



Roadmarking Industry Association of Australia

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PAVEMENT MARKINGS -THEIR ROLE IN IMPROVED ROAD SAFETY

The Roadmarking Industry Association of Australia (RIAA) in harmony with our mission statement is pleased to be actively involved in the promotion of awareness and professionalism throughout all levels of industry by advocating the critically important benefits of professionally applied and maintained quality pavement delineation products.

Almost universally it is agreed that the fundamental need for all road users is the provision of safer roads & driving conditions. It is therefore not surprising that in today's safety (and litigation) conscious society inordinate amounts of money are invested annually into important road safety strategies seeking to stem the tragic loss of lives on our roads. Even with these important strategies in place, what is the current situation in Australia?

The Hon. Tony Rundle MP of Tasmania stated in 2004 that for every road death in Australia, at least 30 people are seriously injured in motor vehicle accidents. These injuries include paraplegia, loss of limbs and serious brain damage. Not surprisingly then he termed that this "the hidden disease".

In her article, "A Sign of The Times: fixourbloodyroads.com", which was published in December 2005, Dr Jacqui Murray quoted the NRMA as saying that in Australia in the 'next 24 hours', five people will die, 539 will be injured and 4,800 crashes will occur on the nation's roads at a cost of \$41 million a day".

If the statistics in these quotes remain constant over the next 12 months this will mean that by this time next year there will have been 1,752,000 motor vehicle accidents on our roads, resulting in 1,825 deaths and 200,000 injuries. The total monetary cost of this carnage? Some \$15 billion.

More than one-half of the total cost of crashes (56%) are 'human' costs related to the 55,000 individuals suffering "serious" injuries (paraplegia, loss of limbs, serious brain damage etc). \$8.4 billion dollars per annum (or \$23 million per day) is directly attributable to the lost output, long-term care, rehabilitation and lost quality of life of these unfortunate individuals.

PAVEMENT MARKINGS ROLE IN MEETING THE ROAD SAFETY CHALLENGE

What role can pavement markings play in improving road safety?

Please consider the following:

- Linemarking is the most fundamental countermeasure ever introduced into road safety. (NSW StaySafe)
- Centre lines and edge lines reduce all accidents by 20%. (Miller, 1992).
- Centre lines and edge lines reduced single vehicle accidents by 34%. (Moses 1986).
- Road marking treatments have the potential to reduce the percentage of crash types by up to 40%. (Australian Automobile Association)
- Linemarking is the most cost-effective safety measure..... it can reduce car accidents by as much as 60%. (AITPM)

You will notice from these quotes that pavement markings can potentially reduce all accidents by between 20 and 60%. What effect would this have on reducing the human and monetary costs that we have just considered?

Each year **pavement markings** could potentially deliver the following positive road safety benefits:

- Between 350,400 and 1,051,200 fewer motor vehicle accidents.
- Between 365 and 1,095 fewer deaths.
- Between 40,000 and 120,000 fewer injuries.
- Between 11,000 and 33,000 fewer individuals suffering "serious" injuries.
- An overall monetary saving of between 3 and 9 billion dollars

Bah! Humbug! What a load of rubbish! I can hear the cries while I write this paper. Why? Because in many situations we already have centre lines and edge lines, so have we therefore not already achieved the potential savings, both human and monetary? Sadly, no. Why? Because many of the specifications that are currently being used by State and Local Road Authorities throughout Australia **simply do not deliver the performance characteristics** that are required to ensure safe driving 24 hours a day, seven days a week, 365 days a year.

The recommendations contained in this paper, if adopted, will substantially improve the quality of pavement marking in this country, both on local roads and rural. The resultant quality pavement markings will be a substantial improvement in comparison to current markings and will therefore definitely result in fewer motor vehicle accidents, fewer deaths, fewer injuries, and definite savings, human and monetary.

But before we consider the recommendations that can potentially improve the effectiveness of pavement marking in this country, let us first consider the need for a nationwide change in thinking and attitude on the part of every person who considers themselves to be dedicated to the provision of safer road & driving conditions.

