Roadside Environment Safety

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Biography
Bruce Corben, before commencing with the Monash University Accident Research Centre in 1993, spent 19 years working in the traffic management and traffic engineering safety fields at VicRoads and its predecessor organisations. During his ten years at MUARC, he has led numerous road safety research projects, specialising in safety of the road infrastructure, including issues associated with speed, roadside safety, pedestrian and motorcyclist safety, and engineering countermeasure development and evaluation.

Abstract
Fatal and serious injuries resulting from vehicle collisions with fixed roadside hazards make up, arguably, the single largest component of all road trauma in Victoria. Some three to four of every ten deaths and serious injuries on Victorian roads, and up to five out of every ten deaths and serious injuries in rural areas, are the result of collisions with roadside hazards. This paper outlines a study that examined the nature and extent of the crash problem and the need for a new approach to roadside safety.

Analysis of Victorian crash data from 1996 to 2000 is used to define the nature and extent of the problem of fixed-object crashes. Crash frequency and severity, and road user and environmental factors that are over-represented in them are identified. Having regard to these crash characteristics, liability and accountability issues are examined. In particular, the recent elimination of the nonfeasance defence is discussed in the context of increasing the incentive for responsible authorities to improve roadside safety.

Finally, world's best practice in roadside safety is examined and the effectiveness of the current design guidelines is questioned. It appears the current design guidelines have failed in substantially reducing the frequency or severity of collisions with fixed roadside objects. The clear zone concept is questioned as an effective means of preventing serious injuries in run-off-the-road crashes, especially along high-speed, high-volume routes. The existing guidelines of 15m median width and 9m far boundary clear zone appear insufficient to reduce impact speeds enough to improve crash and injury outcomes. It is argued that a fundamental review of the road design and system operation standards that determine the inherent level of safety of roadsides is required, followed by the development of new, safer standards.

1. INTRODUCTION

Fatal and serious injuries resulting from vehicle collisions with fixed roadside hazards make up, arguably, the single largest component of all road trauma in Victoria, with up to five out of every ten deaths or serious injuries occurring in this way on Victorian rural roads. This paper outlines a study (Delaney et al., 2002) that examined the issues surrounding fixed object collisions from a number of perspectives and consolidates information on the problem, its possible solutions and state-of-the-art approaches that have been taken both nationally and internationally to address roadside safety concerns. In particular, the nature and extent of the fixed-object crash problem in Victoria is defined using casualty crash data from 1996 to 2000. Having regard to the crash characteristics identified in the analysis, the liability and accountability issues arising from collisions with roadside hazards are explored. The focus then shifts to examine world's best practice in roadside safety and the effectiveness of the current design guidelines. Finally, the key issues arising from the study and future directions for roadside safety are discussed.

2. THE NATURE AND EXTENT OF COLLISIONS WITH FIXED ROADSIDE OBJECTS

From 1996 to 2000, a total of 15,566 casualty crashes involving collisions with fixed roadside objects were recorded in the VicRoads casualty crash database. Of these, approximately 60 percent occurred in metropolitan Melbourne and 40 percent in regional Victoria. From 1997 onwards, the number of collisions with fixed roadside objects occurring on Victorian roads increased slightly in both metropolitan Melbourne and regional Victoria and represented between 16 and 19 percent of all casualty crashes. However, fatalities resulting from these crashes accounted for an average of 32 percent of all road fatalities over the 1996 to 2000 period, suggesting that this crash type contributes more to road fatalities than indicated by frequency alone. This inference is supported by formal testing of the distribution of injury severity for fixed-object crashes which demonstrates with 95 percent confidence that fatal and serious injuries were over-represented in fixed-object crashes when compared to non-fixed object crashes.

