# FLEXIBLE BARRIERS ALONG HIGH-SPEED ROADS – A LIFESAVING OPPORTUNITY

Original version

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## 1. A BRIEF STATEMENT OF THE ISSUE

Single-vehicle crashes represent a major source of road trauma in all Australasian jurisdictions. Conventional measures such as shoulder-sealing, delineation and clear zones have had some limited success in reducing the number and severity of these crashes. In contrast, flexible barriers or wire rope safety barriers (WRSBs) have substantially reduced the risk of serious injury resulting from single-vehicle crashes.

This paper discusses the widespread use of WRSBs as a means of reducing the problem of single-vehicle crashes on high-speed roads, and also addresses some related concerns. Data quoted in this paper generally refer to single-vehicle crashes but because WRSBs are also effective in preventing head-on crashes, this crash type has also been included as specified.

## 2. AN ASSESSMENT OF THE ROAD SAFETY ISSUE

Single-vehicle crashes represent arguably the largest single source of road trauma in Australasia, accounting for around 45% of all fatalities. Data for some Australian jurisdictions and New Zealand show that:

- in South Australia, 60% of all fatal crashes (Transport South Australia, 2006a) and 58% of serious injury crashes in 2005 were single-vehicle crashes (Transport South Australia, 2006b)
- in Queensland in 2003, single-vehicle crashes accounted for 48% of fatal and 38% of serious injury crashes (Queensland Government, 2003)
- in Western Australia in 2002, single-vehicle crashes accounted for 68% of all fatal and 47% of all serious injury crashes (Government of Western Australia, 2003)
- in NSW in 2004, 40% of fatal and 24% of all injury crashes were single-vehicle crashes (RTA, 2004)
- in New Zealand in 2005, 38% of fatal crashes were classified as loss of control or run-off-road (Ministry of Transport NZ, 2005).

Flexible wire rope safety barriers (WRSBs) are increasingly being recognised as an effective countermeasure especially for single-vehicle run-off-road and head-on crashes involving crossing the road median, and are often used in preference to rigid median and roadside barriers which can act as hazards (Grzebieta, Zou and Jiang, 2005). For example, Larsson, Candappa and Corben (2003) recommended the following uses of WRSBs at appropriate sites along for the following categories of road in Victoria:

- for four-lane divided and undivided road formats – barriers should be placed along either side of the median for divided highways and along the centre of the road for single-carriageway roads, with barriers also along both sides of the roadway for both road types
- for two-lane undivided roads – provide continuous barriers along the centre and sides of the road.

Following an extensive review of WRSB possible uses and benefits, an Australian Transport Safety Bureau Working Party (2000, p.23) concluded:

> In many situations, WRSBs have distinct advantages over other conventional barrier types: they can have superior containment properties; they can cause less damage to vehicles and their occupants; they can be easier and safer to repair; and they can be cheaper to install. While they are not suitable in many situations, WRSBs add significantly to the range of treatment options available to traffic engineers.

Nilsson and Prior (2004) reviewed the suitability of steel guardrails, concrete barriers and WRSBs as a form of median separation along lengths of the Pacific highway in New South Wales. They concluded:

> Of the barrier types reviewed, the wire rope safety barrier provides the optimum solution in most circumstances due to the following factors:
>
> - Wire rope safety barriers have the lowest risk of injury and damage in the case of a light vehicle crashing into the barrier …
> - Wire rope safety barriers provide the lowest accident costs
> - Wire rope safety barriers have the smallest hardware footprint
> - The low deflection of concrete barrier is an advantage that is offset by the higher impact severity that results from impact with an immoveable barrier
> - Wire rope safety barriers are the best aesthetic solution because in most circumstances it allows motorists to see through the barrier and does not block the view of the landscape (Nilsson and Prior, 2004, p.7).

Others have gone further in recommending wider use of WRSBs. '… wire rope barriers are generally the safest types of barriers and they are very cost-effective. Wire rope barriers should be the preferred barrier types and the alternative types used only where it is not possible to use wire rope' (Szwed, 2002, p.1).

Research in Victoria has found that the crash types amenable to treatment by WRSBs tend to occur within a small portion of the road network. For example, median-encroachment crashes were found to be concentrated on high-speed, high-volume roads, with a conservative estimate of 40% of median encroachment casualty crashes occurring on Victoria's freeways or State highways (Corben et al., 2001). Studies in Sweden suggest that around 80% of single-vehicle related fatalities occur on 40% of the road network (Larsson, Candappa, & Corben, 2003) Although more research is needed to verify this, indications are that WRSBs need only be installed on a relatively minor proportion of the road network in order to effect a large reduction in the road crash casualties, thereby making this type of treatment economically attractive.

# 3. CURRENT POLICIES AND PRACTICES IN AUSTRALASIAN JURISDICTIONS

For both Australia and New Zealand, Standard 3845:1999 "Road Safety Barrier Systems", addresses the requirements for both rigid and non-rigid (including flexible) barriers. In addition, individual jurisdictions have commonly written their own guidelines, using a range of different documents as well as Standard 3845:1999 (Roper, Green, Tziotis and Veith, 2002).

