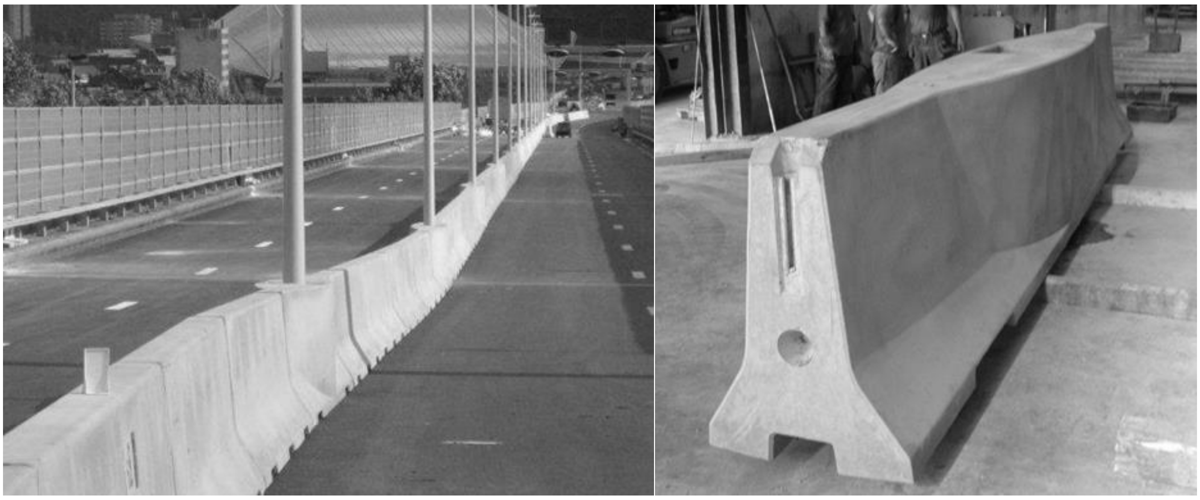

***Figure 7. Example of precast concrete barrier solution with integration of lamp posts***

## Expansion joints on bridges

Expansion joints are part of most bridge constructions up to a certain dimension. Modern restraint systems also have to provide a continuous crash tested connection in these areas. Customized solutions can be provided up to certain expansion joint dimensions by mechanical means. However the integration of hydraulic dampers may be required for larger expansion joints as pictured in 8.

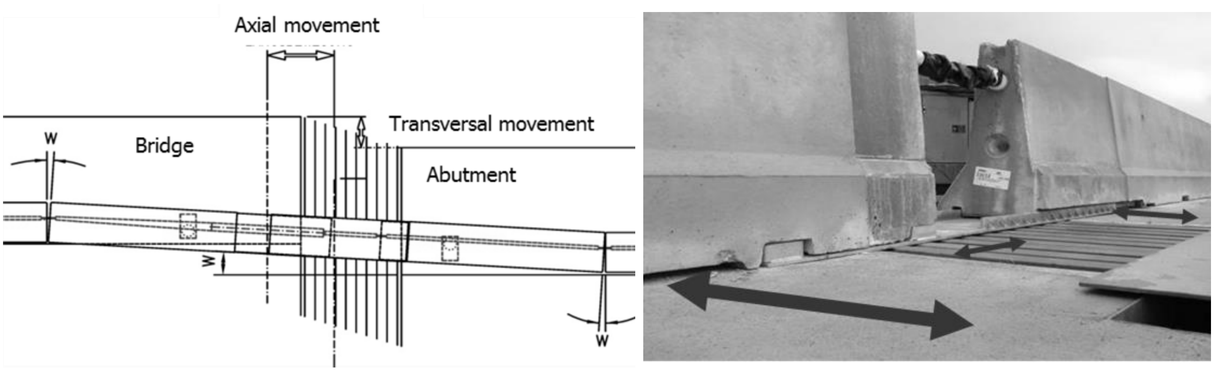


***Figure 8. Requirements (left) and special system for expansion joints on bridges (right)***

## Combined system solution – noise protection / safety barrier

Noise protection close to urban areas becomes more and more of a priority. In the past, only separated products were available. Now there are new products which offer safety in both directions with small space requirements – see Figure 9. New developments of combined products are meeting the demands of today's market.