An examination of the physical characteristics of fixed-object crashes demonstrates that throughout Victoria collisions with fixed roadside objects were predominately the result of crashes involving one vehicle only, which was most often a car. Further, the majority of fixed-object crashes occurred away from intersections and on straight roads. However, there are some significant differences in fixed-object crash characteristics between metropolitan Melbourne and regional Victoria. First, vehicles involved in collisions in metropolitan areas were most likely to collide with trees and poles (27% and 29% respectively), whereas in regional Victoria the most frequently hit objects were trees and embankments (45% and 16% respectively). Nevertheless, in both areas collisions with roadside trees were the most likely to result in a fatality although the relative risk is greater in regional Victoria (6.5% compared to 4%). This result may be due to higher exposure to high-speed roads in regional areas and the increased risk of injury associated with travelling at high speeds. Second, over half of the collisions in metropolitan Melbourne occurred on roads with speed limits of 60 km/h whereas in regional Victoria the majority of collisions occurred on roads with speed limits of 100 km/h. These results are not unexpected given the exposure to roads of these types in the respective areas.

The characteristics of the drivers involved in fixed-object collisions are fairly consistent between metropolitan and regional areas. In particular, statistical analyses of crash data demonstrates that drivers aged under 25 years were over-represented in collisions with fixed objects in comparison to non-fixed object crashes, and is supported by analysis of the licence type held by drivers involved in fixed-object collisions. Drivers who held a learner or probationary licence were over-represented in fixed-object collisions. These results suggest that the risks posed by roadside objects are particularly relevant to younger drivers and that younger drivers could benefit considerably from improvements in the roadside environment in both metropolitan and regional areas.

An examination of environmental conditions associated with collisions with roadside objects demonstrates that the majority occurred during the day and in clear weather conditions. This is probably due more to increased exposure to driving at these times than an inherently greater risk of crashes in these conditions. In fact, fixed-object collisions were over-represented in comparison to non-fixed-object collisions in conditions of poor weather and road surface. Similarly, crashes with fixed roadside objects occurring in darkness were over-represented relative to non-fixed-object crashes, regardless of street-lighting, suggesting that factors other than lighting may influence night-time collisions. Such factors may include alcohol consumption, fatigue and speed.

3. LIABILITY AND ACCOUNTABILITY ISSUES

Collisions with fixed roadside objects are a large and severe contributor to road trauma in Victoria. Road users injured in these collisions are, in general, able to seek compensation from the Transport Accident Commission (TAC) as part of the established, no-fault compensation scheme. However, since the introduction of this government funded scheme, injured road users have been prohibited from seeking damages at common law except in the case of serious injury and death[1]. As a result, the financial costs of road collisions have largely been transferred from the individuals responsible for collisions to owners of motor vehicles through a surcharge on vehicle registration.

The financial costs of providing greater access and security to compensation through a no-fault compensation scheme are significant. Improvements in roadside environment safety could substantially reduce the financial and social costs of road trauma in Victoria. However, there is currently little financial incentive for the responsible authorities to act. Raising awareness of the issues of legal liability and accountability related to collisions with fixed roadside objects may provide such an incentive.

Following the High Court's judgment in *Brodie v Singleton Shire Council and Ghantous v Hawkesbury City Council* ((2001) 180 ALR 145), it is clear as a matter of law that a public road authority owes a duty of care to road users in relation to the exercise of both their powers and duties except in the narrowest of circumstances. The courts have established clear principles in relation to considerations that are relevant in determining the standard of care required of road authorities. The relevant considerations include the level of risk associated with the action, the likelihood of the risk being realised, the severity of any injury if the risk is realised and the cost and practicability of taking action to avoid the risk. The adoption of a common practice and the existence of competing or conflicting responsibilities will also be considered. However, each of these considerations must be examined in the context of the circumstances particular to each case. Therefore, it may be difficult for a road authority to determine prospectively what actions are required to discharge its duty of care.

It has been suggested that the introduction of risk assessment and management plans to be produced by individual road authorities with regard to a set of objective road standards relating to the inspection, maintenance and repair of roads may increase certainty with respect to issues of liability (Department of Infrastructure, 2002). The current lack of a common set of road standards for use by all road authorities presents a number of problems. Road authorities have limited resources and must determine how to allocate them at a system-wide level. The emphasis of the courts on the circumstances particular to each case makes the allocation of resources at this level problematic and the existence of a common set of road standards would be likely to help alleviate the problem. However, this approach is not without its own difficulties.

