Motorcyclists and Wire Rope Barriers

Positioning Paper

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Date: November 2006
Reference: 5-C1092.00
Status: Final

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EXECUTIVE SUMMARY

Whilst road safety barriers have substantive benefits for the majority of errant road users, the appropriateness of road safety barriers for motorcyclists has been raised as a road safety concern.

A range of road safety barriers exist including ‘rigid’ concrete barriers, ‘semi-rigid’ metal barriers and ‘flexible’ Wire Rope Safety Barriers (WRSBs). On the basis of the benefits attainable by WRSBs with respect to their full life costs and road safety benefits, their use has been increasing in New Zealand. Despite their good overall safety record for general road users, motorcyclists have raised concerns that the cable used in WRSBs may act as a ‘cheese cutter’ in the event of a collision by a motorcyclist, whilst exposed posts supporting the cable barrier may also increase the severity of any injury if struck by a motorcyclist sliding along the ground.

Transit New Zealand (Transit NZ), as a responsible Road Controlling Authority that installs road safety barriers alongside parts of its roading network, has sought to establish the current level of international research and practice on the use of WRSBs and any impact that they may have upon motorcycle crashes.

In New Zealand over the five year period between 2001 and 2005, there have been a total of 3762 injury crashes involving motorcycles. Of these, 54 (1.4%) involved collisions with a road safety barrier. Two of the crashes involved a WRSB. With respect to motorcycle fatalities, three out of the 162 (1.9%) motorcycle deaths involved a collision with a barrier; none involved a WRSB.

Guidelines recently produced by the motorcycle industry in Europe[1] states that:

> *“limited research done so far does not warrant the conclusion that cable barriers are more hazardous than other types of barrier. There is general agreement that more research is required on the effects of different types of fence on falling motorcyclists. This applies to the posts that are common to all designs. They inflict the most serious injuries to motorcyclists crashing into a safety fence.”*

The above is reflected in a report prepared by the Advisory Group on Motorcycling[2] to the UK government which includes evaluations from the Transport Research Laboratory (TRL) stating that:

> *“the current conclusion from this work is that all types of barrier pose some form of risk for motorcyclists but wire rope is no more of a risk than other types of post and beam barrier…There is, however, general agreement that the harmful items are the exposed posts of safety barriers, irrespective of their other components.”*

Whilst a number of measures to try and reduce injury severities resulting from motorcycle collisions with semi-rigid barriers have been implemented in Europe, very little has been developed and/or trialled with respect to WRSBs.

Overall, the research notes that whilst WRSBs have the potential to cause serious injury to errant riders, so do all road safety barriers. Indeed, “there is no reliable evidence to indicate that WRSBs present a greater or less risk than other barrier types, or indeed, no barrier at all.”[3] It is important to note that road safety barriers should only be installed where necessary in order to protect road users from hazards, for instance at the edge of a large drop off or on-coming vehicles, where the risk of incurring more serious and life threatening injuries exist without the barrier being installed.

[1] Association des Constructeurs Europeans de Motorcycles (ACEM). Guidelines for PTW - Safer Road Design in Europe. The Motorcycle Industry in Europe. Brussels, Belgium. 2006

[2] Governmental Advisory Group on Motorcycling. Final Report to Government. UK. 2004

[3] Mulvihill and Corben. Motorcyclist Injury Risk with Flexible Wire Rope Barriers and Potential Mitigating Measures. 2004

Given the above:

- Transit NZ will continue to review research being undertaken on the interaction between motorcyclists and WRSBs.
- Transit NZ will continue to work closely with Police and Land Transport NZ/MoT to ensure reporting and coding of motorcycle crashes accurately reflects the severity of the collision as well as the type of barrier struck (where appropriate).
- Transit NZ will continue to remind its designers and consultants of international best practice on the use of road safety barriers including designing for an obstacle free zone next to the road wherever possible, as well as the need to be aware of the characteristics of different types of barriers systems and the designs of different types of barriers with respect to the needs of all road users.

1 Introduction

Transit New Zealand (Transit NZ) appointed Opus International Consultants Limited (Opus) to undertake a literature review relating to the severity of injuries sustained by motorcyclists colliding with road safety barriers, and in particular, the performance and impact of wire rope safety barriers (WRSBs) on motorcyclists in such collisions.

1.1 Background

Transit NZ is committed to the New Zealand Government's Road Safety to 2010 Strategy which aims to reduce road casualties to no more than 300 deaths and 4,500 hospitalisations a year by 2010 through a range of engineering, education and enforcement initiatives.

Two of the priorities set down in the Strategy are for:

- 'engineering safer roads'; and
- 'improving safety for motorcyclists.'

To help address these priorities, the Strategy specifically notes a number of interventions for consideration and uptake. In particular, the Strategy states that it is the intention of Transit NZ to trial "the installation of median cable barriers on rural two-lane highways in passing lane sections to decrease the incidence of head-on crashes". In addition, the Accident Compensation Corporation (ACC) are noted within the Strategy as the lead agency for the development of initiatives to target key injury issues for motorcyclists including targeting licensing and training issues, protective gear, engineering works and community development models.