For too long now existing pavement markings have been viewed and budgeted as a road maintenance issue, to be considered only when and/or if the budget allows for maintenance to be performed. This erroneous view coupled with a poor understanding of what constitutes effective pavement markings, has resulted in **much of the markings on our roads being ineffective and therefore unsafe**. Remember, most road safety strategies are built on the premise that visibly-safe road markings already exist. As this is often not the case our road safety strategies are being compromised at this most basic level.

All of us must embrace (and act upon) the realisation that the uncompromising delivery of high-quality, **well maintained pavement marking is a key road safety measure, fundamental to the success of any serious road safety strategy**.

I sincerely hope that this prelude has highlighted to each of you the genuine need that exists in this country for action in implementing the recommendations that are featured in the following section of this paper. These recommendations, if adopted, will definitely improve the quality of pavement markings (and by default positively impact on road safety) !

HOW VISIBLE SHOULD YOUR ROAD MARKINGS BE?

Unlike paints and related products that are used in domestic and commercial settings to achieve either cosmetic or protective purposes, pavement marking products that are designed for use on our roads must be visible in day & night conditions. They must remain visible even when the road surface has become wet because of rain. If pavement markings are not visible under these conditions, most drivers will have great difficulty in safely negotiating the road on which they are travelling, (the ramifications for this should be obvious).

Can you identify in your mind a stretch of road with which you are personally familiar, that exhibits any of the following symptoms of ineffective markings?

- A multilane lane road wherein the linemarking has deteriorated significantly; to the point that the lanes are not clearly defined.
- A road that, during the day, appears to be well marked, but at night the lines are barely visible.
- A road, that normally appears to be well marked, enabling good vision in both day & dry night conditions; and yet on nights of even moderate rainfall the lines become invisible.

Sadly I am sure that each of us present at this conference has personally experienced these exact conditions, and can probably identify roads in and around the areas that we regularly travel that are clearly dangerous. So what is required to ensure that markings are visible at all times? (with the exception of course of flooding).

The primary performance criterion that delivers visibility of pavement markings, especially at night, is **retroreflectivity**. Essentially, retroreflectivity of pavement markings can only occur if the markings are incorporated with glass beads specifically designed to provide retroreflectivity. (For further information see: AS/NZS 2009 Glass beads for pavement-marking materials).

The basic mechanics of this process are that the beam of light emitted from the headlights of a vehicle enters into glass beads that have been imbedded 60% into the pavement marking materials surface; the light will then retroreflect back to the driver at a sufficient level of brightness as to complete the safe guidance system that markings are meant to deliver. When measuring units of retroreflectivity the value is expressed as $\text{mcd/m}^2/\text{lx}$ (millicandella/per square metre/lux).

Of course the big questions are:

1. What is the ideal minimum level of retroreflectivity to ensure visibility of the markings 24 hours a day, wet or dry?
2. Are the levels of retroreflectivity currently being used by Road Authorities sufficient?

Of Australia's eight States and Territories, four have absolutely no specified minimum levels of dry retroreflectivity. One specifies a level of $100 \text{ mcd/m}^2/\text{lx}$, (the internationally accepted level at which a line becomes invisible at night) and another even allows a level as low as $90 \text{ mcd/m}^2/\text{lx}$.

The situation for minimum wet retroreflectivity values is even worse, with six of our States and Territories not having any requirements that would ensure safe driving in wet-night conditions.

No doubt many of you here today will be alarmed by these facts, as many Local Authorities and private road owners will automatically use their relevant State or Territory's pavement marking specification to formulate their own pavement marking strategies.

So again the question - what is the ideal minimum level of retroreflectivity to ensure visibility of the markings 24 hours a day, wet or dry?

