Peer-reviewed papers

Motorcyclist perceptions of risk when riding

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Abstract

The aim of this study was to explore the perceptions that a sample of South Australian motorcyclists have of the greatest risks to themselves whilst riding on the road. This was inclusive of both commuting and recreational riding.

The analysis was based on the self-reported responses to a questionnaire being used in an ongoing study examining the human factors involved in motorcycling safety and behaviour. Participants responded to an open ended question of: what are the greatest risks to motorcyclists on the road today? Flyers placed on parked motorcycles in the Adelaide Central Business District, presentations at social motorcycle clubs and advertising on online forums provided a total of 72 participants. Age and riding experience of the motorcyclists varied considerably, with the age ranging from 19 to 76 years (mean=49.2, SD=15.4), riding experience from 0.5 to 60 years (mean=19.8, SD=16.6), and average riding each week from 1 to 30 hours (mean=6.2, SD=4.5).

The responses fell across seven distinct themes: other road users, the motorcyclists themselves, aspects of the motorcycle, road surface conditions, road design hazards, roadside environment hazards and policing. Age and riding experience were associated with what riders chose as being most important for motorcyclist safety. Differences between objectively researched hazards and subjectively perceived hazards are discussed.

The results provide some insight into what motorcyclists consider to be the greatest threats to themselves and suggest some directions for future research.

Keywords

Motorcyclists, Risk perception, Hazard identification

Introduction

Motorcyclists continue to have the highest risk of injury or fatality of any road users on Australian roads. The statistical risk of injury and fatality from crashing is well documented, with the Australian rate of a motorcycle fatality per distance travelled at 30 times the rate of car occupants, and approximately 41 times higher for a serious injury [6]. However, the risks as perceived by the riders themselves are less well understood. This paper aims to present what riders consider to be the greatest risk to themselves while riding.

A better understanding of the hazards and risks that motorcyclists are exposed to, as identified by motorcyclists themselves, is important for a number of reasons. First, there are road hazards and risks to motorcyclists that are not experienced by other road users. These motorcycle specific hazards and risks need to be understood better in order to meet the goals of a safe system approach to road safety for all road users, and to better inform those who are deciding policy and allocation of infrastructure resources.

Secondly, it may be the case that the hazards and risks identified may change or be influenced by motorcyclist age and riding experience (and social or group identity). This may have some implications for safety interventions targeted at motorcyclists of specific age groups or motorcyclists of differing riding experience.

Furthermore there may be differences between objectively reported risks identified in research and the subjectively identified risks experienced by motorcyclists. If there are differences between the actual hazards to motorcyclists and the hazards that motorcyclists perceive on the road, then this may itself be a safety risk, especially if the discrepancy is pronounced for younger or novice riders. Such a discrepancy could have implications for training.

Hazard perception and risks specific to motorcyclists

It is important to distinguish between the hazards that motorcyclists are exposed to and those of other road users. Hazard perception is defined as the ability to read the road and anticipate forthcoming events [9]. Recent research into the number and types of identified hazards has suggested that motorcyclists perceive more hazards than car drivers do, and have a more flexible visual search pattern than other road users [11, 5, 7]. A study by Rosenbloom [11], using a video based driving simulator, showed that motorcyclists have a faster response to hazards than non-motorcyclists, while Hosking [5], using a motorcycle simulator, found that motorcyclists with more riding and driving experience had a faster response to hazards and exhibited a more flexible visual scanning pattern than motorcyclists with less riding and driving experience. Similar results were found by Liu [7], whose study which also used a motorcycle simulator, showed that the more experienced motorcyclists crashed less often, received better performance evaluation and approached hazards at more appropriate speeds than less experienced motorcyclists.

Research by Hosking [5] suggests that the differences in the identification of, and response to, hazards between car drivers and motorcyclists are due to several factors, including the need to detect a much larger set of hazards (including many that are not relevant to a car driver), and the increased vulnerability of motorcyclists if involved in a crash. It is suggested that these factors increase the importance of developing visual search strategies that are much more responsive to changing road conditions and hazardous events. Motorcyclists must be able to detect a larger set of hazards than car drivers, with those hazards having a different priority for motorcyclists. For example, road surface hazards, while only a low-priority for car driver safety, can severely impact a rider's ability to stay upright.

The influence of age and experience on the identification of particular hazards

Previous studies that have examined hazard perception have typically used a measure of reaction time, gaze fixation or response to a hazard identified in a simulator or video footage [3, 4, 5, 7]. While it has been shown in using these methods that more driving experience can improve hazard perception in drivers [11] the examination of the influence of age or experience on motorcycling hazard perception has given conflicting results.