The appropriateness of road safety barriers with respect to their road safety performance when struck by motorcyclists however has been raised as a concern. Research from Australia indicates that the probability of a motorcyclist being killed more than doubles in a collision with a road safety barrier compared to motorcycle crashes generally[1]. However, this does need to be considered in the context of motorcycle deaths when hitting other obstacles adjacent to the roadside. It should also be noted that 'general motorcycle crashes' involves not hitting any roadside obstacle of any kind at all.

Furthermore, the severity of the injury sustained by a motorcyclist when colliding with different types and designs of road safety barrier, such as 'median cable barriers' or WRSBs, has been identified as a potential issue by motorcycle groups. Concerns raised by motorcyclists over the use of WRSBs include their potential to act as a 'cheese cutter' in the event of a collision by a motorcyclist and the opportunity for exposed posts supporting the barrier to increase the severity of any injury.

It is naturally a concern to Transit NZ that the installation of road safety barriers, and in particular certain types of barrier, may have an adverse impact on the overall safety performance of its road network. The purpose of this report therefore is to provide general guidance to Transit NZ on the use of WRSBs with respect to the needs of motorcyclists.

[1] Gibson and Benetatos. Motorcycles and Crash Barriers. Report for NSW Motorcycle Council. 2000.

1.2 Road Safety Barriers

Typically, road safety barriers are installed:

- In medians to separate opposing directions of high speed traffic and to prevent crashes into rigid objects within medians.
- Along the left hand side of the carriageway, for each direction of travel, to prevent collisions with roadside trees, poles, embankments, culverts and other hazards.[2]

A range of road safety barrier types are currently available: rigid concrete barriers, semi rigid metal beam barriers, and flexible WRSBs. The use of WRSBs has been increasing in New Zealand on the basis of their successful use overseas. Larsson et al[7] report that "Sweden has used flexible barriers to reduce the incidence of fatalities on treated routes by up to 90%." Whilst these have been used at the edge of the road, they have been extensively used to help separate opposing traffic for '2+1' road configurations where roads have two lanes in one direction and a single lane in the other.

1.3 Standards and Guidelines

Guidance on the use of road safety barriers is contained in the draft State Highway Geometric Design Manual[3]. The Manual is based on the National Cooperative Highway Research Program Report 350 (NCHRP350) as well as the New Zealand and Australian Standard (AS/NZS 3845:1999 Road Safety Barrier Systems) which specifically states that when planning to incorporate road safety barriers within a design "unprotected road users to be taken in to consideration include motorcyclists, pedal cyclists and pedestrians."

The draft Geometric Design Manual provides guidance on the placement and layout of road safety barriers for both roadside and median barrier systems. As part of the guidance, the Manual states that "designers must apply engineering judgement to the nature of all roadside hazards that require shielding by safety barriers and specify higher performance barriers whenever they are considered necessary."

It should be noted that concerns expressed in Australia[4] suggest that not all barriers installed have met the AS/NZS 3845:1999 standard in the past. Furthermore, recommendations made by a Working Party[5] made up of the Australian Transport Safety Bureau (ATSB) along with motorcycle representatives included raising awareness of the need to adopt best practice in the installation and maintenance of road safety barriers taking into account motorcycle riders and other exposed road users. This Working Party report also recommended encouraging road controlling authorities to ensure new barrier treatments comply with the standard and that road controlling authorities undertake audits of existing barrier installations to ensure compliance with the standard and manufacturers' guidelines. As such, Transit NZ has already commenced a programme of road safety barrier audits and regularly conducts workshops on the design of road safety barriers.

The European standard for undertaking crash testing of safety barriers (EN1317) differs from the Australian and New Zealand version in that no mention of motorcyclists or motorcycles is made as part of the standard. As a result, motorcycle groups have claimed that little thought has been given to how motorcyclists or motorcycles may react when striking such obstacles. It is noted that the Highways Agency in the UK is aware of the

[2] Larsson M, Candappa N, Corben B. Flexible Barrier Systems along High-Speed Roads: A Lifesaving Opportunity. Monash University. 2003
[3] Transit NZ. State Highway Geometric Design Manual (draft). 2005
[4] Pearson and Whittington. Motorcycles and the Road Environment. 2001
[5] ATSB Review of Wire Rope Barriers: Working Party Report. Australian Transport Safety Bureau. 2000

concerns relating to the dangers of motorcyclists and road safety barriers and is intending to raise the issue with the EN1317 CEN Standards Committee to prompt discussion on the installation of 'crash barrier post attenuators' as an integral part of the standard.[6] Accordingly, in Europe, motorcycle "riders are dependent on the goodwill of local, regional and national road authorities to adapt existing crash barriers to a standard that would protect motorcyclists"[7] – the so called 'motorcycle friendly' barriers.