To answer this, please consider the following research from Australia and around the world:

- Traffic fatalities are 3 to 4 times higher at night, than day. (Boyce 1981).
- Improved night-time visibility for drivers can be a major factor in reducing accidents. (Boyce 1981).
- Retroreflectivity has more influence over end of line detection distances than head lamp illumination. (Zwahlen & Schnell, University of Ohio USA 1998).
- Larger (1mm) sized glass beads provide more effective wet night visibility. (Kalchbrenner, USA 1989).
- Large glass beads are used to add wet weather retroreflectivity to conventional markings. The beads need to be at least 1mm in size. (CIE International Commission on Illumination, 1999).
- For roads with an AADT of 5,000, the minimum retroreflectivity required is 150 mcd/m²/lx (30m geometry). (Dravitzski, Laing & Potter, Opus Labs NZ. 2004).
- For highway speeds above 80km/hr, a minimum RL value of 150 mcd/m²/lx was recommended. (Migletz, Graham, Bauer & Harwood, 1998).
- For night time wet-pavement conditions, a minimum RL value of 180 mcd/m²/lx was recommended. (Migletz, Graham, Bauer & Harwood, 1998).

Note: When considering that last quote which recommended 180 mcd/m²/lx for wet-pavement conditions, please bear in mind that this is a measurement of the minimum dry retroreflectivity values required to deliver sufficient levels of retroreflectivity (brightness) in wet conditions.

A film of water coating the glass beads in wet conditions reduces the retroreflective performance of pavement markings. A coarse pavement texture (e.g. 12+ mm sprayed seal) may assist the performance of AS/NZS 2009:2002 Type B small-sized glass beads in pavement markings by faster drainage of the water. Generally though, larger glass beads of around 1 mm (AS/NZS 2009:2002 Type D) need to be used to provide wet-night visible pavement markings on all types of road surfaces.

When Type D beads are used, as the pavement becomes wet, the contrast between pavement and the pavement marking is improved.

Based on these reports, the recommended levels of retroreflectivity for roads exhibiting either an AADT of 5,000 vehicles or highways speeds greater than 80km/hr are:

- **A minimum 150 mcd/m²/lx dry**
- **A minimum 100 mcd/m²/lx wet**

Notice how these recommended minimum levels of retroreflectivity are reflected in the following excerpt of the recently released new Australian Standard AS 4049.4—2006 Paints and related materials—Pavement marking materials Part 4: High performance pavement marking system (available from www.saiglobal.com):

TABLE 3
DRY RETROREFLECTIVITY

| Classification | Retroreflectivity mcd/m ² /lx | | |
|----------------|--|----------------|----------------|
| | Initial | Interim(s) | Final |
| RD0 | No requirement | No requirement | No requirement |
| RD1 | >250 | >200 | >150 |
| RD2 | >350 | >250 | >150 |
| RD3 | >500 | >350 | >250 |

TABLE 4
WET RETROREFLECTIVITY

| Classification | Retroreflectivity mcd/m ² /lx | | |
|----------------|--|----------------|----------------|
| | Initial | Interim(s) | Final |
| RW0 | No requirement | No requirement | No requirement |
| RW1 | >80 | >80 | >80 |
| RW2 | >160 | >130 | >100 |
| RW3 | >240 | >180 | >120 |

(Note: This new Australian Standard AS4049.4 – 2006 is highly recommended for anyone interested in setting performance parameters for pavement marking systems.

The performance parameters that are featured in this excellent document include:

Colour; Colour Change; Luminance Factor; Volatile Organic Compounds; Dry Retroreflectivity; Wet Retroreflectivity; Degree of Wear; Slip Resistance and Skid Resistance.

The aim of this Standard is to provide users with the ability to specify requirements for high performance pavement marking systems.)

Of course it must be remembered that **150 mcd/m²/lx dry** and **100 mcd/m²/lx wet** are the recommended **absolute minimum** levels of retroreflectivity, below which they should never fall. Therefore when these figures are used within a specification they should be considered as **the intervention levels at which the re-marking must be instigated.**

It is recommended that the initial levels of retroreflectivity required by new markings be substantially higher than those shown here in order to realise reasonable service life expectations.