The present study, rather than examining response to simulators or video footage, instead focuses on the hazards that are identified by motorcyclists in their real world riding experiences. Age and experience are then examined in terms of differences in which hazards and risks are mentioned the most often. This approach differs significantly to the previously mentioned studies which focus more on the influence of experience or age on reaction time (and gaze fixation) to the identification of simulated hazards.

The potential disparity between subjectively and objectively identified hazards

An indication of the actual hazards and risks that motorcyclists experience comes from the Motorcycle Accidents In-Depth Study [8]. The MAIDS was an in-depth study of motorcycle crashes conducted in Europe. The study analysed 921 motorcycle and moped crashes during the period 1999 to 2000 in five sampling areas located in France, Germany, Netherlands, Spain and Italy. The study found that the primary factor contributing to the majority of crashes was human error (a combined 87.9%), coming first from other road users (50.5%), and then from motorcyclists themselves (37.4%). Environmental factors were the primary causal factor in 7.7% of all cases, while vehicle factors accounted for 0.3% of primary causal factors.

The most frequent human error made by other road users was a perception failure to see the motorcyclists within the traffic environment due to lack of attention, temporary view obstruction, or the low conspicuity of the motorcyclist. The most frequent human error made by the motorcyclist was a decision failure, with the rider failing to make the correct decision to avoid a dangerous condition based on their strategy. Environmental factors included such things as roadway design defects, roadway maintenance, temporary traffic hazard obstructions including construction and maintenance, defective traffic controls and weather related problems. One of the aims of the present study was to see how the hazards and risks identified by a sample of motorcyclists align with the factors identified as contributing to crashes in the MAIDS study.

Approach

In order to gain a better understanding of the hazards and risks that motorcyclists are exposed to, this paper will present the views of what a sample of motorcyclists in South Australia consider to cause the greatest risks when riding. The question of "What are the greatest risks to motorcyclists on the road today?" will be analysed and discussed in the context of the types of hazards that are identified, while looking at whether age or riding experience will influence which hazards are considered important. Finally the consistency between objectively identified hazards (from MAIDS) and the subjectively perceived hazards will be discussed.

Methodology

Sample

Participants were recruited using multiple methods in an ongoing study examining the human factors involved in motorcycling safety and behaviour. Flyers placed on parked motorcycles in the Adelaide CBD during the hours from 9am to 5pm, presentations at social motorcycle clubs, and advertising on online forums provided a total of 72 participants. Data was collected over a six month period from November 2012 to April 2013. Age and riding experience of the participants varied considerably, with the age ranging from 19 to 76 years (mean=49.2, SD=15.4), riding experience from 0.5 to 60 years (mean=19.8, SD=16.6), and average riding each week from 1 to 30 hours (mean=6.2, SD=4.5).

Creating age groups

Due to the large variation in the age and riding experience of the participants and the high proportion of participants from the older demographic, two age groups were created for the analysis. Age groups consisting of those who were over 40 years as "older" and those who were under 40 years as "younger", as presented in Table 1. It can be seen that the majority of the sample of participants were generally older, more experienced motorcyclists.

Table 1: Summary of participant demographics by younger and older age group; means (standard deviations)

	Younger (n=16)	Older (n=56)
Age	25.6 (5.1)	56.4 (8.7)
Riding experience (years)	3.4 (2.2)	25.1 (15.5)
Years not riding	0 (0)	7.8 (8.7)
Average riding hours per week	6.5 (6.7)	6.2 (3.6)

Materials

A questionnaire used as part of an ongoing study collected information including demographic details, active and inactive riding experience in years, average weekly riding in hours and purpose, licence type and motorcycle type. Participants responded to an open ended question of "what are the greatest risks to motorcyclists on the road today?"

Research procedure

Identifying themes and risk items

An initial processing phase consisted of analysing the thematic content of all the responses given by the participants. The type of response varied, with some participants giving a one word identification of a risk, while others responded in the form of sentences describing the context and detail of the identified risk. Responses were analysed and coded by the paper's first author.

The responses were then organised into themes. Within each theme there were specific risk items that were consistently mentioned, or the risks were described in the context of the theme. These provided the main categories of risk within each theme. For example, for the theme of other road users, the main risk categories were behavioural; attitudinal; and inattention-related. Each risk item was allocated to a risk category, with three to five risk categories for each theme.