[6] Governmental Advisory Group on Motorcycling. Final Report to Government. 2004

[7] Federation of European Motorcyclists Associations (FEMA). The Road to Success – improving motorcyclists' safety by improving crash barriers. 2005

2 Motorcyclist Concerns

2.1 General

The Federation of European Motorcyclists' Associations (FEMA) acknowledges that whilst road safety barriers can be a benefit for the majority of road users, they wish for the risks to motorcyclists to be highlighted and the need for "secondary safety measures to address those risks" to be considered when it is necessary to install road safety barriers. Similarly, the UK's Motorcycle Action Group[8] (MAG) highlights that road safety barriers are designed and are often installed simply to meet the needs of the majority of road users, such as cars and trucks, whilst motorcyclists are given little consideration.

An extensive study by the Association of European Motorcycle Manufacturers (ACEM)[9] 'of motorcycle and moped crashes during 1999-2000 in five locations in various countries in Europe identified that roadside safety barriers presented an infrequent but substantial danger to motorcycle riders, causing serious lower extremity and spinal injuries as well as serious head injuries when impacted. The danger to motorcyclists is backed up by research reported on by Gibson and Benetatos[10] who claim that the probability of a motorcyclist being killed as a result of impacting with a crash barrier is more than double that for motorcycle crashes generally. However, as noted previously, this needs to be considered in the context of motorcycle deaths when hitting other obstacles adjacent to the roadside and not hitting any obstacle at all.

MAG believes that vehicle restraint systems such as road safety barriers are an "aggressive means of retention" from a motorcyclists point of view, with WRSBs being viewed as the most aggressive form due to exposed upright posts and wire cables. Research on whether such a view is valid is reported on and discussed in Section 5.

2.2 Wire Rope Safety Barriers

MAG notes that there is a perception that WRSBs may have a 'cheese cutter' effect on motorcyclists striking the cables but acknowledges that the problem goes beyond this and states that the main cause of injury from collisions with road safety barriers is exposed posts and that these are more prevalent and more exposed in WRSB systems.

Other concerns reported from a number of sources (Mulvihill and Corben, ATSB, Pearson and Whittington) include:

- Installation of the WRSB too close to the edge of the road.
- Variable proximity of the WRSB to the edge of road.
- Non-conforming WRSB systems (e.g. collapsible posts).
- Inappropriate use of WRSBs to protect private property such as brick walls.
- Inappropriate maintenance of WRSBs.

Notwithstanding the above, an internet survey of motorcyclists carried out as part of a Masters thesis in Sweden[11] noted that whilst the installation of a WRSB had little impact on the speed the motorcyclists travelled at, over 60% of respondents stated they increased their distance from the barrier. Almost 70% of respondents stated that they felt less secure when riding alongside WRSBs – although no comparison with other types of barrier was made.

[8] MAG. Vehicle Restraint Systems, Safety Fences, Crash Barriers, Motorcyclists. UK. 2005
[9] Association of European Motorcycle Manufacturers (ACEM)[9] 'In-depth Investigation of Motorcycle Accidents (MAIDS)'. (2004)
[10] Gibson and Benetatos. Motorcycles and Crash Barriers. Report for NSW Motorcycle Council. 2000.
[11] Pieglowski T. The Influence of Wire Rope Barriers on Motorcyclists. 2005.

3 Motorcycle Crash Problem

3.1 General

General data on the extent of the motorcycle crash problem in New Zealand has been obtained from the Ministry of Transport's Crash Analysis System (CAS) and their recent 'Motorcycles' fact sheet[12].

Whilst the number of crashes involving motorcycles has decreased markedly since the mid 1980's, crash trends since 2000 have ceased to decrease further. The decrease up to 2000 was partly due to the reduction in the distance ridden by motorcyclists, which fell by almost 40% between 1989/90 and 1997/98. In particular, the annual distance ridden by younger motorcyclists aged 15-24 years reduced by 75%. The impact of this has been a large decline in the number of younger motorcyclists killed or injured in a crash and a corresponding increase in the average age of motorcyclists involved in crashes.

In 2005, there were a total of 36 motorcycle deaths with a further 903 injured, representing 9% of all deaths and 6% of all reported injuries as a result of a road crash. This compares with 146 motorcycle deaths in 1988 (20% of all road deaths).

Motorcyclists are particularly vulnerable to injury in a crash due to the limited protection afforded to them in a crash. The New Zealand Travel Survey[13] indicates that motorcyclists are 18 times more at risk of being involved in a fatal or injury crash than a car driver over the same distance travelled. In comparison, the UK fatality rate for motorcyclists is 36 times higher than that of car drivers with a casualty rate 15 times higher[14].

