THE FUTURE OF SKID RESISTANCE?

Dr Peter Cairney, ARRB Group Ltd, Australia

ABSTRACT

This paper explores the possible role of skid resistance in the not-too-distant future when roads carry a rather different mix of vehicles from that using them today. Three factors are likely to reduce the demand for skid resistance. Reductions in excessive speeds are likely to be achieved through developments such as increased enforcement in conjunction with intelligent speed adaptation. Reductions in the demand for unexpected braking are likely to be achieved through road design changes and advisory technologies at intersections, and by in-vehicle systems to warn of impending collisions. Intelligent braking systems (an extension of anti-lock braking systems) will eliminate skidding, reduce stopping distance and allow steering while braking. The effectiveness of all these technologies is likely to be enhanced by vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications which inform other vehicles in the vicinity when warning messages or avoiding action is being initiated. These developments suggest that skid resistance may become less critical in providing a safe road system in the future. However, increasing community expectations for safety as reflected in the wide adoption of Safe System principles or their equivalent will not allow skid resistance to be traded off against improved vehicle braking performance. Increased travel by powered two-wheelers in response to increasing oil prices is likely to present new challenges in maintaining adequate skid resistance and in eliminating major inconsistencies in skid resistance. Skid resistance is likely to remain a key element in the provision of a safe road system into the future, although priorities for the detailed manner in which it is provided may change.

INTRODUCTION

This paper explores the possible role of skid resistance in the not-too-distant future when we can look forward to a world where roads carry a different mix of traffic from today. Predicting the future is always a hazardous business, but the projections required by this paper are not particularly heroic. All the critical developments are already in service, and other developments referred to are the subject of on-road trials.

There are today many new developments in vehicle safety technology. A range of technologies to improve occupant protection, avoid collisions, increase compliance with speed limits or speed up the response to collisions are either being deployed in the vehicle fleet or have reached an advanced pilot stage. This paper deals only with those developments which are likely to have a direct bearing on the requirements for road friction.

The technologies covered in the paper point to a diminishing role for skid resistance in the future. This is likely to happen in three ways:

- reduction in excessive speeds
- reduction in the demand for unexpected braking
- better control of traction during stopping.

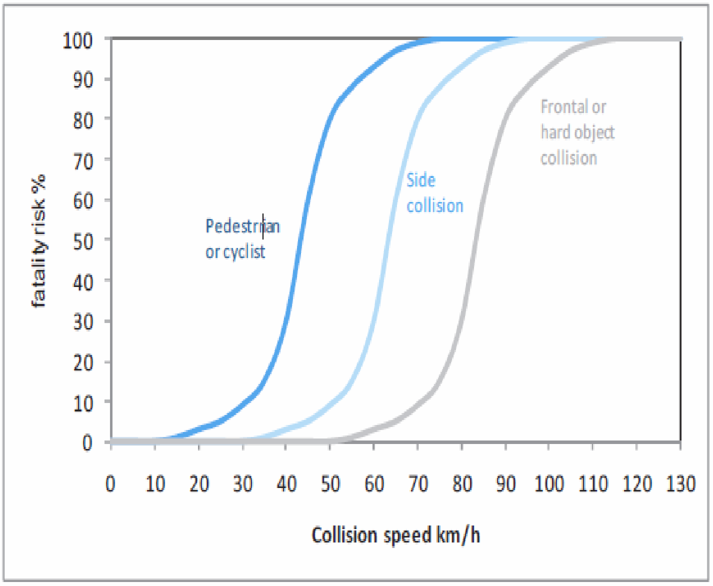
However, these factors are balanced by:

- changed expectations about the level of safety provided
- a different mix of road user types, requiring a more detailed approach to road surface management

A reduced emphasis on skid resistance would, in some ways, be a welcome development as road designers and asset managers cope with the challenges of climate change and resource scarcity (Russell, 2008). The predicted increasing extremity of weather events has direct consequences for skid resistance. On the one hand, longer dry periods are likely to mean reduced skid resistance across the network as a result of prolonged traffic wear without intervening wet periods to restore microtexture. On the other hand, more rainfall during wet periods places an increased emphasis on drainage on parts of the network and on the macrotexture and microtexture of the road surface. Providing adequate microtexture is likely to become more of a challenge as suitable stone becomes more difficult to obtain. There may be pressure on the frequency with which resurfacing is undertaken as the price of bitumen increases as demand outstrips the available supply.

REDUCTION IN EXCESSIVE SPEED

The realisation that modest changes in speed can have major impacts on crash outcomes has led to a major emphasis on speed management throughout the world. Figure 1 summarises many years' research by different investigators using a variety of methods.