The data was then disaggregated by age group and then by riding experience to examine how the themes were distributed across differing age and riding experience groups. The riding experience in years was separated into five groups: 0 to 1 years, 2 to 5 years, 6 to 10 years, 11 to 20 years, and 21 or more years.

Results

From the 175 responses provided there were seven distinct themes identified: other road users, motorcyclists themselves (usually referring to other motorcyclists), aspects of the motorcycle, policing, road surface conditions, road design hazards, and roadside environment hazards. The themes one to four were self-explanatory, with a direct reference to the context of: other road users, motorcyclists themselves, aspects of the motorcycle and to policing procedures. The remaining three themes were created by referring to definitions drawn from AUSTROADS "Guide to road design" publications (Parts 6 and 6b) [13, 14]. These three themes were each related to different aspects of the road: road surface conditions, road design hazards and roadside furniture.

The seven identified themes and the number of associated risk items for each are shown in Table 2. The theme with the highest number of risk items associated with it was "other road users" with 75 risk items identified. This was followed by "road surface conditions" with 35 items mentioned, then "motorcyclists themselves" was the theme with the third highest risk item count (24 items). Combining the three themes associated with the road gives a total of 65 items (37.2% of total responses), making the total number of risk items associated with the road second only to the number of risk items associated with other road users.

Table 2: Identified themes and their associated risk categories

Theme	Risk category	Item count	*% of theme total*
Other road users n=75 (42.9%)	- Inattention	28	*37.3*
	- Attitude	11	*14.7*
	- Behavioural	36	*48.0*
Motorcyclists themselves n=24 (13.7%)	- Inattention	3	*12.5*
	- Attitude	2	*8.3*
	- Behavioural	17	*70.8*
	- Training	2	*8.3*
Aspects of the motorcycle n=8 (4.6%)	- Small size	2	*25.0*
	- Quiet exhausts	2	*25.0*
	- Conspicuity	2	*25.0*
	- Cost of gear	2	*25.0*
Policing n=3 (1.7%)	- Attitude (biased against MC)	1	*33.3*
	- Reliance on cameras	1	*33.3*
	- Laws (preventing full use of MC)	1	*33.3*
Road surface conditions n=35 (20%)	- Badly maintained (surface)	18	*51.4*
	- Potholes	6	*17.1*
	- Bad repairs (friction changes)	9	*25.7*
	- Oil/diesel spills	2	*5.7*
Road design hazards n=19 (10.9%)	- Lane width	2	*10.5*
	- Manholes	5	*26.3*
	- Reflective markings (when wet)	7	*36.8*
	- General design	4	*21.1*
	- Poor/missing signage	1	*5.3*
Roadside environment hazards n=11 (6.3%)	- Roadside barriers	5	*45.5*
	- Debris on road	2	*18.2*
	- Close roadside furniture	2	*18.2*
	- Weather (run-off)	2	*18.2*
Total Risk Items= 175			

As each theme was comprised of differing categories of risk, the next stage of the analysis was to examine the risk categories by the frequency of items within a category and their percentage of the theme total. For the theme of "other road users", the behavioural risk items accounted for almost half of the items mentioned, with a total of 75 items. These included the behaviour, in general, of cyclists (n=4), heavy vehicles (n=3), cars (n=12), and also specific driving behaviours such as not using head checks when changing lanes (n=8), using mobile phones (n=3) and crossing solid white lines when cornering (n=4). Inattention was mentioned as a risk item for other road users 28 times; 37.3% of the theme total. The remaining risk item associated with other road users was "attitude". This consisted of aggressive and negative attitudes towards motorcyclists, as well as reluctance to accept motorcyclists as valid road users and to respect their "space" on the road. "Space" on the road was used as a reference to the safe following or overtaking distance that would be shown to other road users, or a "buffer zone", as well as to the legitimate right to be on the road.

The theme of "motorcyclists themselves" had 17 behavioural risk items accounting for 70.8% of the theme total. These consisted of behaviours such as riding beyond one's ability (n=5), racing/speeding (n=5), weaving through traffic (n=3) and general risk taking or not wearing correct protective gear (n=4). Inattention was the next highest risk factor, mentioned three times (12.5% of the theme total), followed by attitude, poor and over-confidence (n=2); and then by training (n=2), specifically the lack of good training for returning riders.

