Road Markings - Cosmetic or Crucial?

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Biography

Bob has been involved at the 'coal face' of pavement marking applications since 1968. His activities in the industry include initiating and coordination of training, initiation of large scale field trials, and initiating a great deal of innovation in the areas of equipment, methods and procedures. Bob has been involved in various industry committee and consulting rolls with Standards, ARRB, and the Roadmarking Industry Association of Australia, as well as presenting many papers at local and international conferences. Employed with Potters Industries as their Technical Services Manager, Bob has experience with pavement marking activities throughout the Asia Pacific Region, Europe and North America.

Abstract

Horizontal painted pavement marking materials are applied to road surfaces to provide safe guidance for the travelling road user public. These markings need to function both day and night, wet and dry, to provide safe guidance and clear signals at a consistent level while presenting a preview of the forward road geometry. Such delineation systems may create a potential hazard if the differential friction between the marking and the pavement exists, particularly for cyclists and motorcyclists.

Potters Industries, having the luxury of a dedicated purpose built R&D application test vehicle (The DART) and the luxury of suitable test deck areas, has taken the initiative in developing safer systems and generating data to assist the pavement marking industry. These trials have been partnered by RTA's Scientific Services Branch. Requirements for Performance Based Contracts for pavement markings are fast approaching, with little data to assist the specifying engineer on realistic intervention levels that can deliver safe performance outcomes. These 'safe outcomes' should include minimum levels in dry night visibility, wet night visibility and skid resistance for both transverse and longitudinal pavement markings, throughout the life of these markings.

To provide the anticipated levels of skid resistance, usually requires a surface application of angular particles. These angular particles may create shadows over the surface applied glass beads and render the line invisible during night conditions. The challenge has been to find a balance between angular and spherical surface applied particles, in size, quality, quantity, ratio and method of application, that can provide durable cost effective horizontal pavement markings with excellent dry night delineation, excellent wet night delineation and a high level of skid resistance.

Left: Potters Industries R&D pavement marking application testing vehicle, the DART (Delineation Assessment, Roadmarking Technology). This equipment has been used, in partnership with the RTA's Scientific Services Branch, to apply various road marking treatments.
The vehicle is capable of applying most of the common roadmarking binders used in Australia, including waterborne paint, extruded thermoplastics and audible tactile thermoplastic. Applications of other innovative materials can and have been accommodated.

Introduction

In a series of field trials conducted around Australia, Potters Industries has sought to improve the performance of road markings. The results reported in this paper are taken from data generated over the past two and a half years, in Canberra, in a partnering with the NSW Roads and Traffic Authority Scientific Services Branch. Our work has largely been driven by these four key issues:

1. Line marking must be a high priority road safety measure not a low priority maintenance issue

Line marking must be considered, first and foremost, as a road safety measure. clearly defined road alignment is one of the most important pieces of information for the driver and one of the many benefits of good line marking is its road safety performance in the most adverse conditions; wet weather and at night. Good line marking becomes even more important with an aging population. The older you get the more illuminating road information must be.

2. Maintenance programs must be based on performance not on routine time intervals

Typically lines are re-marked at yearly or two-yearly intervals rather than when their performance has deteriorated. In some cases poor quality line marking remains untouched for months if not years and in other cases lines are re-marked prematurely. Currently there are very few systems used to measure the condition of day or night visibility of painted road marking, nor in some States, is there a wet night visibility requirement.

Quality management principles and specific research indicates that a performance based program will produce better value for money than current procedures.

3. Good line-marking is a relatively low cost traffic management measure with potentially high benefits

Overseas and local research has shown that quality line marking is one of the most efficient accident prevention measures.

4. Best practice standards must be implemented

There are no uniform standards for line marking across Australia and too many standards are set at a very low level. Uniform standards, set at a high performance level, should be implemented as a matter of priority.