WRSBs were first trialled in Australia in 1991 in New South Wales. Since then, all jurisdictions have used these barriers under various conditions albeit initially to a limited extent: it was estimated that by 2000, WRSBs accounted for less than 1% of the aggregate length of installed safety barriers (Australian Transport Safety Bureau 2000).

However usage seems to be increasing. As one example, VicRoads has amended its guidelines for the installation of median barriers, stating that median barriers need to be installed on new freeways and highways where the Annual Average Daily Traffic (AADT) volume will be greater than 30,000 vehicles per day within 5 to 10 years - or where the AADT will be between 20,000 and 30,000 within 5 to 10 years, if the width between inner traffic lanes is less than 6 metres. Where the AADT will be less than 30,000 vehicles per day within 5 to 10 years, a risk assessment should be carried out to evaluate the safety implications and the need for a median barrier, including consideration of traffic volume and median width (VicRoads, 2003). As the most recent example, Tasmania recently announced its decision to further trial their use along stretches of roads and highways with high crash levels.

# 4. A REVIEW OF THE RESEARCH

## 4.1 International applications

In 1998 Sweden committed to extensive use of WRSBs especially along lengths of its 13-metre undivided rural roads, as well as along especially, select lengths of motorways. The former use a 2+1 road configuration (Larsson et al., 2003): WRSBs are positioned along the middle of a three-lane, undivided road, providing alternate sections of two lanes in one direction separated from one lane running in the opposing direction. Upon contact with an errant vehicle, WRSBs deflect and re-direct these vehicles by absorbing the impact energy, thereby avoiding the severe outcomes associated with head-on collisions, rollovers or crashes into rigid objects.

WRSBs are now widely used throughout the world, including Europe and the USA. Despite this widespread use however, few overseas evaluation studies of their impact have been found. The most reliable evidence found in preparing this paper, relates to Sweden's early experiences with their 2+1 road configuration, where the incidence of fatal head-on and run-off-road crashes on treated routes were reduced by around 90%, all serious casualty crashes fell by around 60% and all casualty crashes by 24% (Derr, 2003). Elvik and Vaa (2004) in their analysis of several evaluations of median barriers along divided multi-lane highways, concluded that WRSBs were associated with a 29% reduction in all casualty crashes – a level comparable with steel guard rails and substantially better than concrete barriers, which were reported as associated with a 15% increase in casualty crashes.

## 4.2 Australasian Applications

Records of barrier use and associated evaluation studies in Australia are only in their preliminary stages. One brief study by VicRoads based on 17 kilometres of WRSB installation at six sites, indicated a 92% reduction in casualty run-off-road crashes (Szwed, 2002). This reduction is an order of magnitude greater than the average effect of a range of engineering treatments implemented in Victoria between 1989/1990 and 1993/1994, that reduced all casualty crashes by 8.6% (Corben, Deery, Mullan, & Dyte, 1997).

Another study looked at the feasibility of applying a large-scale flexible barrier program to Victorian roads (Larsson et al., 2003) and found the erection of barrier systems on most multilane roads, especially rural roads to be generally straightforward, as the cross-section of the road remains virtually unchanged. That is, existing multilane roads tend to be of a high standard already, having sealed shoulders and medians, implying that WRSBs can be installed on these roads with minimal additional work. However, application of 2+1 barrier systems along Victoria's two-lane, two-way, undivided roads, as in Sweden, cannot be immediately adopted as most standard road widths in Victoria are less than Sweden's, making it difficult to readily accommodate a third lane. In some circumstances, a third lane may already exist in the form of an overtaking lane.

It is, therefore, more practical to place barriers along the centre and sides of two-lane, two-way, undivided roads and to use the existing overtaking opportunities (e.g. occasional overtaking lanes), rather than providing alternating overtaking lanes as in the 2+1 layout. Barriers can be readily dismantled in most circumstances, and overlapping sections of the barrier provide regular breaks for broken-down vehicles to be promptly cleared. To accommodate the extra width of the Swedish standard of 1.25 m for the central barrier, either road widening or strengthening of the road shoulders to their full load-bearing capacity would be required to allow vehicular travel over them.

Research indicates that the 2+1 road layout itself does not provide major additional safety benefits. Rather, the 2+1 configuration suits the types of road that have historically been constructed in rural Sweden, and results in improvements to traffic operations (NCHRP, 2003). This suggests that the use of WRSBs, with or without the 2+1-lane configuration, should still produce the predicted major reductions in road trauma.