"Aspects of the motorcycle" had a total of eight risk items. The small size of scooters accounted for half of the risk items, with their lack of power and conspicuity mentioned four times. The lack of noise from the quieter exhausts of newer motorcycles was mentioned twice, with participants feeling it was a risk as other road users were less likely to hear them approaching. The remaining two risk items were related to the high cost of protective gear preventing its purchase and use (both times mentioned by scooter riders).

The theme of "road surface conditions" had a total of 35 risk items associated with it. Over half of the risk items (51.4%) were related to the poor maintenance of road surfaces. Bad repairs resulting in surface friction changes were mentioned nine times (25.7%), potholes were mentioned specifically six times (17.1%), and oil or diesel spills on the road accounted for the remaining two risk items.

For the theme of "road design hazards" there were a total of 19 risk items spread over five risk categories. The highest reported risk item was "reflective markings" (n=7) accounting for 36.8% of the theme total. This category included the raised safety bars on the median strip, and

the white lines and reflective "cat's eyes" when the roads were wet. Manholes were the next highest risk item for this category, mentioned five times (26.3%). The sunken or lowered surface of the manholes in contrast to the road, their slippery surface, and the excessive number were all mentioned as a risk. The general design of the roads, as being biased towards cars and against motorcycles, was mentioned four times (21.1% of theme total), while the width of road lanes particularly when cars are parked was mentioned twice. Poor or missing signage was mentioned once.

The theme of "roadside environment hazards" consisted of 11 risk items. The most mentioned risk item was for roadside barriers (5 items, 45% of the theme total). These included Wire Rope Safety Barriers (WRSB) and ARMCO metal safety barriers. Close and aggressive roadside furniture including "stobie" utility poles, trees and vegetation, particularly on blind corners, were mentioned twice; wildlife and debris on the road were mentioned twice; and the build-up of water on corners, due to ineffective storm water run-off, was mentioned twice.

The final theme of "policing" contained only three risk items. One item was related to perceived over-zealous "revenue-raising" attitudes targeted at motorcyclists; one item was related to the lack of police presence, with cameras declared to be a poor substitute; and one item was related to laws preventing the full use of the scooter/motorcycle in heavy traffic conditions (using bike/bus lanes, lane splitting).

Distribution of themes across age groups

The next stage of the analysis was to examine whether particular themes were related to certain age groups. This analysis focused on the themes, rather than the particular risk items that comprised them. Due to the different numbers of participants in the two age groups the proportion (percentage) of responses, rather than response frequencies, for each theme are presented. Table 3 shows the distribution of responses for younger (under 40 years) and older (40 years and over) groups across the seven themes, with the percentage of responses for each theme. The highest three responses for each age group are highlighted.

Table 3: Age group distribution - percentage of responses by theme for each age group

Theme	Younger (n=35)	Older (n=140)
Other road users	**34.3**	**45.0**
Motorcyclists themselves	11.4	**14.3**
Aspects of the motorcycle	14.3	2.1
Policing	2.9	1.4
Road surface conditions	**17.1**	**21.4**
Road design hazards	**17.1**	8.6
Roadside environment hazards	2.9	7.1
Total	100	100

The highest percentage of responses for both age groups was for the theme "other road users", with 34.3% of total responses for the younger age group and 45.0% of total responses for the older age group. The theme of "road surface conditions" was the next highest response for both age groups, with "road design hazards" for the younger age group and "motorcyclists themselves" as the third highest response for the older age group. The small number of participants in the younger age group (n = 16) mean that this can only be treated as a preliminary analysis, in need of further examination with a larger sample.

Distribution of themes across experience groups

The next stage in the analysis was to examine how the responses and themes were distributed across differing riding experience groups. Table 4 shows the distribution

Table 4: Experience group distribution - percentage of responses by theme for each experience group

Theme	0 - 1 year (n=11)	2 - 5 years (n=20)	6 - 10 years (n=19)	11 - 20 years (n=62)	21 + years (n=63)
Other road users	**18.2**	**40.0**	**57.9**	**40.3**	**46.0**
Motorcyclists themselves	9.1	**20.0**	5.3	**16.1**	**12.7**
Aspects of the motorcycle	**27.3**	10.0	0.0	3.2	1.6
Policing	0.0	5.0	5.3	0.0	1.6
Road surface conditions	9.1	**15.0**	**15.8**	**19.4**	**25.4**
Road design hazards	**36.4**	10.0	5.3	12.9	6.3
Roadside environment hazards	0.0	0.0	**10.5**	8.1	6.3

of responses for each experience group across the seven themes, with the percentage of responses for each theme. The highest three responses for each experience group are highlighted.