Table 1 below shows the total number of crashes involving motorcyclists in New Zealand between 2001 and 2005 split by road type and speed limit area (urban roads have a speed limit of 70km/h or less). The table shows that overall, almost two thirds of motorcycle crashes occurred on urban roads. The split in motorcycle crashes by urban or rural location is similar to statistics from overseas. In total, almost a third of all motorcycle crashes occurred on the state highway network; the majority of these however were on the open road. Of the 1346 motorcycle crashes occurring on the open road, 199 (15%) involved a head-on collision; over a third of the open road motorcycle crashes occurred when a rider lost control of their motorcycle on a corner.

Table 1 Motorcycle Injury Crashes 2001-2005

	Local	State Highway	Total
Open	599	747	1346 (36%)
Urban	2013	408	2421 (64%)
Total	2612 (69%)	1155 (31%)	3767 (100%)

Table 2 shows the severity of motorcycle crashes by speed limit area and type of road. As might be expected, over 70% of the fatal crashes occurred on the open 'high speed' roads. Furthermore, 55% of open road crashes result in a fatal or serious injury crash compared to 32% of urban road crashes.

[12] Ministry of Transport. Motorcycles Factsheet. NZ. Updated June 2006.
[13] Land Transport Safety Authority. New Zealand Travel Survey Report. NZ. 2000
[14] RoSPA. Motorcycling Safety Policy Paper. UK. 2006

Table 2 Motorcycle Injury Crashes by Severity 2001-2005

	Fatal	Serious	Minor	Total
Open	116	621	609	1346
Urban	48	716	1657	2421
Total	164	1337	2266	3767

Motorcycle crash information from the UK and the ACEM MAIDS[15] study indicates that motorcycle deaths and injuries are most often as a result of collisions with other larger vehicles such as a car rather than single motorcycle collisions with roadside objects such as road safety barriers. However, deaths and severe injuries as a result of collisions with roadside objects are obviously a concern.

3.2 Road Safety Barrier Collisions

A search of the CAS database for New Zealand reveals that between 2001 and 2005, there were a total of 65 injury crashes reported as involving motorcyclists and road safety barriers. A further 11 were reported as being non-injury.

A more detailed assessment of these 76 crashes was carried out to determine the true nature of these collisions as well as the type of barriers involved. This assessment identified that a number of reported 'barrier' crashes included collisions with pedestrian handrails and wooden sight fences. Accordingly, these crashes have been removed from the data set shown in Table 3 so that the final data set consists of 57 injury crashes (1.5% of reported motorcycle injury crashes). Of the 47 open road crashes, three quarters were on the State Highway network.

It should be noted that it is unlikely that those crashes shown as 'non-injury' within the Traffic Crash Report are all correct given that sprains and bruises sustained by a road user should be coded as a 'minor injury'. For instance, it is highly likely that motorcyclists sliding into a barrier would sustain at least some minor abrasions as a result of the crash. For consistency with the CAS database, these crashes have not been included in the data shown below. It should be noted however that the injury crash and casualty numbers are likely to be higher than those shown if 'non-injury' crashes were correctly reported.

Table 3 Motorcycle and Road Safety Barrier Injury Crashes 2001-2005

Location		Fatal	Serious	Minor	Total
Open	State Highway	2	17	16	35
	Local	1	6	5	12
Urban	State Highway	0	0	1	1
	Local	0	5	4	9
Total	All	3	28	26	57

Overall, Tables 2 and 3 show that 4.3% of all reported motorcycle crashes involved a fatality whereas 5.3% of all reported motorcycle crashes involving a road safety barrier involved a fatality. However, when considering open road motorcycle crashes alone, these figures reverse to show that 8.6% of open road reported motorcycle crashes involved a fatality whereas 6.4% of open road reported motorcycle crashes involving a road safety barrier involved a fatality. The above compares with 7.3% of open road reported motorcycle crashes involving a fatality not hitting any roadside object at all.

[15] Association of European Motorcycle Manufacturers (ACEM)[15] 'In-depth Investigation of Motorcycle Accidents (MAIDS)'. (2004)

Similarly, the data indicates that 1.5% of all motorcycle crashes involved a road safety barrier; these accounted for 1.9% of all motorcyclist fatalities. However for open road crashes alone, 3.4% of motorcycle crashes involved a road safety barrier accounting for 2.6% of open road motorcyclist fatalities

The above compares with data presented by Mulvihill and Corben[16] for the UK in 1991 in which 0.3% of motorcycle crashes involved a road safety barrier, which in turn accounted for 2.1% of all motorcycle fatalities.

Notwithstanding the above, it should be noted that it is unclear in many ‘road safety barrier’ crash statistics whether the barrier, although causing an injury, prevented a more serious or fatal crash.

3.3 Detailed Assessment of Motorcyclist and Road Safety Barrier Crashes

The detailed assessment of crash reports has allowed a better understanding of the barrier types involved in the motorcyclist collisions. Unfortunately, in almost half of all the crashes reviewed, the type of barrier involved cannot be ascertained from the traffic crash reports. However, from the 28 crashes with a stated barrier type, 18 (64%) involved ARMCO or metal barriers, 8 (29%) were with concrete barriers, and 2 (7%) were with WRSBs. It should be noted that these proportions will obviously be impacted upon by the total length of different types of road safety barriers installed on the road network in New Zealand.