WHAT IS THE STANDARD OF YOUR CURRENT MARKINGS?

Equipped now with a clear understanding of what the minimum levels of retroreflectivity should be, how can you determine the standard of the markings on your road system?

The first thing you need to be aware of is that the $\text{mcd/m}^2/\text{lx}$ figures quoted herein are those shown when testing with a retroreflectometer that utilises a 30 metre geometry as it's angle of measurement. In Australia 30 metre geometry hand held retroreflectometers (used for spot checking retroreflectivity) are available. There are also companies that provide retroreflectivity measuring services utilising truck mounted retroreflectometer systems that can measure any length of road at any interval that you could possibly want at highway speeds (and provide you with computer generated reports for your analysis).

It must be stressed however, that the only way for you to ensure the veracity of the readings of these instruments is to ensure that they have been calibrated using Secondary Standards that are traceable to the requirements of the National Measurement Laboratory (NML).

In direct response to increased performance expectations, and with the total support of industry and every Road Authority throughout Australia and New Zealand, Secondary Standards have been developed. The use of traceable Secondary Standards provides protection for contractors and road owners alike, eliminating any dispute as to the real standard of works performed.

Also, beware of the dangers inherent in the reliance on daytime visual assessments of pavement markings as a tool for assessing the quality of your markings. REMEMBER: for a marking to be visible 24 hours a day, in both dry and wet conditions, it MUST have sufficient glass beads in-situ to deliver this most important of safety features - retroreflectivity. It is simply not possible to determine from within a car, travelling at speed, during the day, whether this is the case.

If you must perform a visual assessment then this should at least be performed at a time when retroreflectivity is both important and apparent – AT NIGHT (and maybe even a wet one at that).

(Note: Standards Australia is close to releasing another new standard: AS 4049.5 Guidelines for the performance assessment of pavement markings. This new Standard will: standardise field performance assessment procedures; provide guidance on the use of assessment data; and on the development of a performance based management system).

OTHER ROAD SAFETY STRATEGIES INVOLVING PAVEMENT MARKINGS THAT ARE BEING ADOPTED INTERNATIONALLY:

CENTRELINE AUDIO TACTILE MARKINGS

The 'Insurance Institute for Highway Safety' in the USA recently published a report on the findings of trials in that country utilising what we call audio tactile markings (known as rumble strips in America). The report was entitled: "Crash Reduction Following Installation of Centreline Rumble Strips on Rural Two-Lane Roads" (Persaud, Retting & Lyon September 2003).

Notice the following findings:

The results of this research demonstrate that centerline rumble strips are an effective countermeasure on rural two-lane roads. As expected, they had larger effects on frontal and opposing direction sideswipe crashes, a 25 percent reduction in injury crashes, but the effects on other more numerous crash types also was large. The overall reduction in rural two-lane crashes attributable to centerline rumble strips was 14 percent.Consideration should be given to wider application of centerline rumble strips on rural two-lane roads"

Whilst on the subject of centreline audio tactile markings, you should be aware that the Roads and Traffic Authority of New South Wales (RTA) is currently trialling the use of this marking system in that State. The RTA is also trialling the use of PMMA (poly methyl methacrylate) materials as a possible addition to the thermoplastic markings that have predominately been used for audio tactile markings in Australia. These trials are also seeking to significantly enhance the retroreflectivity of audio tactile markings by utilising larger glass beads of around 1 mm (AS/NZS 2009:2002 Type D) to enhance wet-night visibility.

The RTA is to be applauded for taking this pro-active stance in the field trialling of alternative marking systems with a view to enhancing road safety.