The creation of a common set of road standards for use by all road authorities may unintentionally lead to the adoption of lower rather than higher standards of safety to ensure that

[1] Section 93 Transport Accident Act

all road authorities are capable of meeting the guidelines. Clearly this would be less desirable than the current system in which the constraints on each road authority are considered in the context of the individual circumstances. The current approach allows some flexibility without applying a lower standard “across the board”. Further, introducing road standards may cause road authorities to become complacent in relation to their duty to provide a safe roadside environment. There would no longer be any incentive to consider the issue of roadside environment safety beyond the application of the guidelines. Expenditure to improve roadsides beyond the requirements of any guidelines would be considered unnecessary. Ideally, any new guidelines introduced would maintain this flexibility whilst ensuring that appropriately high standards are adopted. Finally, it is the current position of the courts that common or standard practice is only indicative of the standard of care required and it is possible that in particular circumstances the adoption of such standards would not meet the required standard of care.

Legal liability and institutional accountability for collisions with fixed roadside objects must be determined with reference to individual circumstances. However, growing awareness of the issues surrounding liability may, in part, provide the necessary incentive for responsible road authorities to act to improve roadside environment safety. The recent decision of the High Court enables greater accountability to be assigned to responsible road authorities by the Courts. However, whether this will ultimately reduce serious trauma is unclear. So too is the timeframe in which any beneficial effects might be felt as a result of a strengthening of the legal accountability of the many and varied authorities with a role to play. Therefore, it is necessary to consider other factors that influence roadside environment safety.

4. WORLD’S BEST PRACTICE IN ROADSIDE ENVIRONMENT SAFETY

The primary purpose of this section is to demonstrate that there are feasible technical solutions to reducing the frequency and severity of roadside crashes. Both local responses to the issue and some examples of world’s best practice in the area will be used for this purpose.

Victorian Response

There are many circumstances that may contribute to the prevalence of roadside crashes. As highlighted in Section 2, younger drivers, drink-driving and high-speeds are each over-represented in this crash type. Improved management of these factors will, amongst other consequences, reduce roadside crashes specifically. However, there is also increasing recognition of the role of road and other environmental issues in countering crashes. At one level, this has been reflected in the implementation of road-based treatments to reduce run-off-the-road crash risk (e.g. improved horizontal alignment and skid-resistant pavement to reduce the chances of loss of vehicle control, shoulder sealing to increase the chance of re-gaining control of the vehicle, the use of tactile edgelines to improve driver alertness). At a broader level, it has resulted in a perceived need to provide a more forgiving environment in the event that run-off-the-road incidents do occur. The latter emphasis may be collectively termed ‘roadside hazard management’ and consists of two key strategies:

- first, the development of clear zones. These are areas of land immediately adjacent to the carriageway that have been freed of unprotected hazards, thereby allowing an errant vehicle to either come to a stop or substantially reduce speed, without experiencing an injury-producing collision;
- second, otherwise modifying roadside hazards, especially trees and poles (VicRoads, 1998) so that any impact is either totally avoided or has reduced consequences.

From 1989/90 to 1993/94 in Victoria, over 400 locations were treated specifically to reduce crashes into fixed roadside objects. Two hundred and fifty-four of those treatments were selected for evaluation (other treatments were excluded due to insufficient data for full evaluation (Corben et al., 1997)). Selected treatments were categorised, including: hazard removal/reduction, hazard delineation, road and roadside geometry changes, roadway delineation, road surface improvements and traffic operations.

Statistically reliable results demonstrated that over the entire sample of treatments, casualty crashes were reduced by nine percent and casualty crash costs by 16 percent, indicating that the treatments were effective in reducing both the frequency and severity of casualty crashes. Individual treatment types were also found to have beneficial effects. In particular, changes to road geometry such as pavement widening, improved cross-fall and culvert widening resulted in an overall reduction of 23 percent, with changes to horizontal road geometry showing a 44 percent reduction in casualty crashes. Further, improvements to the road surface such as skid resistance, shoulder sealing with tactile edging resulted in an overall reduction of 30 percent, while large-scale shoulder sealing cut casualty crashes by 32 percent.