The two crashes with the WRSB were both on the state highway and both involved an upright motorcyclist hitting the barrier. The crashes resulted in the Police reporting one serious injury and one minor injury. (It should be noted that in the minor injury crash, the rider suffered concussion as a result of the crash and accordingly, the crash should therefore be classified as ‘serious’ in accordance with Land Transport NZ guidelines.)

The review indicates that for the three fatalities, two involved ARMCO barriers whilst the barrier type for the remaining crash is unclear given that both wooden sight rails and metal barriers existed at the crash scene. Two of the three fatal crashes involved collisions with barriers on the approach to a road bridge. It should be noted that WRSBs would typically not be used on bridge approaches.

Fourteen (25%) of the 56 crashes with the barrier location known involved motorcyclist collisions with barriers in the central median. Of the remainder, 31 (55%) hit a barrier to the left hand side of the road in the direction of travel and 11 (20%) the right hand side. Details of the hazards being protected by the ‘roadside’ road safety barriers (rather than the median barriers) are unknown. Accordingly, it is unknown whether the provision of the road safety barrier potentially reduced the severity of the crashes or not.

Thirty-two (57%) of these 56 crashes occurred with an upright rider hitting the barrier; 24 (43%) occurred with the bike or rider sliding into the barrier. All three fatalities involved an upright rider. It should be noted that research carried out by Quincey et al (1988) and cited by Gibson and Benetatos[17] is that approximately 60% of fatal motorcycle crashes with crash barriers involved the rider sliding into the barrier with the other 40% remaining upright.

[16] Mulvihill and Corben. Motorcyclist Injury Risk with Flexible Wire Rope Barriers and Potential Mitigating Measures. 2004
[17] Gibson and Benetatos. Motorcycles and Crash Barriers. Report for NSW Motorcycle Council. 2000.

4 Motorcyclist Injury Mechanisms

Mulvihill and Corben identify three main ways that collisions between motorcycles and road safety barriers can occur, based on a number of studies:

- Hitting the barrier whilst still on the bike – From this type of impact, most injuries result from the shallow impact angle when the rider slides and tumbles along the tops of the posts supporting the barrier.
- Sliding into the crash barrier with the bike.
- Sliding into the crash barrier after separating from the bike - in a majority of fatal crashes, most injuries occur as the rider falls, slides and tumbles along the base of the posts hitting his/her head.

The Mulvihill and Corben report goes on to note that a further factor in the severity is the part of the body struck in the crash. The report cites a study by Hell and Lobb (1993) that reported that the most likely areas of the body to be injured for motorcyclists across all types of collisions are legs, head and thorax and suggests that the severity of injuries in barrier crashes may increase due to the fact they are more likely to strike vital regions of the body.

4.1 Crash Testing Results

Research from 1999 cited by FEMA[18] noted that the impact differences on motorcyclists between concrete, steel beam and modified steel beam road safety barriers was unknown, with problems associated with accurate testing and the cost of such work. Little data is noted at that time as being available for WRSBs with few motorcycle crashes against them. The report suggests that WRSBs may theoretically pose similar dangers to conventional metal barrier posts. Similarly, the 2000 Monash University Report notes limited information on motorcycle and barrier crashes and the lack of established testing procedures for motorcycle crash testing.

A number of difficulties exist with regards to the testing of motorcycle crashes with road safety barriers. Testing concerns relate to the time and costs associated with physical testing; whilst micro-simulation modelling requires the simplification of the crash scenario. However, recent advances have been made with physical crash testing guidelines for motorcyclists having now been developed by a group appointed by the International Organisation for Standardisation.

Crash test results from 2005 are presented in a paper by Berg et al[19] using real life and micro-simulation tests. Real-life crash tests were carried out on a conventional steel barrier system and a concrete barrier with a motorcycle driven in an upright position as well with a motorcycle and dummy rider sliding on the road surface. Micro-simulation testing was carried out for a concrete barrier and a WRSB. It should be noted however that the simulation exercises are described as preliminary and work is continuing to refine them.

From the real-life crash testing for the conventional steel barrier, an upright rider suffers severe but not life-threatening injuries due to the "aggressive contacts and snagging with some of the roadside protection system's stiff parts and open profile." In the case of the concrete barrier for an upright rider collision, the rider actually went over the top of the

[18] Final Report of the Motorcyclists & Crash Barriers Project. Federation of European Motorcyclists Associations (FEMA).Belgium 2000
[19] Berg A, Rucker P, Gartner M, Konig J, Grzebieta R, Zou R. Motorcycle Impacts to Roadside Barriers – Real World Accident Studies, Crash Tests and Simulations carried out in Germany and Australia.. Proc 19th ESV, Paper No 05-0095, Washington DC, USA.2005

barrier. Whilst severe injuries were sustained, again these were not life-threatening. It should be noted that in the case of the concrete barrier, the motorcyclist was not effectively decelerated with the consequent risk of the motorcyclist being thrown over the side of the barrier which may have subsequent dangers attached to it. In addition, the concrete barrier did not dissipate as much kinetic energy via deformation as the steel system which may have resulted in a relatively higher severity of injury during the primary impact with the concrete road safety barrier.