Conclusions

- Accelerated wear testing in 'extreme conditions' has to date provided some very useful data. Nearly two and a half million lane vehicles, including 500,000 heavy vehicles, have 'screwed' around the curves where some of these markings have been applied. With some of the pavement marking treatments it is becoming obvious that high levels of skid resistance may be achieved and maintained without compromise to high levels of both dry-night and wet-night visibility. In fact, it appears that the addition of angular surface applied particles, to some quality binder and glass bead marking systems, may provide further improvements to the durability of these road-marking systems.
- Wet night visibility is achievable and sustainable.
- The method of application is an important consideration in the performance of the pavement markings, particularly for the combinations of waterborne paint and wet-night-visible sized (1mm) glass beads.
- Adhesive coated glass bead treatments should be mandatory for application to some types of road-marking binder systems..

Roadmarkings for wet-night visibility

Large beads (1mm) are used to add wet-weather retroreflectivity to conventional markings. The large beads allow the water to drain off more quickly than smaller beads thus more quickly recovering their dry weather retroreflectivity. This gives a level of wet weather retroreflectivity. It has been established that the beads need to be at least 1mm in size and preferably larger.

When rain starts to fall, the exposed surface of the beads and the paint start to get wet. The initial wetness will distribute itself uniformly over the surface until the force of gravity within the water film overcomes the surface tension which holds it in place. Then the water will flow down off the bead surfaces into the valleys between them. The process of wetting starts with a rapid build up of water film until it reached around 55 microns, after which the film increases only slightly in thickness on the beads because the rate of flow off the beads surfaces increases rapidly as the rainfall rate increases.

In 'worst case' testing it has been established that a dry marking with 1mm glass beads and a retroreflective measurement of about 250mcd/lux/m^2, when exposed to artificial rainfall rates of up to 125mm/hour (5 inches/hour), will provide a measurement of about 100mcd/lux/m^2 throughout the steady state rainfall conditions. When the rainfall stops the excess water will drain away , leaving the equilibrium film which adheres by surface tension. This film disappears reasonably quickly, and the measure of retroreflectivity will be seen to quickly climb towards the 'dry' measurement. Similarly, with observations before, during and after artificial rain, the roadmarkings with the smaller standard beads showed that the readings drop rapidly to near zero in rain and do not recover for a considerable period after the rain stops.

Intervention Levels

Road markings are deemed to have reached the end of their serviceable life when they reach 'intervention level'. For retroreflectivity, this is generally set at 100mcd/lux/m² (MX30 retroreflectometer). Some State Road Authorities also have a minimum requirement for wet night visibility. For skid resistance, this is generally set at 45BPN for transverse markings. (There is no current requirement for skid resistance of longitudinal markings in Australia. However, the word is that the requirement is likely to be set at 40BPN.)

Above: The lines that appear quite visible on a dry day, may provide a different picture on a wet night.

Results

This project has been partnered with interested groups including, the NSW RTA, ACT Dept Urban Services, Totalcare Industries, Rohm and Haas, Bristol Paint, Crystalite Design and TCP.

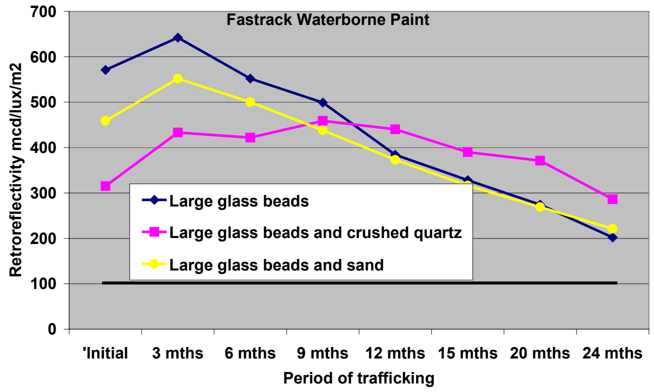
There are many combinations of materials that have been applied to a variety of road surface types and alignments. Some of these applications have been exposed to traffic for more than two years. In this report, the focus has been on reporting the performance of markings that have been applied to a dense grade asphalt road surface, as this is probably the most potentially troublesome surface with regard to skid resistance. Reporting covers data related to the performance of only those markings, that were applied on a curved road alignment, to test the performance of these markings in 'extreme' trafficking conditions. These markings have been applied as left-side 150mm wide continuous edge-line markings on a left curved road alignment. The AADT is 6,300 and the heavy vehicle count is 20%. Therefore the daily lane vehicle count is 3,150, with 630 of them being trucks. Some of the markings, having been applied some twenty four months ago, have had 2.3 million lane vehicles 'screwing' around this curved alignment, including half a million trucks.