Source: Wramborg (2005).

Figure 1: The relationship between fatality risk and collision speed in different crash scenarios

The most visible aspect of this has been the widespread introduction of speed cameras. There is ample evidence to show that speed camera enforcement is an effective way to reduce crashes (e.g. Diamantopoulou & Corben 2002). Speed camera enforcement is likely to continue at least at current levels for the foreseeable future. One further development is likely to result in even higher levels of compliance with speed limits, and that is point-to-point speed enforcement. Experience with the A 77 in Scotland shows how effective this type of enforcement can be (Cameron 2008). While skid resistance would not necessarily be a factor in all of the crashes prevented, given the wide range of crash types prevented by speed cameras, it would probably be a factor in a considerable proportion of them.

However, technology is not all on the side of enforcement. Intelligent speed advice – advice based on the vehicle's current speed in relation to the prevailing speed limit – is already a reality. Many commercial suppliers already offer systems which provide drivers with advice which will keep them below the speed limit nearly all of the time, operating as an adjunct to a sat/nav system, or via a cell phone. Systems vary in terms of the degree of control they exercise over speeds, from advisory only, through increasing resistance to depressing the accelerator, to direct control over maximum speed. Since anything other than providing advice is likely to be controversial and take a long time to attract enough support to ensure its introduction, discussion is confined to advisory systems only.

The Roads and Traffic Authority of NSW has recently completed a major trial of a more sophisticated system than those available commercially (RTA 2011). In the system used in this trial, the on-board device has wireless access to a centralised database managed by RTA. Not only does this system have speed limit information for all the roads in the trial area, but it allows instant updating of this information so that, for example, temporary speed limits associated with road works can be communicated to the speed zone database as soon as the new speed limit becomes effective. This overcomes one of the limitations of the current commercial systems. Included on the data base are advisory speeds, e.g. at curves so that the driver will receive a warning if the vehicle's approach speed is too fast.

The trial involved 1.9 km travel by 114 vehicles and included a broad cross-section of volunteer drivers. Data recorders in the vehicles recorded speeds before and after installation of the ISA device; the records had a GPS reference so that the location of each speed measurement could be related to the speed limit.

When the ISA device was active, 89% of drivers reduced the amount of time they spent exceeding the speed limit; when the device was reactivated, 86% of drivers spent more time exceeding the speed limit than when the device was active. Across all drivers, the probability of speeding was reduced by almost one-third.

Mathematical modelling suggested that if all vehicles were fitted with Advisory ISA , road fatalities would be reduced by 8.4% and the number of road users injured by 5.9%. This would be equivalent to approximately 150 lives and 5000 injuries per year across Australia.

Intelligent speed advice is emerging as a practical proposition, and is likely to be a feature of all future vehicles. In its advisory form, the device does not require elaborate installation, so that retrofitting is not a barrier to uptake. This is likely to have a major impact on speeds in the near future.

Systems external to the vehicle that advise if the vehicle's approach speed to a potential hazard is too high have been in place in a number of countries for some years now. Work from the UK demonstrates just how effective these can be. Winnett & Wheeler (2002) evaluated vehicle – responsive speed reminder signs. If the vehicles were exceeding the speed limit, a speed limit sign with corner-mounted flashing lights was activated. The mean speed reduction across all sites was 7.5 km/h, and a statistically significant reduction in crashes resulted. However, it should be recognised that vehicle-responsive signs are effective only at the point where they are installed, whereas ISA is effective across the entire road network.

REDUCTION IN THE DEMAND FOR UNEXPECTED BRAKING

Another significant development is in-vehicle systems to warn of an impending collision, and possibly take action to avoid it. Collision warning systems (CWSs) utilise radar, laser sensors or video cameras to detect vehicles, pedestrians or objects in the vehicle's path. Analysis of the changing sensor input gives an indication of the rate of approach and the time remaining before an impact. Passive CWSs warn the driver of the collision and prepare the vehicle's safety systems for the collision (i.e. adjust head restraint, adjust seat position, pre-tension seatbelts, etc.) but do not intervene to take control of the vehicle. Active CWSs on the other hand will, if the driver does not respond to the warnings, activate the vehicle's braking system in an attempt to avoid the collision or minimise its impact

It seems likely that most drivers would take advantage of this warning and make a more timely stop than would otherwise be the case. However, if the driver does fail to respond, then the system swings into crash avoidance mode and applies the brakes.

Applying the estimated crash reduction effects to crash patterns across Australia suggests that collision avoidance systems would result in a reduction of between 107 and 179 fatal crashes and between approximately 1500 and 3,800 serious injury crashes annually (Austroads 2010). These would represent substantial reductions in the number of crashes where the skid resistance of the road surface is a contributing factor.

Vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication are likely to reduce the need for excessive braking in a number of ways. Vehicles are to be equipped with wireless transmitters and receivers which will allow a vehicle to inform other vehicles in the vicinity when avoiding action is required. For example, if a vehicle's ESC or collision avoidance system is activated, a message is transmitted which can be received by vehicles in the immediate vicinity. These vehicles can in turn inform other vehicles following them into the area and so on, for as long as it useful for the message to be maintained. With intelligent braking systems, the control module will be able to compute stopping distance from the inputs required to manage the braking process; repeated indications of long stopping distances at a site could potentially be used as a flag that surface friction requires remedial action.

Various forms of intersection management under development rely on V2V or V2I communication. The simplest form would be where, using V2V communication, vehicles approaching each other on separate legs of an intersection inform each other of their presence. Other versions rely on sensors detecting vehicles approaching an intersection, then relying on V2I communication to inform vehicles on conflicting paths.

Simple versions of such systems are already in use, where conventional signs outside the vehicle are used to signal the need for behavioural change to drivers. A system has recently been trialled in Sweden in which a variable speed limit sign displayed a lower speed limit on the main road when a vehicle was approaching the intersection with a minor road (Swedish Road Administration 2006). Speed reductions of between 5 km/h and 15 km/h were reported.

BETTER CONTROL DURING BRAKING

The greatest impact on the demand for skid resistance is likely to arise from technologies which improve the effectiveness of braking and which enable a greater degree of vehicle control to be exercised during braking.

Anti-lock braking systems (ABS) are now widely available on vehicles sold in developed countries. However, the benefits of skid prevention come at the cost of longer stopping distances, and there appears to have been no overall reduction in crashes as a result of the introduction of ABS in cars and other light vehicles (Kahane and Deng 2009).

Electronic stability control (ESC – also known by a number of proprietary names associated with individual manufacturers) is widely available in many current models of vehicle, and is mandatory for all new vehicles sold in Victoria from the beginning of 2011 onwards. It allows a driver to maintain steering while braking, making collision avoidance more feasible.

Electronic stability control (ESC), also known as electronic stability programs (ESP), is an active safety system that reduces the risk of a driver losing control of the vehicle. ESC builds upon features such as anti-lock braking systems (ABS) and traction control to stabilise the vehicle when it changes direction from that intended by the driver. ESC reduces the risk of single vehicle crashes by:

- correcting impending oversteering or understeering
- stabilising the vehicle during sudden evasive manoeuvres e.g. swerving
- improving handling on gravel and unmade roads e.g. road shoulders
- improving traction on slippery or icy roads (VicRoads 2007).

ESC uses a number of intelligent sensors to compare differences between the vehicle's actual course and the driver's steering wheel input, in particular when a vehicle has deviated from the driver's steered direction and the driver has lost control of the vehicle. When the impending instability, oversteering and understeering are registered, the ESC stabilises the vehicle by selectively braking individual wheels and reducing engine torque to bring the vehicle back on course

It has proved to be very effective in reducing crashes, particularly run-off-the-road crashes.

The latest study from the University of Michigan Transportation Research Institute (Green & Woodrooffe 2006) confirms the results of earlier studies worldwide that ESC is highly effective in preventing fatal single vehicle crashes, especially rollovers in SUVs. The study found that for single vehicle crashes, ESC reduced the risk of a fatal crash involvement by 31% for passenger cars and 50% for SUVs. For fatal rollover crashes, there was a reduction of 40% for passenger cars and 73% for SUVs.

Brake Assist (BAS) is a power assistance system which increases braking forces beyond the forces a human driver would be likely to apply, resulting in reduced stopping distance. When combined with ABS or ESC, it is likely to result in fewer collisions, and in reduced impact forces in the collisions which do occur.

In emergency situations, driver braking behaviour often does not achieve the maximum possible performance from the vehicle's braking system. The reasons for this include delays in braking reactions, not applying the brakes with sufficient force, and misjudging the vehicle's rate of deceleration.

BAS uses information about the rate of increase of pressure on the brake pedal to decide whether an emergency braking manoeuvre is being attempted. When an emergency stop is detected, BAS ensures that the braking system of the vehicle is applied to its maximum potential, involving both maximising the braking forces applied while allowing the anti-lock braking features to operate. On a dry road, a BAS could reduce stopping distance by 45% (Road Safety Committee 2008).

