1. Purpose of this Fact Sheet

The purpose of this document is to describe how flexible road safety barrier systems can contribute to the safety of roads and roadsides, a key aim of Western Australia’s Towards Zero road safety strategy. This Fact Sheet provides information on the safety performance of flexible barrier systems and is not intended to cover the technical aspects of barriers generally. Road asset managers seeking more detailed information on flexible barriers and their application should consult the relevant design manuals and guidelines.

2. The Problem

Western Australia’s Towards Zero road safety strategy for 2008-2020 states that one-fifth of metropolitan, over one-third of regional, and nearly two-thirds of remote, road deaths and serious injuries occur when a driver loses control of their vehicle and it leaves the road. This equates to a third of all deaths and serious injuries in the state. For the period 2005 to 2007, the actual number was 2,983 deaths and serious injuries. The estimated cost to the community of these three years of run-off-road crashes is $1.8 billion.

When a driver loses control of their vehicle and it leaves the road, the problem is that it is likely to strike a roadside hazard or in some cases, roll over.

Vehicles are not designed to withstand the impact forces associated with a roll-over and they will not protect occupants in such an event. The consequences for occupants in this situation can be dire.

However, collisions with roadside objects are the most common type of crash involving fatal and serious road trauma and are the greatest burden on society.
Head-on crashes also result in high severity injuries. While head-on crashes only account for 5 percent of total deaths and serious injuries, they account for 12 percent of all fatalities on WA roads.

The following table shows the numbers of fatal and casualty crashes in WA where drivers have lost control of their vehicle and it left the road or collided head-on with another vehicle.

### Table 1: Head-on and Run-off-Road Fatal and Casualty Crashes in WA, 2005 - 2009

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Metropolitan</th>
<th>Rural</th>
<th>Remote</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Head-on</td>
<td>493</td>
<td>1.6</td>
<td>226</td>
<td>4.0</td>
</tr>
<tr>
<td>Run-off-road</td>
<td>4,087</td>
<td>13.3</td>
<td>2,889</td>
<td>50.9</td>
</tr>
<tr>
<td>All crash types</td>
<td>30,657</td>
<td>100</td>
<td>5,677</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: official crash records provided by the WA ORS, analysed at MUARC.

This table shows that head-on crashes occur proportionally more in rural areas than in metropolitan or remote areas. Run-off-road crashes occur proportionally more in remote areas accounting for more crashes than all other crash types put together. Figure 1 shows the types of objects with which vehicles collide in run-off-road crashes.

![Figure 1: Types of Objects Hit, 2005 – 2009](image)

3. **Safer Roads and Roadsides**

The best way to tackle run-off-road crashes from an engineering perspective is to:
- try to keep motorists from leaving the road, and
- reduce the consequences of leaving the road.

3.1 **Keeping Motorists from Leaving the Road**

Drivers leave the road for a variety of reasons including inappropriate speed, poor perception, inadequate control, poor driving conditions, distraction or fatigue. A range of road and roadside treatments can be used to reduce the likelihood that motorists who lapse in concentration or make an error of judgement will leave the road. If drivers do leave the road, barriers are one tool which can be used to minimise the consequences.
The safest roadsides are those that will not cause a vehicle to roll over and contain no roadside hazards. The “Clear Zone” concept\(^1\) was developed to provide such a hazard free recovery area adjacent to the traffic lane. The clear zone width generally can vary between 3m and 10.5m\(^2\) and is dependent on:

- speed;
- traffic volumes;
- batter slopes; and
- horizontal geometry.

As researchers look for new methods to further reduce serious road trauma, some are beginning to question the adequacy of the Clear Zone Concept. It has been argued that clear zones often offer only modest protection for vehicle occupants\(^3\). Victoria has recently increased the Clear Zone requirements by extending the width to 15m for roads carrying more than 50,000 vehicles per day\(^4\).

Not all hazardous roadside objects can be removed from the Clear Zone, either because of the cost of removal, because it is not feasible to relocate the objects elsewhere (for example, in the case of power poles or trees) or due to public perception of intrinsic social or environmental value.

The preferred treatments (in order of preference) of roadside hazards are:

- removal;
- relocation to reduce the risk of collision;
- redesign so that they can be safely traversed;
- redesign to be frangible or break away, or to otherwise reduce the severity of collision;
- shielding with a safety barrier or crash attenuator; and
- if the above alternatives are not appropriate, delineation of the hazard and reducing the speed of vehicles.

A barrier should only be installed when the consequences of vehicle impact with the barrier is likely to be less severe than the consequences of impact with the feature being shielded.

4. Road Safety Barriers

All safety barrier systems are designed to absorb energy that is released in a collision and prevent a more serious collision with the hazard they are shielding. They can generally be divided into three broad types comprising flexible, rigid and semi-rigid barriers. This fact
sheet focuses on the performance of flexible barriers, although brief descriptions of other types are included for comparison purposes.

All barriers used in Australia should comply with the requirements of the Australian and New Zealand Standard AS/NZS 3845:1999, “Road safety barrier systems”5.

As a general principle, the first priority should be to use the more flexible barrier as this will minimise the severity of any vehicle impacts with the barrier and provide the best outcomes for the occupants.

4.1 Flexible Barriers
Flexible Barrier is a term used to describe wire rope barrier systems. This is because relatively large deflections occur in the wire rope system during vehicle impacts.