Left: Majura road is the heavy vehicle bypass for Canberra. All heavy vehicles that feed in on three main highways, must use this bypass road.

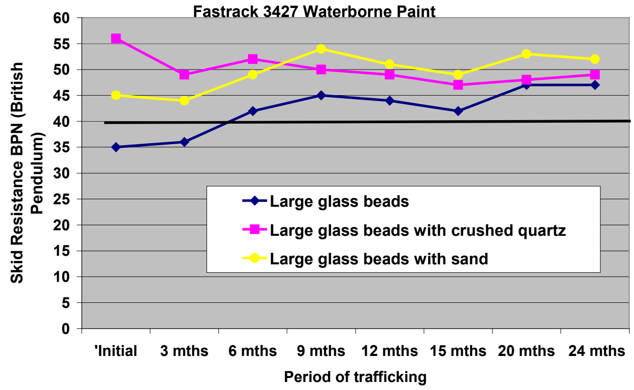
Road markings are exposed to accelerated wear by applying them as left-side edge-line markings on a left-curved road alignment.

The markings to date have had more than 2.3 million lane vehicles 'screwing' around the curve. Half a million of these have been heavy vehicles.

Waterborne paint based on FASTRACK 3427 acrylic emulsion was tested with and without angular surface applied particles. **Figure 1** shows the performance in retroreflectivity over a twenty four month period. The combination applied with crushed quartz of 1.6mm to 1.0mm @ 200g/m² has performed with the most consistency, and is currently the best performer of the three, with a retro measure of near 300mcd. **Figure 2** plots the performance of the same combination in Skid Resistance. All three combinations have performed well, apart from the line without angular material, which has not performed *as* well during the *initial* months of trafficking.



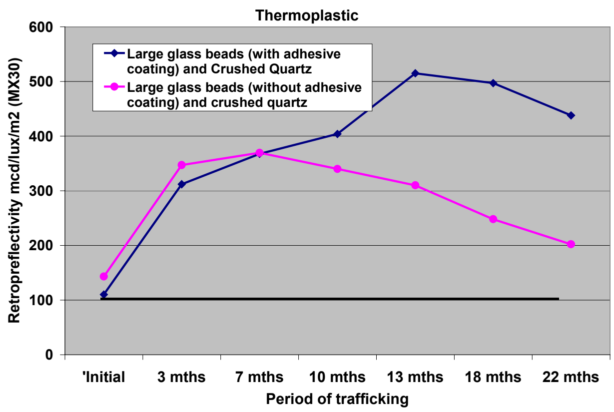
Above: Figure 1.



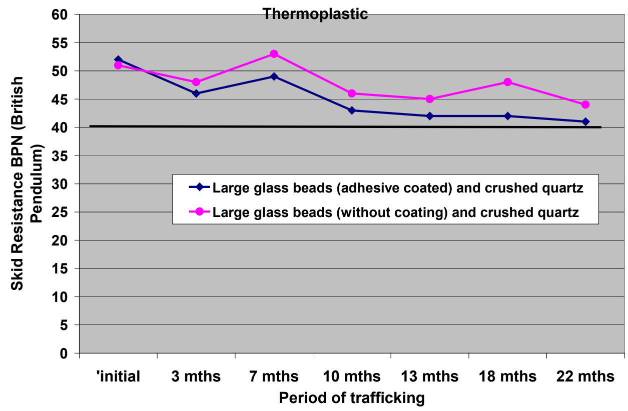
Above: Figure 2.

