# Does Friction and Colour Equal safety?

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## Abstract: Does Friction and Colour Equal Safety?

This paper introduces a discussion for:

1. Identifying what makes a High Friction Surface Treatment;
2. Comparisons are made between natural quarried aggregates and Calcined Bauxite in terms of surface friction and Polished Stone Values;
3. The type and durability of Coloured Surface Treatments, and;
4. Safety outcomes from the use of both materials in terms of Friction and Colour.

Examples are described where:

1. The material has performed well above its Specified requirements;
2. The uses of inappropriate materials that have reduced the life of the treatment are discussed, in terms of failure mode describing the material properties and the reasons that led to the failure.
3. The benefits gained from using High Friction and Coloured Surface Treatments.

The report concludes that when a properly designed and applied High Friction or Coloured Surface Treatment is used on a suitable road surface where there is a high incidence of congestion and crashes that an immediate reduction in crashes should be expected with a corresponding reduction in travel time.

Rationale -
This paper presents:

1. Practical application of proven road safety surfacing materials that have a record for reducing crashes and improving traffic flow.
2. Conclusions on the potential life of the treatment, and benefits from use are presented and discussed based on Austroads Research and evaluation.
3. This paper will be of interest to the conference delegates as it identifies the practical surface requirements for the application of a High Friction and Coloured Surface Treatments.

# DOES FRICTION AND COLOUR EQUAL SAFETY?

## 1. INTRODUCTION

The application of a High Friction Surface Treatment is aimed at the reduction of skidding related accidents and in turn reduced road trauma in other words it saves lives, the use of Coloured Road Surface Treatments compliments the High Friction Surface Treatment by providing another element to surface condition identification by vehicle drivers. Research has indicated that a reduction of between 30% and 50% in skidding related accidents can be achieved with the application of a properly designed, specified and applied High Friction Surface Treatment or Coloured Road Surface Treatment at critical locations.

## 2. BACKGROUND

The term 'skid resistance' is often used to describe certain road surfaces. The use of skid resistance as a general term is fairly ambiguous as skid resistance is a combination of road surface friction (microtexture), road surface texture (macrotexture) and vehicle tyre hysteresis (ability of the tyre to envelope the exposed aggregate) all of which are needed to reduce the stopping distance of a vehicle under braking.

Friction is required to grip the tyre, texture is required to remove water to ensure tyre contact with the aggregate assisted by the tyre tread pattern and hysteresis is required to ensure that the tyre can deform around the aggregate and increase or decrease the amount of grip depending on the hardness of the rubber compound and the harshness of the exposed aggregate particles. A road surface material should therefore impart the friction and texture required to achieve maximum contact with the vehicle tyres.

Coloured Road Surface Treatments have been used extensively over recent times to provide a clear definition between areas of the road system that are allocated for the specific use of either Bus, Tram, Cycle or Pedestrians with benefits that include:

- Improved delineation and definition of road space;
- Increased compliance with the road rules;
- Reduction in Bus, Tram and vehicle travelling times;
- Increased awareness of other road users;
- Reduction in traffic collisions.

## 3. HIGH FRICTION AND COLOURED SURFACE TREATMENTS

To ensure the integrity of the High Friction and Coloured Surface Treatment they should be viewed as a three layer system that includes the aggregate, the binder layer and the asphalt substrate beneath. Each has certain performance properties that will ensure that the applied system achieves a long and durable life.

### 3.1 SUITABLE SUBSTRATE MATERIAL

The High Friction Surface Treatment is normally applied at specific locations where high fatigue asphalts, such as Stone Mastic Asphalt (SMA) or specially designed Dense Graded Asphalt (DGA) have been placed. These locations include:

- The approaches to and exits from:
  - Traffic light controlled intersections;
  - Pedestrian / School crossings;
  - Rail level crossings;
  - Roundabouts; and
- The area within:
  - Roundabouts; and
  - Tight curves (radius <250 m).

Higher horizontal forces are applied to the asphalt substrate because of the increased frictional grip when using the High Friction Surface Treatment and therefore the asphalt has to be capable of withstanding these increased shear forces. Research has indicated that some materials have minimal inherent strength to withstand these increased applied horizontal forces. Of the various asphalt types available it is desirable to use either a Stone Mastic Asphalt or Dense Graded Asphalt as these are designed to have low air voids to reduce the potential for moisture infiltration into the asphalt whilst retaining superior structural and shear restraining characteristics.