WIDER MARKINGS

In it's report entitled: "The Use of Wider Longitudinal Pavement Markings -Research Report 0024-1", the 'Texas Transportation Institute' reported *strong evidence that wider markings provide the following benefits to drivers, suggesting improved roadway safety:*

- *improved long-range detection under night time driving conditions (older drivers benefit the most),*
- *improved stimulation of the peripheral vision,*
- *improved lane positioning and other driver performance measures, and*
- *improved driver comfort.*

In regard to longitudinal markings, the report stated that: "*it is clear that longitudinal markings must be at least 4 inches (100mm) in width*". The report further showed that 34% of State Road Authorities in USA are now using 150mm lines and some other States are even using 200mm lines.

OTHER FACTORS FOR CONSIDERATION:

'Transportation Research Board' - USA

"It has been established that for night time low-beam conditions, a driver requires a minimum recommended preview time (comprising both eye fixation time and driver reaction time) of 3.65 seconds at 80km/hr, of oncoming road geometry to enable safe negotiation without the driver requiring to shift attention away from the road, to look for other clues" - (Zwahlen and Schnell, Transportation Research Board, January 1998, Washington DC).

High quality road marking's inherent night-time retroreflectivity (brightness) provides this improved 'road preview time' or 'end-of-line detection distance'.

The Road Safety Needs of Older Drivers

Statistically we live in a rapidly ageing population.

Studies suggest that after age 21, we require 20% more light for each 13 years we age, in order to be able to see as well as we did at age 21.

Older drivers, therefore, need more light in order to navigate their way safely. In an aging population, which wants to maintain its mobility, the need for quality line marking has become a critical issue requiring the attention of road owners and specifiers alike.

All drivers interact with environment clues whilst driving. Indeed driving is a series of decisions based 90% on visual clues. Peripheral vision has proved to be far more important than generally recognised for driver orientation, and the visual field of 175° at age 20, declines to 150° by age 70. Both the speed and level of adaptation to light degenerate with the ageing process. Any action that can be taken to increase the visual aspects of driving will be proportionally beneficial.

Put simply – **older drivers require much higher levels of retroreflectivity** to enable safe navigation of our roads.

AusRAP Australian Road Assessment Program

The recently released AusRAP Australian Road Assessment Program reportedly showed that most national highways are not up to acceptable safety standards.

This program sought to institute a 'Star Ratings' classification system; rating roads from 1-star (least safe) to 5-star (safest). Of the some 19,000km of our national highway network that were rated, the majority of roads rated just 3 stars.

AAA Executive Director, Lachlan McIntosh has been quoted as saying that those roads achieving the 3-star rating (the majority of roads assessed) were below those expected of a national network of roads.

"We should expect that, with increasing traffic, we can have a national network which has low risk and hence a low crash rate. Five people die every day on Australian roads and 61 are seriously injured – these tragic statistics could be significantly lowered if more attention is paid to incorporating simple safety features in all road design and maintenance. Research confirms that improving roads can contribute more to reducing road deaths than improving driver behaviour and vehicle safety".

The design elements that influence 'run-off road' and 'head-on crashes' that were analysed by AusRAP included the role of line marking

CONCLUSIONS:

Embrace (and act upon) the realisation that the uncompromising delivery of high-quality, well maintained pavement marking is a key road safety measure that is fundamental to the success of any serious road safety strategy.

If you are not already doing so, work towards specifying **150 mcd/m²/lx dry** and **100 mcd/m²/lx wet** as the absolute minimum levels of retroreflectivity, below which your markings must never fall. And then ensure that you use effective assessment techniques to ensure that this is the case.

The RIAA encourages the adoption of new technologies (i.e. audio tactile centrelines where necessary and the use of wider lines) that will enhance road safety. We are also committed to remaining actively involved in the promotion of awareness and professionalism throughout all levels of the Australian pavement delineation industry.

We therefore welcome the opportunity to work along with any and all concerned parties in facilitating an environment wherein all road users can travel our roads in maximum safety.

To this end we would encourage you to contact us here at the Roadmarking Industry Association of Australia for any further information or assistance in enhancing road safety through the utilisation of enhanced marking systems. Our contact details are shown at the beginning of this paper.

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