Estimates for the effectiveness of Brake Assist are somewhat tenuous, but applying such estimates as there are to Australian crash patterns indicated possible reductions of between 100 and 315 fatal crashes and between approximately 500 and 2000 serious injury crashes (Austroads 2010).

Used together, these technologies are likely to greatly reduce collisions involving motor vehicles over the coming years. Linking advanced braking systems to collision warning and collision avoidance systems is likely to be particularly effective. As these technologies spread throughout the vehicle fleet, the incidence of a wide range of types of collision is likely to be reduced.

SAFE SYSTEM AND INCREASING COMMUNITY EXPECTATIONS

Does this mean that, at some time in the distant future, when these technologies are widespread in the vehicle fleet, road authorities can stop worrying about skid resistance, or at least start to worry about it less?

There are three reasons why this is not likely to happen.

Safety technologies will function better with good skid resistance

The various braking technologies still require a basic level of skid resistance before they operate effectively. Only Brake Assist is likely to reduce stopping distance under normal braking. ABS prevents wheel lock and ESC permits steering while braking, both at the expense of longer stopping distances.

Many of the potential benefits of the new safety technologies will be dissipated unless skid resistance is maintained close to current levels.

Safe System principles – a game changer

Many road authorities in developed countries have committed to Safe System principles, or something very like them.

The essence of Safe System is that in traffic crashes, no road user should be killed or receive injuries from which they cannot recover (OECD 2008). This to be achieved through:

- improved occupant protection

- improved roads and roadside
- encouragement of alert and compliant road users
- speed limits matched to the survival curves for different environments.

If the goal of zero deaths and irrecoverable injuries is to be achieved, then no advantages can be neglected, and trading off the grip of the road surface against harder braking and the ability to steer while braking is simply not acceptable. Rather, every effort should be made to capture the full crash reduction benefits of these technologies by maintaining or enhancing current levels of skid resistance.

The ultimate goal of zero deaths and irrecoverable injuries might seem to be a demanding one, but there has been considerable progress over the last forty years or so. In 1970, the road fatality rate in Australia was 30.4 per 100,000 people while in 2010 it was 6.1 deaths per 100,000 people. On an optimistic reading, we are already 80% of the way there.

The goal of zero deaths and irrecoverable injuries may prove to be unachievable, but the essential question is, how close can we get? From the figures cited above, there is a high probability that new technologies will result in a considerable reduction in vehicle collisions. Coupled with other initiatives that we believe have the capacity to improve safety, such as formal requirements for large amounts of supervised practice on the part of young drivers and improved safety management of companies' vehicle fleets, there is a good prospect that road deaths and serious injuries can be reduced to a small fraction of their current levels. In this environment, there is likely to be less acceptance of road deaths and injury, and an insistence on the part of the community to do whatever can reasonably be done to prevent crashes. In this environment, maintaining adequate levels of skid resistance is likely to retain critical importance. Trading off skid resistance against improved vehicle braking characteristics will not be an option.

Changes in mobility patterns

There a number of factors which are likely to lead to substantial changes in the way people travel over the next few years. Increasing congestion and rising oil prices are likely to lead to less travel by oil-powered private car and more travel by public transport, walking, cycling and motorcycling.

While alternative power sources such as compressed natural gas or coal-fired electricity may sustain the use of private cars to a greater or lesser extent, the trend in private car use is likely to be downwards. More people walking to their destination for all or part of their trip (as a public transport passenger) will place a greater burden on pedestrian protection; good skid resistance at pedestrian facilities will be essential in this environment.

An increase in motorcycling is likely to prove to be a particularly serious challenge. Motorcycling is already increasing more rapidly than road travel generally, up by 38% between 2003 and 2007, compared to 7% for road travel as a whole (Australian Bureau of Statistics 2008). The fatality rate for motorcyclists is approximately 34 times higher than the fatality rate for car occupants (Victorian Government no date). Motorcycle riders are more vulnerable to low skid resistance than are drivers of four-wheel vehicles, and are particularly vulnerable to inconsistencies in skid resistance.

If motorcycle numbers increase considerably in the future, then there is likely to be demand not just for adequate levels of skid resistance across the network, but more attention to ensuring consistency of skid resistance across high risk sites.

Along with a change in emphasis, there may be a case for developing more sophisticated risk models based on expected number of stops required and road friction available. This information could be used to generate an expected distribution of stopping distances, which would provide a more objective basis for identifying problem sites and prioritising actions.

CONCLUSIONS

New technologies offer the prospect of reduced demand for road friction. This may be anticipated as a result of reductions in excessive operating speeds, reductions in emergency situations, and improvements in stopping distance and retaining control while braking.