As with all asphalts there is a binder coating on the aggregate particles at the surface, this binder has to be removed by traffic prior to the application of the High Friction Surface Treatment, the subsequent increase in surface voids by the removal of this binder coating and the exposed microtexture of the aggregate enables the applied High Friction Surface Treatment binder to mechanically grip the asphalt substrate.

The main failure mode identified with a properly designed, specified and applied High Friction Surface Treatment is one of cohesive failure where the strength of the substrate is insufficient to withstand the traffic applied forces. This form of failure can be identified by the substrate remaining adhered to the underside of the High Friction Surface Treatment.

If other types of asphalt or sprayed / chip seals are used as the substrate there is an increased risk of substrate cohesive failure due to the reduced strength of the material, in particular early in the life of the surfacing material when the binder is still relatively soft during summer. On the other hand when concrete has been used as the road surface the concrete has to be specifically treated to provide a textured surface onto which the High Friction and for that matter the Coloured Surface binder can adhere.

### 3.2 HIGH FRICTION SURFACE TREATMENT

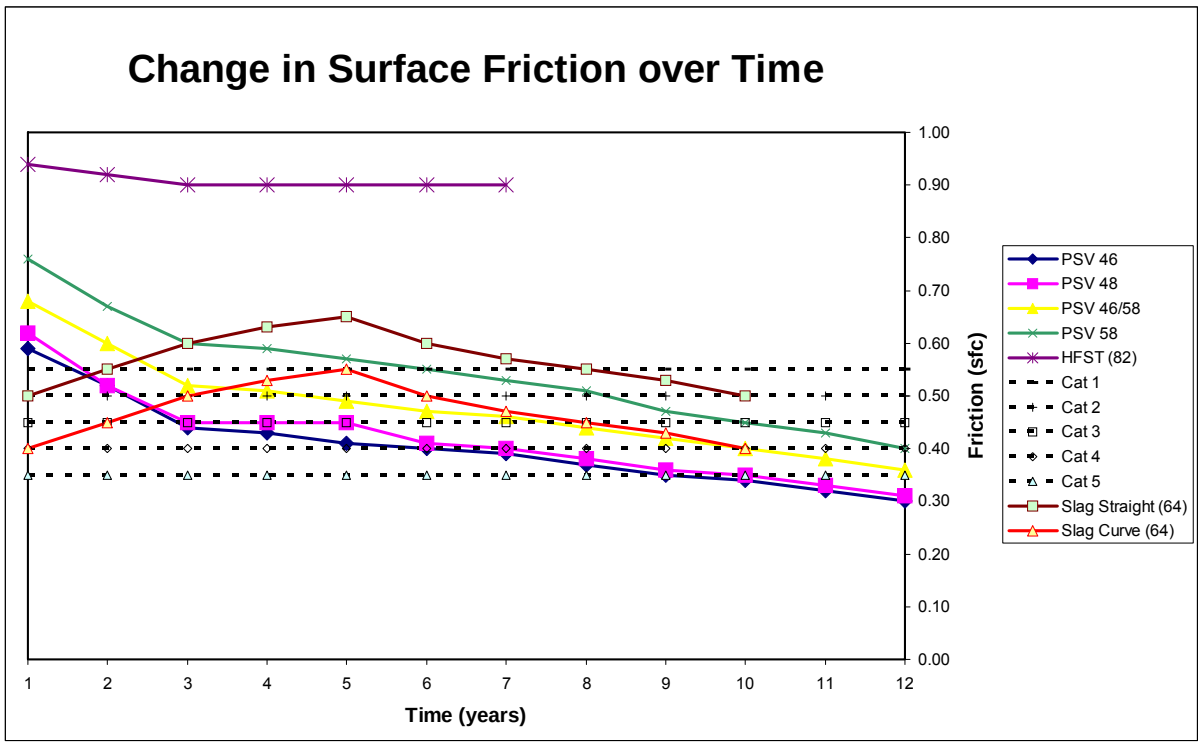
High Friction Surface Treatments should deliver high levels of surface friction on opening to traffic and retain the high level of friction for a period of 5 to 10 years.