International Approaches

Roadside crashes as a frequent and severe road safety issue, are by no means unique to Australia. In the US, roadside crashes account for 25 to 30 percent of all road fatalities, with the main obstacles struck being trees or shrubs, guard fences or barriers, utility poles, culverts or ditches and embankments (Ogden, 1996). Similarly, in Sweden over 25 percent of motorists killed collide with fixed objects along the side of the road, with half of these fatalities resulting from collisions with trees (Nordic Road and Transport Research, 1998).

Given the magnitude of the problem, both the US and Sweden – along with other jurisdictions around the world - have launched programs to counter roadside crashes. In a wide-reaching response to the problem, the National Cooperative Highway Research Program in the US identified key strategies and actions. These included the use of shoulder rumble strips to alert drowsy or inattentive drivers that their vehicle is drifting off the road, strategic removal or shielding of trees and poles close to the roadway, public education campaigns equivalent to those used to combat drink-driving, increase awareness of the issue and promote safer behaviours, improved safety management programs, particularly to identify roadside crash black spots, proactive highway maintenance programs to eliminate conditions leading to vehicles running off the road (e.g improved skid resistance on curves, elimination of potholes and shoulder drop-offs) and improved roadside hardware design to reduce their likelihood of developing into hazards (Opiela and McGinnis, 1998).

The US approach is essentially a step-by-step or incremental approach to a severe and long-standing problem. In contrast, the Swedish response occurs more at a system level: the key assumption being that the road-transport system itself is basically unsafe. In support of this assumption, it has been estimated that if all road rules were followed by all road users, fatalities would fall by almost 50 percent and injuries by 30 percent. This means that even under optimum conditions, over 40 percent of fatalities and 70 percent of injuries would remain (Elvik, 1997 as cited in Carlsson, 2000). Thus, the task is to re-develop the system so that user errors will not lead to death or serious injury. For this to be achieved, the system must be designed to ensure that no user in the event of a crash is exposed to impact forces that can kill or severely injure that user.

The requirement imposed on the road system to manage more safely impact forces has led to a number of developments in Sweden, several of which have proven effective in countering roadside crashes. In particular, Swedish road authorities have shown their faith in barriers by progressively implementing an innovative approach for a category of roads. In Sweden, 13-metre roads were used as a compromise means to improve the safety of dual carriageways, by allowing for relatively wide sealed shoulders while still maintaining standard lane width. Early evaluations showed that some safety improvements notwithstanding, these roads remained inferior to motorways. Consequently in the 1990s, 'the 2+1 solution' was introduced, whereby on some 13-metre roads, sealed shoulder widths were reduced to one metre each side of the road, a third lane was introduced, with the middle lane changing direction, usually every 1.5 to 2.5 km. In some instances, road markings are used for lane delineations and direction changes. In most cases, however, wire cables have been used to separate opposing directions, transition zones have been carefully planned, with cabling used to both direct and keep separate the opposing traffic streams, a more forgiving road environment has also been established through the removal of solid objects and through tapering culvert ends. Where it has not been possible to improve hazardous roadside areas, cables have also been used as side barriers.

At the time of writing, more than 200 kilometres of road have been so developed, with one 32-kilometre stretch (the E4 Gavle-Axmartavlan road) being the main evaluation focus. Interim results have been positive in that the '2+1 solution' is proving to be a low-cost approach to improving safety, compared to other options. Further, traffic behaviour, including safety, has surpassed expectations, although it is too early to have statistically reliable estimates of the latter. Public attitudes towards the barriers have also changed dramatically, from very low acceptance levels initially to being acceptable to almost one-half of all drivers. Nevertheless, some difficulties continue. In particular, emergency vehicle drivers have reported concerns with hindrances in one-lane sections, work zone safety appears to be a problem, traffic blockages though infrequent, take a long time to clear, cable barrier repair costs have been higher than expected and it has been necessary to extend the lane width from 4.75 metres to 5.75 metres in sections with only one lane.

In a study of guidelines for median barrier use (Corben et al., 2001), the erection of wire rope barriers was predicted to reduce fatal and serious injury crashes for the target crash types by 90 percent. This estimate is based on real-world experience and analysis of demonstration projects undertaken along high-speed, single-carriageway rural roads in Sweden. For crashes of lower injury severity, it was assumed in the median barrier study that no reduction in these crashes would occur. This is because, with the installation of barriers, crashes can be expected to increase at the lower severity end of the range. For this reason, it was felt that a more conservative approach to predicting reductions in the number of lower severity crashes was warranted.