The theme of "other road users" had the highest percentage of responses for all experience groups with the exception of the 0 to 1 year group, which had "road design hazards" as the highest percentage response (36.4%), followed by "aspects of the motorcycle" (27.3%). The theme of "motorcyclists themselves" was the second highest response for the 2 to 5 year experience group, and the third highest response for the two groups with the most riding experience. The theme of "road surface conditions" was in the top three responses for all experience groups with the exception of the 0 to 1 year group. However, due to the constraints on the sample with a low representation of participants with lesser experience and younger age this should only be treated as a preliminary analysis.

Discussion

Identification of hazards

The results are consistent with previous studies showing the high level of attention that motorcyclists allocate to risks associated with the road in general, particularly road surface hazards, and also the risks associated with other road users [5, 11, 7]. This may reflect a high degree of hazard perception, or, more likely, hazard perception more specific to the risks most relevant to motorcyclists. Although it was not possible to compare the identified hazards with what other road users would identify, the study does highlight the significance that motorcyclists place on other road users and on the condition of the road surface as potential hazards.

Differences between the age and experience groups

In terms of the differences between the age groups in where the remaining highest risk themes were identified, the younger age group were more concerned with design aspects of the road, particularly items that affected the friction when wet, such as manholes and line markings. The older age group was more concerned with the road surface hazards, such as potholes and poorly maintained or repaired roads. This difference in perceived hazards for the younger and older motorcyclists may reflect the difference that riding experience and different skill levels make. The concept of having an element of control over the risks may also be relevant here, with the ability to control some risks and not others guiding attention to what is considered more of a risk [2].

While it was not possible to track and examine how the sources of risk change over time for individuals, comparing the low experience groups with the higher experience groups appears to show some differences in where the main concerns are. For motorcyclists with less riding experience it appeared that aspects of the road design and of the motorcycle were the greatest concern. Motorcyclists with more experience tended to be more concerned, again, with other road users, motorcyclists themselves and the road surface conditions.

A further issue to consider in how risk is identified and experienced by motorcyclists is the concept of group identity and the role that this plays in assigning blame or attributing the source of risk. This includes the aligning of self-identity and blame with particular in and out-groups; between car drivers and motorcyclists, between younger and older motorcyclists, and high and low risk takers. Which group one identifies themself with will in part dictate where one will perceive the greatest risk [12]. It is possible that group identity, or "us and them" thinking, may also be a factor that tends to identify other road users as the bigger risk, similar to findings from Musselwhite [10]. The risk theme of motorcyclists themselves was third highest for the older age group, which may be indicative of another in-and-out group situation, this time between younger riders riding beyond their means or racing and the more responsible experienced riders who are more concerned with road craft [2].

Consistency with hazards identified in MAIDS

There were some differences and some similarities with the primary contributing factors identified in the MAIDS report [8]. Other road users were identified in the MAIDS report as a primary contributing factor in 50.5% of crashes and they were the highest mentioned theme accounting for 42.9% of the total responses in the present study. However, while motorcyclists were identified as the primary contributing factor in 37.4% of the cases in the MAIDS study, they comprised only 13.7% of this sample of responses. This suggests an inconsistency between perceived and actual risks. Another possibility is that the wording of the original question may have influenced the responses, particularly in regard to the category of "motorcyclists themselves". Specifically, the question "What are the greatest risks to motorcyclists?" may have led respondents to externalise the responses to factors that have a direct effect on them, rather than if the question was posed in the form "What are the primary crash causation factors, or what are the greatest risks to motorcycle safety?"

A further difference can be seen in the environmental factors identified in the MAIDS and the present study. While the environmental primary causal factors identified in MAIDS were 7.7% of all cases and 14.6% of all other contributing factors, road condition, design and roadside environmental hazards accounted for 37.2% of the total risk factors in the present study.

These differences between the objectively reported crash causal factors of motorcyclists and environmental factors with the subjectively identified risk factors may suggest a possible opportunity for education and training. Providing accurate information of crash causation in motorcycling licensing and training courses, and helping to identify where the main risks for crashes are for motorcyclists of differing age or experience groups, may help in keeping focus and attention on the most relevant hazards while riding. An examination in more detail of the types of human failure factors identified in the MAIDS report (perception, comprehension, decision and reaction failures), as compared with the perceived risk items associated with other road users and motorcyclists themselves using the present study's methodology, may also be a useful avenue for future research.