For sliding motorcyclists against both the steel and concrete barriers, the Head Injury Criteria (HIC) limit (which identifies when significant head injury will occur) was exceeded, indicating risks of severe and life threatening injuries.

Testing was also carried out on a modified steel barrier system incorporating a ‘closed-box’ profile at the top of the barrier to prevent snagging and an under-run protection beam to prevent direct impact with the barrier posts. The results from this test indicate that there was a lower level of risk when impacting with this system although in the case of ‘sliding’ crashes, elements of the testing indicated ‘head accelerations’ above biomechanical limits.

Using micro-simulation testing for an upright rider with WRSBs, the front wheel of the motorcycle tends to snag with the barrier post whilst the rider's leg and foot gets trapped against the barrier. As the rider is thrown up and forwards, the rider's leg subsequently snags with cables resulting in the motorcyclist being thrown over the barrier. The test indicates concern not only that the rider's limbs become caught in the barrier, but also that the front wheel gets caught by the posts.

The testing suggests that with a steel or concrete barrier, survivable injuries will occur when the motorcyclist collides in an upright manner. Risks exist though with the concrete barrier as the motorcyclist could be catapulted over the barrier, potentially into an oncoming vehicle if the barrier is in the median. However, when motorcyclists skid into either of the above barriers, life-threatening injuries are likely. The micro-simulation for the WRSB with an upright motorcyclist suggests that snagging of some sort will occur resulting in high deceleration forces and thus increasing the injury risk for the rider.

Overall, the report notes that findings suggest that “while the current design of flexible barriers has safety advantages over concrete barriers for passenger vehicles, the opposite may be true for motorcyclists.” Regardless of the barrier type however, risks of serious motorcyclist injury when colliding with the barrier will be high due to the lack of protection provided to a rider on a motorcycle.

In addition to the above, Mulvihill and Corben[20] suggest that whilst posts used in WRSBs “tend to be energy absorbing when struck by passenger and larger vehicles, however, due largely to mass differences between a rider and, for example, a passenger car , the posts are less forgiving when hit by a motorcyclist who has left the road. In situations where the motorcyclist separates from the motorcycle upon impact, evidence suggests that the collision with the barrier posts poses a greater hazard to the motorcyclist than the steel cables.” This is a concern for WRSBs which require a greater number of posts per length than conventional metal barrier types, particularly in situations when seeking to reduce the deflection of WRSBs by decreasing the spacing of the posts.

The Mulvihill and Corben report indicates that sharp edges of supporting posts can cause serious injuries when struck, even at low velocities. The report cites research by Ellmers in

[20] Mulvihill and Corben. Motorcyclist Injury Risk with Flexible Wire Rope Barriers and Potential Mitigating Measures. 2004

1997 that "the most critical outcomes results not from impacting with the post itself together with the high deceleration, but from the sharp edge of the post that causes serious injuries." The report notes that IPE-100 I-shaped posts which are commonly used as support posts are the most aggressive compared to the sigma (Σ), Z or C-shaped posts. Research cited in the FEMA report by Koch and Brendicke in 1998 found that sigma 100 posts could cause only bruising in a collision while IPE 100 I-shaped posts could cause fractures or amputations. It should be noted that Transit NZ does not approve the use of I-shaped posts as part of a WRSB system.

Regardless of the various tests carried out to date, as noted in the 2006 ACEM Guidelines for PTW [Powered Two Wheelers] – Safer Road Design in Europe[21], "limited research done so far does not warrant the conclusion that cable barriers are more hazardous than other types of barrier. There is general agreement that more research is required on the effects of different types of fence on falling motorcyclists. This applies to the posts that are common to all designs. They inflict the most serious injuries to motorcyclists crashing into a safety fence."

The above is backed up by the Advisory Group on Motorcycling: Final Report to Government in the UK which includes evaluations from the Transport Research Laboratory (TRL) stating that " the current conclusion from this work is that all types of barrier pose some form of risk for motorcyclists but wire rope is no more of a risk than other types of post and beam barrier…There is, however, general agreement that the harmful items are the exposed posts of safety barriers, irrespective of their other components."