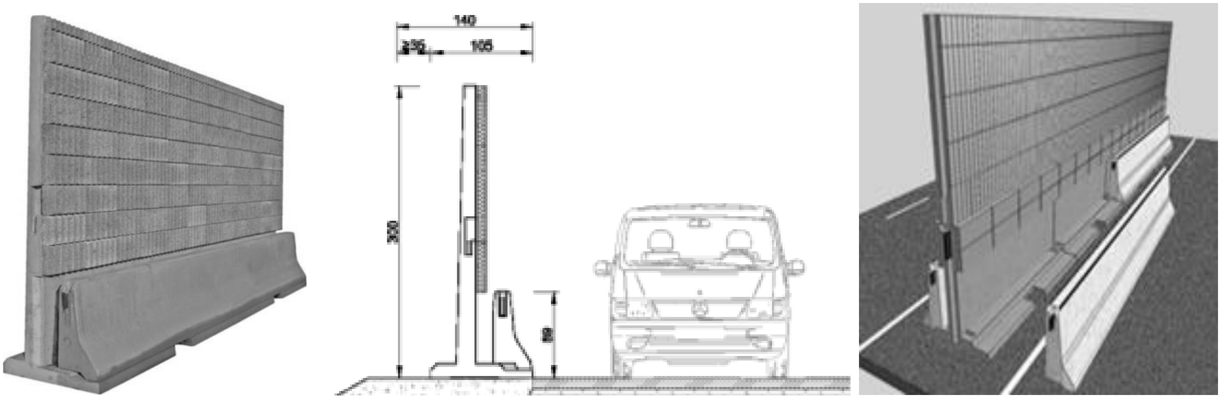

***Figure 9. Combined system solution DB LSW tested in accordance with EN1317***

Combined system solutions (tested by EN1317 and EN1793) can be placed close to the source of noise, and increasingly with absorptive, not reflective, noise wall technolog. This opportunity may remove the need for big noise protection walls with heights of more than 6m next to the motorway.

**Traffic safety development – International comparison**

Increasing road safety is an important goal for all countries. The national programs for the reduction of road fatalities and accidents in general, are an important input for increasing the economic efficiency of a country. Following statistics in Table 3 give an overview about the statistical development in the field of transport safety of individual countries, and show the leading fatality reduction rates in European countries such as Germany and Austria that use the systems highlighted in this paper.

***Table 3. Road safety development of countries (ITF, 2014)***

| Road Fatalities[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Recent data | | | | | Long-term trends - Average annual change | | | |
| Country | 2009 | 2008 | Evolution 2008-2009 | Evolution 2000-2009[3] | 2000-2009[3] | 1990-1999 | 1980-1989 | 1970-1979 |
| Argentina[4)] | 7,364 | 7,552 | -2.5% | 12% | 2.2% | - | - | - |
| Australia | 1,507 | 1,441 | 4.6% | -17% | -2.1% | -3.0% | -1.7% | -0.9% |
| Austria | 633 | 679 | -6.8% | -35% | -4.7% | -4.0% | -2.7% | -1.8% |
| Belgium[2] | 955 | 944 | 1.2% | -35% | -4.7% | -3.8% | -2.0% | -3.0% |
| Cambodia[4] | 1,717 | 1,638 | 4.8% | 328% | 17.5% | - | - | - |
| Canada | 2,130 | 2,419 | -11.9% | -27% | -3.4% | -3.1% | -2.8% | 1.6% |
| Czech Republic | 901 | 1,076 | -16.3% | -39% | -5.4% | 1.3% | -1.7% | -4.0% |
| Denmark | 303 | 406 | -25.4% | -39% | -5.4% | -2.3% | -0.3% | -5.4% |
| Finland | 279 | 344 | -18.9% | -30% | -3.8% | -4.4% | 3.2% | -5.2% |
| France | 4,273 | 4,275 | -0.05% | -48% | -6.9% | -0.7% | -1.8% | -2.1% |
| Germany | 4,152 | 4,477 | -7.3% | -45% | -6.4% | -3.8% | -4.7% | -3.4% |
| Greece[2] | 1,456 | 1,553 | -6% | -29% | -3.7% | 0.4% | 3.7% | 3.4% |
| Hungary | 822 | 996 | -17.5% | -32% | -4.1% | -6.7% | 3.2% | 0.8% |
| Iceland | 17 | 12 | 41.7% | -47% | -6.8% | -1.5% | 1.3% | 3.4% |
| Ireland | 239 | 279 | -14.3% | -42% | -5.9% | -1.6% | -2.2% | 1.4% |
| Israel | 314 | 412 | -23.8% | -31% | -4.0% | 1.2% | 1.0% | 0.8% |

The following aspects can be interpreted as major influences on annual figures:

- In decade 1990-1999 more and more products made of concrete influences the market
- in year 1998 the final draft of EN1317 comes in force and substitutes existing standards and national regulations
- in decade 2000-2009 all countries of the European Union are obliged to implement EN standards especially EN1317; the new standards and regulations pushed the development of new products which as a result lead to more than 100 new products for passive traffic safety were developed in this decade
- during 2008-2009 the American Association of State Highways and Transportation Officials adapted in total the NCHRP standard of the USA – 2009 the new standard MASH comes in force

**Actual Developments**

Country-specific actions to improve road safety:

- European Union: part 5 of EN1317 comes in force (2008) and includes the monitoring of production of restraint systems under compliance with test conditions
- European Union: the demand of vehicle intrusion as a performance parameter of restraint systems by tenders is becoming increasingly more prominent
- Germany: Harmonisation of approval procedure for use of restraint systems is raising the availability and combination of products on long-time view – suppliers are called to offer

**Conclusion**

The technology highlighted here presents alternatives to many of the current ways of doing things in Australia. Whilst the alternatives are only introduced briefly, we hope this opens up the possibilities available to road designers, specifiers and authorities when seeking to make Australian roads safer.

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