The two Australian studies cited (Larsson et al., 2003; Szwed, 2002) were conducted in relation to Victorian roads. However as most roads in Australasia are built generally to Austroads standards, it is believed that the large-scale installation of WRSBs along major freeways and highways throughout Australasia would be relatively straightforward. This assessment assumes that any installation would comply with established engineering practices: for example, ensuring appropriate sight distances for drivers traversing lanes on curves adjacent to the installation of barriers. Research conducted to date has concentrated largely on WRBs' crash reduction benefits. There is also the need however, for further research to assess their impact on crash severity, for example by examining changes in Abbreviated Injury Scale scores.

# 5. POLITICAL, SOCIAL AND OTHER FACTORS

## 5.1 Motorcyclist Concerns

The concerns raised are generally centred on the potential for WRSBs to act as a "cheese-cutter" and for the exposed steel posts to cause severe injury to riders who strike them. A review of crash data from both overseas and in Australia, showed that motorcyclist injuries as a result of impact with WRSBs were either non-existent or minimal (Australian Transport Safety Bureau, 2000). More recently, Sweden, with well over 800km of WRSBs on its roads, does not have any records of motorcyclists being seriously injured directly through WRSB contact (Larsson et al., 2003).

While current records of motorcyclists being injured by WRSBs are difficult to find, this may be at least partly a reflection of the limited use of these barriers, especially in Australia. There remains a basic question: are organizations such as Motorcycle Council of Australia justified in terms of their members' safety in supporting the continued use of concrete safety barriers in lieu of WRSBs. Berg, Rucker, Gartner, Konig, Grzebieta and Zou (2005) used both crash tests and computer simulation at Monash University to assess the casualty outcomes of several motorcyclist scenarios using a variety of different barriers, including WRSBs. They concluded that concrete barriers and WRSBs both pose high risk to motorcyclists in the event of impact, albeit through different mechanisms.

Motorcycling is intrinsically risky, as reflected in the finding that motorcyclists are around 30 times more likely to be fatally injured compared with other vehicle users travelling the same distance (ATSB, 2002). Given that research indicates that 60% of all run-off-road casualty crashes involve a roadside hazard (Szwed, 2002; VicRoads, personal communication 2006), there is a substantial likelihood that an out-of-control motorcyclist leaving the roadway will impact a fixed object, such as a tree or pole, or even collide with on-coming vehicles, in the event of no barriers being present. Howerver, Carlsson (2009) reported that the fatality risk for motorcyclists reduced by 40-50% on 2+1 roads in Sweden.

## 5.2 Heavy Vehicles

An initial investigation indicates a high success rate of containment of heavy vehicles:

> "… although flexible barriers were not designed specifically to restrain heavy vehicles, they appear to have performed well in heavy vehicle impact tests around the world; (one particular barrier make) designed specifically to contain a tensile force of two tonnes, has contained heavy vehicles imposing tensile forces of over 11 tonnes on the wire ropes", p13 (Jacques, Franklyn, Corben, & Candappa, 2003).

However, further study is needed to understand more fully the effectiveness of WRSBs in heavy vehicle impacts. For example, crash tests of WRSBs using heavy vehicles as the test vehicle, have resulted in large dynamic deflections of the flexible barriers when impacted at relatively low speeds (80 km/h). Further, while there is ample field evidence that some heavy vehicles have been contained, there is also evidence that some semi-rigid steel type barriers are also ineffective at containing trucks.

## 5.3 Costs

In terms of the cost of installation, WRSBs can cost as little as (AUD) $30 per metre when based on the scale of the Swedish installations. For Australia, Szwed (2002) put then-current costs at around $130 per metre, while Nilsson and Prior 2004 put it lower at $115 per metre – costs which are broadly comparable to conventional barrier types. It is anticipated that large-scale barrier programs would ultimately reduce current installation costs to approximately those of Sweden's.

### 5.4 The need for further research and evaluation

There are other research and evaluation issues that need further investigation. For example, the deflection of vehicles crashing into WRSBs needs to be better understood to reduce the likelihood of serious secondary collisions. Additionally, different manufacturers' wire ropes deform to varying extents upon collision, requiring different clearance widths either at the sides or in the centre of roads. Standard practices for dealing with these variations need to be developed.

Even though the deflection width may exceed the clear zone or median width, the time at maximum deflection is minimal and the impact severity is still substantially reduced.

## 6. CONCLUSIONS

The very limited studies conducted on the effectiveness of WRSBs overseas and within Australasia have produced strongly positive results, indicating a reduction in the incidence of fatal run-off-road crashes of around 90%, a reduction significantly higher than other existing infrastructure countermeasures. To date, Sweden has not had a fatality as a direct result of a vehicle, driven under standard conditions, colliding with a flexible barrier. Moreover, no data has been found to indicate that WRSBs are inherently more hazardous to motorcyclists on impact than the more rigid barrier types or the actual roadside objects.

While there is an urgent need for confirmation of the early evaluation results, given the significant safety benefits of the barriers afforded to the great majority of road users, it is recommended that road authorities continue to use WRSBs where technically appropriate. At the same time, the need for on-going research both to demonstrate safety benefits and to improve barrier design for all road user groups is recognised.

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