The findings from this study may be of help towards the overall goal of making the roads safer for all road users. Taking into consideration the safe system approach to road safety [1], there is the importance of designing a road environment and maintaining a road surface condition that accommodates all road users as equally as possible. There is also the challenge of shifting the mind set of all road users to see the traffic environment as a more of a shared space, so as to reduce some of the competitive and aggressive attitudes and behaviours between different types of road users [10].

Limitations

There are limitations to this study that may threaten the degree to which the results can be generalised to the entire motorcycling population. The majority of participants were from the older age group and, although there are positive aspects to this, such as the increased identification of differing types of risks that years of riding experience exposes one to, it also limits what can be said about which risks are more important to riders of less experience or of a younger age.

The method of participant recruitment may also be a factor that could add bias to the results. By focusing recruitment on the Adelaide CBD there may be an over-representation of commuting riders with recreational only riders less well represented, although the recruitment from social motorcycle clubs and internet forums added to the balance between commuting and recreational motorcyclists. There is also the problem of response bias, with participants who agreed to take part in the study not necessarily representative of the motorcycling population as a whole.

A further potential limitation to the study comes from the methods used in coding of the themes and risk items. The use of thematic analysis software may have provided differing risk themes and categories. Further reliability and consistency testing of the themes may prove useful in improving the generalisability of the results.

Conclusions and future research

In conclusion, this study provided some insight into what motorcyclists consider to be the greatest risks on the road. The identified differences between the objectively reported crash causal factors of motorcyclists with the subjectively identified risk factors may suggest a possible opportunity for education and training. Ensuring that accurate information of crash causation is included in motorcycling licensing and training courses, and helping to identify where the main risks for crashes are for motorcyclists of differing age or experience groups, may help in keeping focus and attention on the most relevant hazards while riding.

The results of this study may prove useful in the consideration of infrastructure resources, with the importance of the road surface conditions as potential sources of risk highlighted for motorcyclists. The use of media campaigns to address the issues of risk from other road users, particularly due to inattention and competitive or aggressive attitude, may also be of some benefit. Further work could be done to explore how perceptions of risk change over time with age and experience. A more detailed comparison between primary and contributing motorcycle crash causal factors, the types of human failure factors (perception, comprehension, decision and reaction failures), with the perceived risk factors of motorcyclists may be of benefit to assess the degree to which they align. By using a more representative sample it may also be useful to explore the effect that age and riding experience have in identifying and managing risk, and in how this may change throughout a motorcyclist's riding career.

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Computer modelling of a test device for investigating injury causes in vehicle rollovers

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Abstract

Vehicle rollovers account for a large percentage of the total fatalities in vehicle crashes. The high fatality rate related to vehicle rollovers clearly indicates the extent of the problem. In Australia's National Road Safety Strategy for the decade 2011-2020, one of the requirements for safer vehicles is the development of a dynamic rollover test protocol. Although the nature of the severe injuries occurring during vehicle rollovers is known, the actual causes are still mostly unknown. In this regard, the Jordan Rollover System (JRS) is a device that could be used to investigate in a testing environment what happens to occupants during a typical vehicle rollover.

This paper describes a modelling effort to simulate vehicle rollover dynamic testing using the JRS. A Finite Element (FE) model that accurately reproduces the geometry and functionality of the JRS testing rig was initially built. The model was then validated against an actual test involving a Sport Utility Vehicle (SUV). The FE model proved to be capable of replicating both the vehicle dynamics and deformation occurring during an actual rollover test with the JRS rig.

The developed FE model will be a valuable tool to investigate different crash scenarios by varying the initial vehicle roll, pitch, yaw angles and roll rate. In particular, simulations will be able to identify the ability of the rig to replicate crashes under initial conditions derived from real-world rollover crashes, which may be significantly more severe than the test rig has to date been used for.

Keywords

Vehicle rollover, Jordan Rollover System (JRS), Crashworthiness, Numerical simulations, LS-DYNA.

Introduction

Background

Although vehicle rollovers represent only a small percentage of the total road crashes in Australia, they account for a large percentage of the total fatalities. Australian rollover crashes account for: 12% of all Australian road fatalities; around 35% of all occupant fatalities occurring in a single vehicle crash injury event; around 17% of Australian spinal injuries; and are now greater in number than fatalities occurring in frontal or side impact vehicle crashes [6, 16]. The estimated cost of rollover crashes in Australia is around $3 billion per annum. Similar magnitude of the problem occurs also in the USA and Europe; one in every three occupant lives are lost in vehicle rollover crashes in the USA, whereas in Europe around 10% of road users are killed in such crashes.