Thermoplastic

Of the two Thermoplastic markings that we have chosen to focus on in this report, both have angular crushed quartz of 2 to 1mm surface applied, at a ratio of 1:1 with Large glass beads. One of the markings has beads with an adhesive coating applied to them, the other is of uncoated beads. In **Figure 3** both markings performed similarly in retroreflectivity, up to the seven month mark. For the duration since, the uncoated beaded marking as been declining, and currently measures less than half that of the coated bead marking, in retroreflectivity, while the 'coated' beaded section has performed above expectation. (Conventional markings would be pushed to provide much above the 300 line, let alone compete with the shadowing of the angular surface applied particles). Skid resistance of the same combinations, shown in **Figure 4**, shows the uncoated bead marking, performing consistently better over the period. This is probably because of the increased texture provided by the 'pock marks' where the uncoated beads have been dislodged from the Thermoplastic. However the 'coated' bead section has also maintained good skid resistance.



Above: Figure 3.

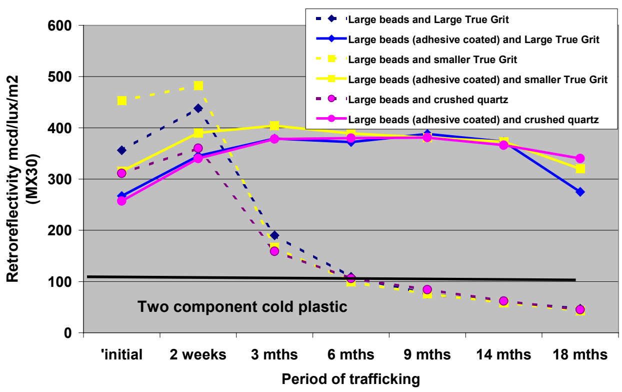


Above: Figure 4.

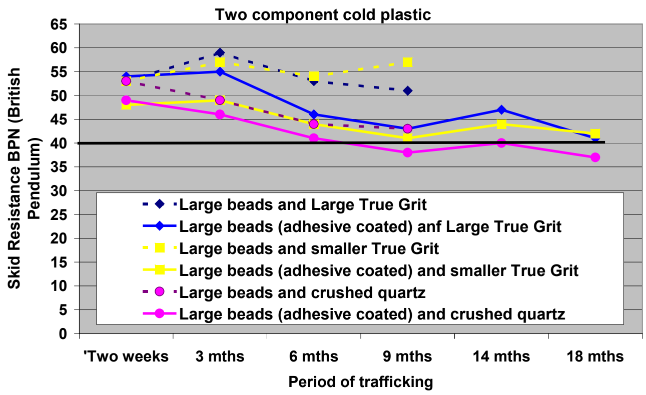
Degaroute® – Two component cold plastic.

Two-part cold applied plastic has been tested with three types / sizes of angular surface applied particles. A large 2mm to 1mm sized 'True Grit' was tested against a 1 to 0.5mm sized 'True Grit' and a 1.6 to 1.0mm Crushed Quartz. All angular particles were applied at a rate of 200g/m². The trial included beads that were treated with an adhesive coating.

In **Figure 5**, after only two weeks of accelerate wear trafficking, the three combinations using <u>uncoated beads</u> have started to decline in retroreflectivity, while the combinations using adhesive coated beads, parallel at just under the 400 mark, for about a year before we start to see any decline. (Conventional markings would be pushed to provide much above the 300 line, let alone compete with the shadowing of the angular surface applied particles). **Figure 6** shows the performance of the combinations of markings in skid resistance. The three combinations using uncoated beads were considered redundant after the nine month measure, as the skid resistance was improving only because of the texture provided by the 'craters' remaining, due to the heavy bead loss. Of the three remaining coated bead markings, the crushed quartz marking has not performed as well as the large and smaller 'True Grit' combinations. Both of these combinations have settled into a consistent range during the past twelve months.