However, these are offset by increasing expectations regarding road user safety, expressed in philosophies such as Vision Zero and Safe System, which aim for the elimination of deaths and serious injuries on the road, and which do not permit trading off road friction against advances in vehicle design.

They are also offset by changes in travel patterns in Australia. Increasing public transport use, increasing walking and cycling, and increasing motorcycling are likely to be some of the results of increasing fuel prices. This is likely to result in a change of focus for the management of road surfacing with even greater emphasis on the provision of high levels of skid resistance in areas of high pedestrian activity, and increased emphasis on eliminating inconsistencies in surface friction to more safely accommodate two-wheelers, especially on routes or at sites used by large numbers of two wheelers, or where they are particularly at risk.

REFERENCES

Australian Bureau of Statistics 2008 Survey of Motor Vehicle Use, Australia, 12 months ended 31st October 2007, Australian Bureau of Statistics, Catalogue number: 9208.

Austroads 2010 Reviewing ITS Technologies and Road Safety Opportunities, Austroads Report no AT-T157-10

Cameron, M 2008, Development of strategies for best practice in speed enforcement in Western Australia: supplementary report, MUARC report 277, Monash University Accident Research Centre, Clayton, Vic, Australia.

Diamantopolou, K & Corben, B 2002, 'The impact of speed camera technology on speed limit compliance in multi-lane tunnels', *Road Safety Research, Policing and Education Conference 2002, Adelaide, SA,* Transport South Australia, Adelaide, SA, vol. 1. pp.79-84

Green, P & Woodrooffe, J 2006, The Effectiveness of Electronic Stability Control on Motor Vehicle Crash Prevention, report number UMTRI-2006-12, University of Michigan Transportation Research Institute, Ann Arbor, Michigan, viewed 17 September 2008, <http://deepblue.lib.umich.edu/bitstream/2027.42/39110/1/99599.pdf>

Kahane, CJ & Deng, JN 2009 The Long-Term Effcet of ABS in Passenger Cars and LTVs National Highway Traffic Safety Administration report DOT HS 811 182, viewed 10 May 2011,
VicRoads 2007, Electronic Stability Control (ESC), Active crash prevention technology, VicRoads, Victoria, viewed 17 September 2008, <http://www.vicroads.vic.gov.au/Home/Cars/RoadSafety/Electronic+Stability+Control.htm>

OECD 2008 Towards Zero: Ambitious Road Safety Targets and the Safe System Approach OECD International Transport Forum, viewed 01/05/2011 http://www.internationaltransportforum.org/jtrc/safety/targets/targets.html

Road Safety Committee 2008, Inquiry into vehicle safety, Road Safety Committee, Parliament of Victoria, Melbourne, Vic, viewed 3 August 2009, http://www.parliament.vic.gov.au/rsc/Vehicle_Safety/vs_default.html

Roads and Traffic Authority 2010 Results of the NSW Intelligent Speed Adaptation Trial, viewed 01/05/2011, http://www.rta.nsw.gov.au/roadsafety/downloads/isa_trial/isa_trial_results.html

Russell, K 2008 Address to the Plenary Session on Asset Management, ARRB Conference, 2008, Adelaide

Swedish Road Administration 2006, Variable speed limits: evaluation at intersections, Swedish Road Administration, viewed 6 October 2008, <http://publikationswebbutik.vv.se/upload/3140/88884_E_Evaluation_at_intersections.pdf>

Victorian Government no date Victoria's Road Safety and Transport Strategic Action Plan for Powered Two Wheelers 2009–2013

VicRoads 2007, Electronic Stability Control (ESC), Active crash prevention technology, VicRoads, Victoria, viewed 17 September 2008, <http://www.vicroads.vic.gov.au/Home/Cars/RoadSafety/Electronic+Stability+Control.htm>.

Winnett, MA & Wheeler, AH 2002, Vehicle-activated signs: a large scale evaluation, TRL 548, TRL, Crowthorne, Berkshire, UK.

Wramborg, P 2005 A new Approach to a Safe and Sustainable Road Structure and Street Design for Urban Areas Paper presented at Road Safety on Four Continents Conference, Warsaw, Poland

AUTHOR BIOGRAPHIES

Peter Cairney has worked in the areas of driver behaviour and road safety for thirty years. His background is in cognitive psychology and human factors. He has worked on a wide range of issues, including road signs and markings, driver errors, rail crossing safety, community road safety programs, and the relationship between road surface characteristics and crash occurrence. Much of his work in recent years has been concerned with intelligent transport systems and vulnerable road users, including evaluations of traffic signal features to improve pedestrian safety, and improved guidance on curves to assist motorcyclists.