There are a number of systems that purport to be High Friction Surface Treatment on the market, however the ability to have a frictional life of 10 years is rarely achieved with mixed material or where a further layer of binder or bond coat has been applied over the aggregate surface. In this instance the binder would need to be worn off the surface of the aggregate to improve the level of friction. Experience has indicated that this can take up to six months with the very hard binders polishing to a low level of friction prior to the aggregate exposure.

There are also binders that are used in several systems that do not penetrate into the substrate surface voids and therefore ultimately strip from the surface, in particular there are binders which if applied when the surface and the surface voids are dry will work effectively, however if there is the slightest hint of moisture then the binder hardens immediately whether it has penetrated or adhered properly or whether the aggregate has been gripped sufficiently.

There are some who believe that a natural quarried aggregate with a high PSV will provide a long lasting friction resistant surface material. This unfortunately is not the case; naturally occurring aggregate has a minimal level of friction life, whereas the Calcined Bauxite which has a much higher PSV retains its high level of surface friction under very high stress conditions.

This is based on the measurement of friction over time. Figure 1 provides an indication of the likely friction levels that can be achieved when using Natural Quarried Aggregates, Slag Aggregates and Calcined Bauxite.




Information obtained from several VicRoads Reports

Figure 1: Change in Surface Friction over time.

It is the micro crystalline properties of the aggregate that imparts the surface friction to the vehicle tyres, this is identified by the laboratory test for Polished Stone Value (PSV) which ranks and enables an aggregate with a high PSV to be identified. The higher the PSV the longer the aggregate will take to polish. Although not sophisticated the test is simple, quick and consistent. Its output enables Engineers to rank the frictional performance of materials quickly, for most road conditions and designs.

Natural quarried aggregates have been found to polish to unacceptable low friction levels in a short period of time, making them unsuitable for use as a long term high friction aggregate. Natural aggregates that have been artificially hardened such as Calcined Bauxite provide an aggregate that produces and maintains a very high surface friction level.

The aggregate that is to be used as a High Friction Surface Treatment should have a minimum PSV of not less than 70. The PSV test simulates the polishing effect of the aggregate but insufficient time is allocated to measure the natural weathering cycle that would occur on the road. It is suggested that the PSV test data should be compared to the actual results as measured on the road, in particular when using slag aggregate.

The issue with a High Friction Surface Treatment is that there is currently no standard specification in Australia or New Zealand that clearly defines the performance and durability requirements. This omission of a standard specification results in the client being offered sub standard or sub performance high friction systems that will eventually result in the destruction of the market. It is essential to ensure a level playing field for the state road authorities in terms of guaranteed safety performance outputs.

### 3.3 COLOURED ROAD SURFACE TREATMENTS

A Coloured Surface Treatment has to achieve suitable levels of surface friction but its primary function is to retain a suitable level of colour for a minimum period of 5 years.

The application of colour aids in the identification and improvement to traffic flow, studies undertaken in the UK, Figure 2 indicates that in London there was a reduction in travel time during peak period for bus and taxi as well as all other traffic after the application of a red bus only lane.

There are also many other applications of colour that appear on our road system, unfortunately along with the good ideas of colour and high friction there is not a corresponding improvement in communicating their intent to the travelling public. Cases in point are the grid lines that have appeared at some intersections, which mean no stopping in this area. It is clear that this is either unknown to the majority of the drivers or is being ignored. Inherently the appropriate use of coloured surfacings can generate safety improvements and create zones within the road that demonstrate a clear shift in encouraging alternative forms of transport such as cycling, bus, etc.