Above: Figure 5.



Above: Figure 6.

NOTES

1. Each of these product trial combinations were applied at different times and during different conditions, with maybe slight differences in road texture and road geometry to one another, and should be treated as stand alone trials. It would not be appropriate to compare products.
2. Keep in mind that the marking combinations that have been chosen to report, are sections where accelerated wear testing conditions have exposed the markings to conditions of trafficking, that put these markings under a high degree of stress. The same combinations of markings, have also been applied to straight aligned sections of the same road, and the results on this alignment are quite different. Markings that have been transversely applied to traffic flow, provide a different picture again. The limited space provided does not allow me to report these results. However, the author of this paper can make these results available on request. Thanks again to all of those partnering in this project. Particularly the RTA's Scientific Staff, who form part of the team that partner and carry out the periodical measuring and reporting.

Method of Application

Most of the surface applications of spherical particles were with the use of Potters Speedbeader™ equipment. Speedbeader delivers the glass beads to the painted line in such a way as to create a static-bead-drop-environment, thereby minimising 'bounce' and 'roll' of the glass beads. Retroreflectivity is equalised for bi-directional traffic movement and bead loss is minimised with this method of application **(Figure 7**).

During the development of the Speedbeader static bead application method and the development of the dual paint gun application method for improved placement of paint to chipseals, photos and retros were recorded by the RTA Road Authority. In the first test painted marking applied in a conventional manner to a chip seal pavement at an application speed of 15km/hr, with a retroreflectivity of 170mcd/lux/m. Compare this to the following application using the new improved method and on a similar road surface. Applied at 20km/hr the retroreflectivity measures 340mcd/lux/m². When we compared the two application methods of conventional with the new application to an asphalt surface, we see that at 15km/hr the retroeflectivity is 200mcd/lux/m² (**Figure 8**), while the improved method at 20km/hr provides retroreflectivity of 470mcd/lux/m² (**Figure 9**).

In all of Potters trials, using waterborne paint, since trial No AU006 (1999) we have used the dual paint gun method. This method requires two paint guns to be angled in toward one another so as to cause the two paint streams to intersect at the pavement and create an angle between the streams of around 60°.
Conventional paint applications, using airless paint application equipment, generally has the paint forces through very small spray tip apertures at very high pressures of between 1,000 to 3,000 psi. At these pressures the paint is fired from the paint gun at a velocity of 300km/hr or greater. The terminal velocity of the paint with the pavement has many effects on the placement of the paint. Some paint may be injected into the pavement, while there is also much fine misted splashing and some flash vaporisation.
The newly developed dual gun method had provided much improved results on irregular substrates such as chip-seals, by providing a more even film of paint over the aggregate, thereby providing improved bead embedment, durability and retroreflectivity. (See Potters CD ROM, containing three short explanatory videos).
This method has not proven to be any more beneficial on the smoother asphalt surfaces, apart from possible limiting of the 'injection' of the paint, however, it does not appear to have any adverse effects either. And as road surfaces change regularly in texture it has been found better to retain this paint gun geometry for applications to all types of road surfaces.

Left: Speedbeader application system. Demonstrating the dual paint gun technique and the static placement of glass beads from the Speedbeader.

NOTE: The cross-wind protection shroud has been removed for the purpose of this photo.

Figure 7.

Other Field Trials

Potters have many other field trials current in a variety of locations across Australia, generating performance data in a variety of environmental conditions and on a variety of road surfaces. These trial have been arranged in partnership with various State Road Authorities, including the Queensland Main Roads, The New South Wales Roads and Traffic Authority, The Australian Capital Territory's Department of Urban Services, Victoria's Vicroads and Main Roads Western Australia.

Figure 8

Above: Conventional application showing poorly placed glass beads. Retroreflectivity measures 200mcd/lux/m²

Figure 9

Above: Speedbeader application showing excellent placement of glass beads. Retropreflectivity measures 470mcd/lux/m².

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