Wire rope barrier systems comprise wire ropes (generally 3 or 4 cables) supported on weak posts that are installed primarily to support them. The design enables the cables to readily strip from the frangible posts during impact, thereby minimising snagging and ensuring that the vehicle is smoothly redirected. Upon impact the posts separate from the wire rope and the kinetic energy of the vehicle is largely dissipated through the deflection of the wire rope.

Flexible wire rope barriers are amongst the best available crash countermeasures with crash reductions of up to 90%. Rigid and semi-rigid barriers generally achieve about half this figure. Flexible barriers perform better is because they manage the exchange of energy in a more controlled way for a vehicle that has encroached into the roadside.6 7 8

Following an average impact, the maintenance activities and costs associated with repairing wire rope barriers are minimal. It is only the damaged posts that need to be replaced. The wires are not normally re-tensioned. These flexible systems are suitable for either roadside or median applications.

There have been examples in Australia where wire rope barriers have performed well on impact by heavy vehicles. Larger deflections should be expected in such cases.
4.2 Semi-rigid Barriers

Semi-rigid safety barriers mainly include systems that have a steel beam attached to wooden or steel posts. These barriers deform permanently under impact and complete sections have to be replaced.

Advantages/ disadvantages, appropriate use?

4.3 Rigid Barriers

Rigid safety barriers are basically a reinforced concrete wall constructed to a profile and height that is designed to contain and redirect errant vehicles. When impacted by a vehicle a rigid barrier experiences negligible deflection and therefore results in a more severe impact than would be experienced with a semi-rigid or flexible barrier.

Rigid barriers are generally only used where there is insufficient space to accommodate the deflections of semi-rigid or flexible barriers. Traditionally they have been used where there were significant truck volumes and containment was important. However as experience with flexible barriers has grown, flexible barriers are being considered where only rigid barriers may have been considered in the past.

5. Head-on Crashes

While head-on crashes are not as frequent as run-off-road hit-object crashes, they have very high severity and can also be reduced with central or median barriers of the type described above. The same arguments and technical considerations apply to flexible barriers in medians as for roadsides.

Wire rope barriers in some cases can have advantages in a fiscal as well as safety context. The high cost of duplicating roads can be forestalled or even avoided by adopting the 2+1 design that has been used successfully in Sweden.9
The 2+1 design comprises two lanes in one direction and one in the other, separated by a wire rope barrier. The two lanes alternate from one side of the barrier to the other side thus providing frequent overtaking opportunities for both directions.

When used as an alternative to road duplication, there is no longer a need for wide median reserves: a median width of less than two metres is required for flexible barriers to provide a high level of protection against head-on collisions.

There are clear financial and environmental savings from this approach. Both the capital cost and the long-term environmental footprint of the highway are markedly reduced.

6. Motorcyclists

When a motorcyclist is involved in a crash, the rider usually separates from the motorcycle and continues forward movement sliding along the pavement until coming to a halt due to surface friction, or until colliding with something. Just sliding along the pavement at high speed without striking anything else can cause severe trauma to a motorcyclist because their clothing is abraded and shredded by the road surface.

If an errant motorcyclist collides with an object, the results are similar for most types of objects ie colliding with sign posts, bollards, fence posts, walls, poles, safety barrier posts etc will all lead to similar trauma.

In the early 2000's when wire rope barrier were first being installed, a number of motorcyclists objected to them fearing that the wire rope may cut or slice them in a collision. A number of research projects were initiated to look into these objections.\textsuperscript{10, 11, 12, 13}

The conclusion from almost a decade of research and experience is that there have been very few motorcyclist collisions with wire rope barrier. The risk to motorcyclist is more from the posts than the wire because motorcyclists usually fall to the ground and slide after a collision. The wire rope is thicker than it appears and would abrade rather than cut clothing if a motorcyclist somehow remained upright on the motorcycle after colliding with the wire rope barrier. The consequences of colliding with a wire rope barrier are generally much less than the consequences of the collision with the object which the barrier is providing protection form.

A number of modifications have been identified which may make wire rope barrier less aggressive towards motorcyclists.
A number of devices have been developed to help reduce the impact of a motorcyclist sliding into them. Some surround the post with an impact absorbing material and others are in the form of continuous tubes which collapse under a vehicle impact but allow an errant motorcyclist to slide along without being snared by the posts.

Post shields have also been developed for semi-rigid barrier systems because their posts can snag an errant motorcyclist in a similar way to a flexible barrier post.

Purely from the perspective of benefit-cost analysis, it is difficult to justify the cost of the above add-on devices because of the low incidence of motorcycle collisions with barriers.

7. Summary and conclusions

All the road safety evidence supports the use of flexible wire rope as the first choice of barrier because of its superior safety performance and ease of maintenance. Semi-rigid barriers should only be used where flexible cannot be accommodated and rigid where both flexible and semi-rigid cannot be properly installed. Other considerations may come into play that will also influence the nature and application of barrier systems used.

The early criticisms of wire rope barriers from motorcycle riders have not been vindicated. There are features that can be added to wire rope barrier that may improve the safety outcomes for motorcyclists although because of the additional cost and relatively low incidence of risk, these are only likely to be justifiable on routes where motorcycle riding is high or the crash risk is greater.

Flexible road safety barrier systems have an important role to play in reducing the trauma associated with run-off-road and head-on crashes. They can therefore make a significant contribution to the aims of Western Australia’s Towards Zero road safety strategy.

8. References

1Main Roads, WA (2007). Assessment of Roadside Hazards, File No. 05/9104, Document DO6#26105


Grzebieta, R. *Motorcycle Crashes into Roadside & Median Road Safety Barriers*. Univ of NSW.

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