Urban areas, in which lower speed limits apply, account for a substantial proportion of the road trauma involving impacts with fixed roadside objects. In these lower speed environments, the Swedish approach places less emphasis on providing forgiving infrastructure and more emphasis on reducing impact speeds. The over-riding goal is to keep impact speeds below the levels at which a vehicle is no longer capable of protecting its occupants. In many common urban crash types, this speed is around 30-50 km/h. Where collisions involve fixed hazards, such as trees or poles, the tolerable impact speed may be as low as around 30 km/h, especially for side-on collisions. In such cases, high-level intrusion of poles or trees into passenger compartments commonly occurs. Even modern-day vehicles, equipped with high-standard safety features, cannot adequately and consistently protect their occupants in such impacts. Therefore, general urban speed limits of 50 km/h apply along Sweden's urban roads, unless the inherent safety of the road and roadside is such that higher speeds can be tolerated without the loss of life or long-term health. That is, the speed limit is set on the basis of what is safe when human errors occur, rather than what is safe when drivers are performing well.

Thus, the Swedish strategy emphasises providing inherently safe and forgiving infrastructure in high-speed settings, and limiting operating speeds to safe levels should a roadside crash occur in lower speed settings.

5. CURRENT DESIGN GUIDELINES

Guidelines relating to minimum clear zone widths have been and continue to be the main means by which road authorities attempt to provide safe roadsides. The current 9m minimum clear zone width, for straight roads in high speed settings, with driveable batter slopes, were defined after a study conducted over 30 years ago found that up to 85 percent of errant vehicles could recover within 9m from the edge-line of the road, given the roadside was relatively flat and there was no significant curvature of the road (Wilson et al., 1999).

The clear zone concept has been questioned as an effective means of preventing serious injuries in run-off-the-road crashes, especially along high-speed, high-volume routes. For the case of a 15m median width, errant vehicles will, in many common crash scenarios, be able to reach the opposite carriageway. In addition, analyses of braking profiles of errant vehicles on high-speed roads in common crash scenarios demonstrate that there is often insufficient time for drivers to commence braking before reaching the far boundary of a 9m clear zone (Delaney et al., 2002). The impact speeds with rigid objects situated beyond the clear zone would frequently exceed the capacity of even the safest vehicles to protect their occupants. Therefore, in order for meaningful improvements in the inherent safety of roadsides to be achieved, new much safer designs are required.

6. CONCLUSION

The extent and severity of collisions with roadside hazards have been recognised for decades, both internationally and locally, however, it remains a major source of human trauma in Victoria and, indeed, throughout much of Australia. That the most frequently struck hazards - poles and trees - form part of the built-environment, especially in urban areas, is a particular concern. In the last five years, well over 600 people have been killed in this manner, with the attendant huge economic impact.

Conventional approaches to preventing loss of life and long-term health as a result of these types of crashes tend to be incremental, rather than changing in a fundamental way, injury risk. That is, they achieve only small reductions in crash risk, injury risk, or both, across a relatively small proportion of the road-transport system. A vigorous and concerted new effort is required if this long-standing problem is to be reduced substantially. In particular, vigorous, committed leadership is required across the diverse range of organisations for which road safety is not the "core business" or represents only one of several organisational goals. There is a clear need to instil a very strong sense of organisational ownership that goes well beyond the fear of litigation. Further, systematic, evidence-based programs for eliminating infrastructure deficiencies, in terms of crash risk, injury risk or both are required, as are new and comprehensive road-transport system standards to prevent new hazards being created or built.

A key recommendation of the study was to urge government to establish an over-riding safe design philosophy for its various agencies with responsibility (formal or informal, direct or indirect) for roadside safety. Such a philosophy would provide the fundamental underpinning required to ensure safe roadsides are an essential goal of developing and operating the road-transport system in Victoria. In effect, this would require a formal accountability for designing and building safe roads (analogous, for example, to the position of the Swedish National Road Administration), rather than treating safety as a “by-product” of transport, to be managed.

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