[21] Association des Constructeurs Europeans de Motorcycles (ACEM). Guidelines for PTW - Safer Road Design in Europe. The Motorcycle Industry in Europe. Brussels, Belgium. 2006

5 Countermeasures

5.1 General

Collisions between motorcycles and road safety barriers are likely to result in an injury regardless of the barrier type and/or whether the rider hits the barrier or the supporting posts. Accordingly, it is appropriate to consider how to reduce road safety concerns arising from the use of road safety barriers in general. This approach has led to the development and experimentation with 'motorcycle friendly' barriers in a number of countries in Europe. Whilst a number of these metal barriers have been installed or existing metal barriers retrofitted at a number of locations in Europe, including France and the UK, a number of countries have adopted a different approach specifically to WRSBs. In particular, Norway, Denmark and Holland have either removed or decided to no longer install WRSBs in response to lobbying by motorcycle groups despite there being no conclusive evidence that WRSBs are a greater or lesser risk than other types of barriers.

Appropriate Placement and Type of Road Safety Barriers

The ACEM Guidelines for PTW (Powered Two Wheelers)[22] suggests that designers seek first and foremost to provide and design for an obstacle-free zone next to the road and this approach is adopted by Transit NZ. The erection of road safety barriers should be avoided wherever possible if alternative measures suffice, including the removal of the hazard. This is reinforced by Pearson and Whittington[23] who cite the ATSB Working Party report (2000) that "unwarranted usage or inappropriate placement of a safety barrier can obviously create a hazard for motorcyclists where none might otherwise exist."

Where road safety barriers are required, the advice is that they should be placed as far away from the edge of the roadway as possible in order to provide a clear zone from the edge of the road to the barrier to allow road users the opportunity to recover. This approach is reinforced by Transit NZ's State Highway (draft) Geometric Design Manual[24], although the Manual also notes that in some instances, moving the barrier away from the carriageway can have a negative effect by increasing the impact angle, which may result in increased collision severity.

Furthermore, when installed, different barriers have different performance characteristics and achievement of optimal safety outcomes depends on selecting the appropriate type of barrier for the site conditions. (To this end for example, whilst not specifically related to motorcycle safety, the Highways Agency in the UK have recently introduced a new policy for the provision of median road safety barriers following a review of the performance and maintenance of concrete and steel barriers. Where annual average daily traffic flows exceed 25,000 vehicles per day, concrete barriers will be installed for future schemes as well as when maintenance requirements require new barriers to be installed. This is due to

[22] Association des Constructeurs Europeans de Motorcycles (ACEM). Guidelines for PTW - Safer Road Design in Europe. The Motorcycle Industry in Europe. Brussels, Belgium. 2006
[23] Pearson R and Whittington B. Motorcycles and the Road Environment. Paper to the 'Road Safety: Gearing Up for the Future' Conference. Western Australia. (2001)
[24] Transit NZ. State Highway Geometric Design Manual (draft). 2005

the significant benefits from a maintenance view point plus health and safety benefits when having to maintain such structures.)

Accordingly, the above requires designers to fully consider and justify the provision, location and type of road safety barriers rather than simply apply a standard approach as part of any roading scheme. Care is obviously required in the provision of continuous road safety barriers with respect to the issues identified above compared to interruptions in the provision of the barriers where the barriers are not felt to be needed given that the terminal ends of barriers may form a hazard in themselves.

'Motorcycle Friendly' Barriers

The Motorcycle Council of NSW position statement[25] states that "there are no crash barriers that can be considered 'motorcycle friendly'. In the event of a motorcyclist impacting with a crash barrier the likelihood is that they will be severely injured" and further notes that little research into what constitutes a 'motorcycle friendly' barrier has been carried out, nor how to make existing barriers less aggressive in causing injury to motorcyclists.

Notwithstanding the above perspective, potential may exist to try and further protect fallen riders from exposed support posts, particularly in places where motorcyclists may be most at risk, for instance at sharp bends. Protection can either be in the form of secondary barrier rails below the main road safety barrier or through providing padding and protection on the posts themselves. Limited evaluation on post protectors suggests that the severity of injuries can be reduced. Whilst both forms of mitigation have been used in Europe, for instance by the Highways Agency in the UK at the Cloverleaf Junction in Kent[26] where a secondary rail was attached below the existing metal beam barrier, neither approach easily lends itself to WRSBs. Discussions between Opus and Brifen, a manufacturer of WRSBs, however has indicated that a system (Mototub) consisting of plastic tubing attached to the WRSB below the cable to deflect motorcyclists away from the posts is currently being trialled in France.

The literature review identified two alternative forms of protection specifically designed for WRSBs. The two options include aluminium covers for the WRSBs designed by the Baltic Construction Company in Sweden, in response to the 'cheese cutter' concerns. Alternatively, the Santedge Road Safety Barrier design covers both posts and cables. The 2004 Monash report by Mulvihill and Corben notes that the latter product has not been tested nor is it known if such devices have been installed anywhere. Such measures are likely to require large scale expenditure.

Modification of Barrier Post Designs

Mulvihill and Corben[27] report on work being undertaken by the FHWA in the United States which suggests that a potential approach for WRSB posts is to weaken the posts and/or use thin-walled tubular posts. Although no BCR analysis has been undertaken, the high cost of producing non-standard posts was identified as a potential limitation. Pearson and

[25] Position Statement – Crash Barriers. Internet download from the Motorcycle Council of NSW Inc. www.mccofnsw.org.au (2005)
[26] Innovation and Research Focus. Article in Issue No. 65, May 2006. UK.
[27] Mulvihill and Corben. Motorcyclist Injury Risk with Flexible Wire Rope Barriers and Potential Mitigating Measures. 2004

Whittington[28] also cite a report by Duncan et al (2000) that indicates WRSB posts have been made more frangible by reducing design thickness. However, manufacturers have suggested that any further reduction in the thickness of the posts may impact and compromise the overall performance of the barrier. It is also worth noting that ‘frangibility’ depends on characteristics of the body impacting on the post.

Other reported information indicates Swedish research proposing the removal of hooks and other protruding narrow objects to minimise snagging concerns. This is obviously an issue for some WRSB systems that have hooks on the posts to ‘hold’ the external wire in place.

Barrier ‘Cushioning’

The Austroads 'Guide to Traffic Engineering Practice Part 15: Motorcycles' suggests that shrub planting is ‘intuitively’ desirable in order to provide some cushioning of any impacts and decelerate a rider sliding towards the barrier.

Mulvihill and Corben in their 2004 Monash report provide some background information on the use of vegetation to help decelerate errant vehicles and note that such an approach was unsuccessful in satisfactorily decelerating the vehicle although the results were encouraging from a ‘human body impact’ point of view. Overall however, it is recommended that care is needed adopting such an approach without “robust supporting evidence.”

[28] Pearson R and Whittington B. Motorcycles and the Road Environment. Paper to the ‘Road Safety: Gearing Up for the Future’ Conference. Western Australia. (2001)

6 Conclusions

This report provides a brief breakdown of motorcycle crashes and road safety barriers in New Zealand and summarises the research findings relating to motorcyclists and WRSBs that have been published in a number of international documents.

In New Zealand over the five year period between 2001 and 2005, there have been a total of 3762 injury crashes involving motorcycles; only 55 (1.5%) of these involved collisions with a road safety barrier. Two of the crashes involved a WRSB. With respect to motorcycle fatalities alone, three out of the 162 (1.9%) motorcycle deaths involved a collision with a barrier; none involved a WRSB.

Overall, the research notes that whilst WRSBs have the potential to cause serious injury to errant riders, as do all road safety barriers, "there is no reliable evidence to indicate that wire rope barriers present a greater or less risk than other barrier types, or indeed, no barrier at all."[29] Similarly, design guidelines prepared by the motorcycle industry[30] note that "limited research done so far does not warrant the conclusion that cable barriers are more hazardous than other types of barrier. There is a general agreement that more research is required on the effects of different types of fence on falling motorcyclists. This also applies to the posts that are common to all designs. They inflict the most serious injuries to motorcyclists crashing into a safety fence."

The lack of evidence relating to the impact on motorcycle crash severity of different types of road safety barriers, and WRSBs in particular, is due to the limited amount of accurate real-world or micro-simulation testing along with the limited number of reported crashes involving motorcyclists and WRSBs. Undertaking such tests is costly and time consuming although more work is being carried out internationally on this topic.

Whilst there is no clear evidence to suggest that WRSBs are any more dangerous than other barrier types for motorcycles, it is clear that road safety barriers in themselves do provide an obstacle to errant road users – which, depending upon their use and positioning, may result in a worse crash than if they had otherwise not been provided. The UK Transport Research Laboratory (TRL) and others note that whilst there is inadequate information about the impact effects of motorcyclists with different types of barriers, it is true to note that different barriers have different performance characteristics and that achieving optimal safety outcomes depends on determining the need for the barrier as well as selecting the appropriate type of barrier for the site conditions. Accordingly, care is required when specifying the need for road safety barriers as well as when determining the type and location of such measures.

[29] Mulvihill and Corben. Motorcyclist Injury Risk with Flexible Wire Rope Barriers and Potential Mitigating Measures. 2004
[30] Association des Constructeurs Europeans de Motorcycles (ACEM). Guidelines for PTW - Safer Road Design in Europe. The Motorcycle Industry in Europe. Brussels, Belgium. 2006

7 Recommendations

Whilst a number of European countries have recently shied away from the use of WRSBs, given the lack of clear evidence concerning the impact of WRSBs on the severity of motorcycle crashes, it is recommended that:

- Transit NZ will continue to review international research being undertaken on the interaction between motorcyclists and WRSBs.
- Transit NZ will continue to work with Police and LTNZ/MoT to ensure reporting and 'coding' of motorcycle crashes accurately reflects the severity of the collision as well as the type of barrier struck (where appropriate) in order to provide a true basis for justifying appropriate interventions.
- Transit NZ will continue to remind its designers and consultants of international best practice on the use of road safety barriers including designing for an obstacle free zone next to the road wherever possible, as well as the need to be aware of the characteristics of different types of barriers systems and the designs of different types of barriers with respect to the needs of all road users.

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