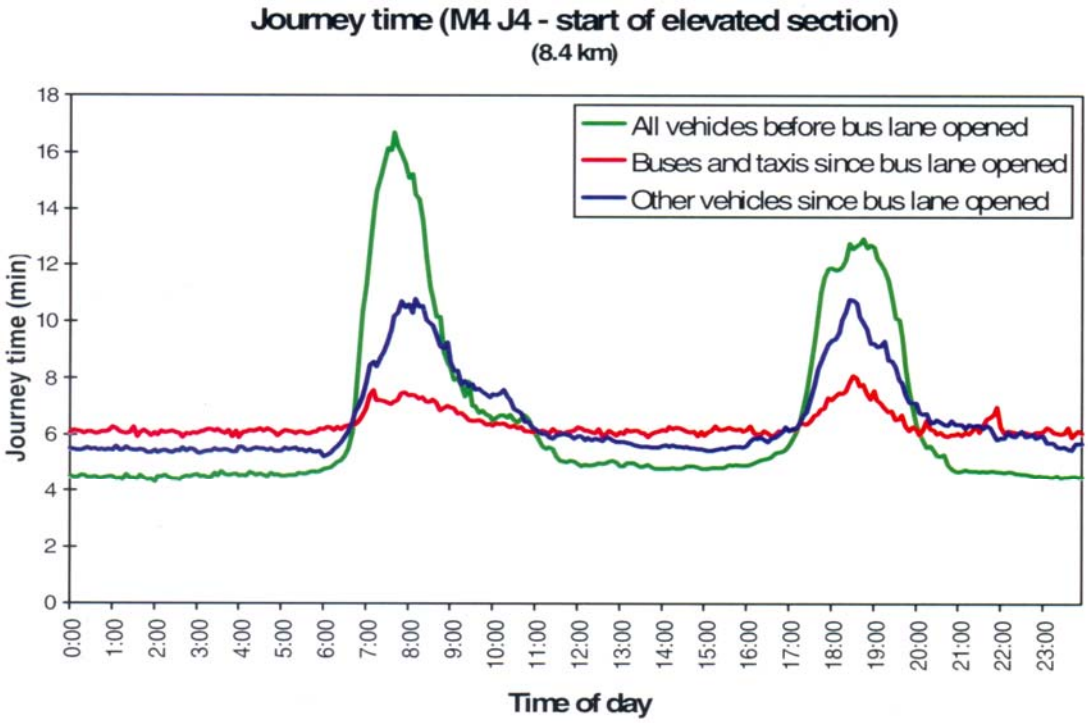



Figure 2: Change in Travel Time.

Coloured Road Surface Treatments are generally applied either at specific locations such as immediately prior to major intersections or over long lengths of the road surface where the traffic travels at a relatively constant speed. In the case of cycle and pedestrian facilities there is only occasional vehicular traffic, in this instance the substrate asphalt does not need to have the same performance parameters as for an on road application of a high friction surface treatment.

Understanding the level of continuous performance of colour on the road surface is another issue, currently there are systems that use natural aggregates which are colour coated to match the coloured binder used, i.e. a natural white aggregate is colour coated red and applied onto a red coloured binder. The problem with this system is that when the colour coating wears off the surface of the aggregate the white aggregate will predominate and the impact of the colour chosen for the road surface will be compromised.

Unfortunately similar to high friction surface treatments there are materials that purport to be long lasting coloured surface treatments. Figure 3 indicates such a material where the concrete was not properly prepared prior to the application of the thixotropic cold applied plastic material which was unable to penetrate into the surface voids and has delaminated.

Figure 3: Cold Applied Plastic Coloured System applied to a concrete substrate

This occurs with all aggregates including calcined bauxite, except for the synthetic aggregate "Synthite®", this material is a 100% Australian developed recycled translucent aggregate that when the colour coating wears off the trafficked aspect of the aggregate the colour is reflected through the translucent material in conjunction with the binder colour beneath. This aggregate has undergone independent laboratory testing to identify the potential colour life, and friction measurements. The results indicated that the colour stability and structural competence is greater than 5 years for colour retention and macrotexture.

The aggregate for use on a road system for the delineation of bus / tram or cyclists does not always require such a high PSV as a high friction surface treatment although it may at times be traversed by other vehicles heavy braking is not the normal requirement. However as the traffic is travelling at a constant rate and to ensure that issues such as differential friction levels between wheelpaths and between lanes does not become an issue an aggregate with a polished stone value close to natural aggregates is required.

The colourless synthetic aggregate when colour coated and applied onto a coloured binder produces and maintains a high level of colour retention under even the harshest of Australian weather conditions (Figure 4). This material has a PSV of 62 which is similar to the top end PSV of quarried natural aggregates.

To retain long term functional durability in terms of colour definition output, the aggregate and binder system has to have colour stability throughout the surfacing layer, rather than just on the surface which has a minimal colour performance life. This is enhanced by having a range of aggregate chip sizing available to apply to differing usage applications.

Figure 4: 1- 3 mm Synthite® – Green, Orange and Red – Photographed in full sun

Colour is measured by using colour co-ordinates, Figure 5 to express the overall colour change in terms of “the greater the value the bigger the colour change”. The non-subjective numerical values were evaluated using CIELAB 1976 method where both intensity and colour change can be measured.

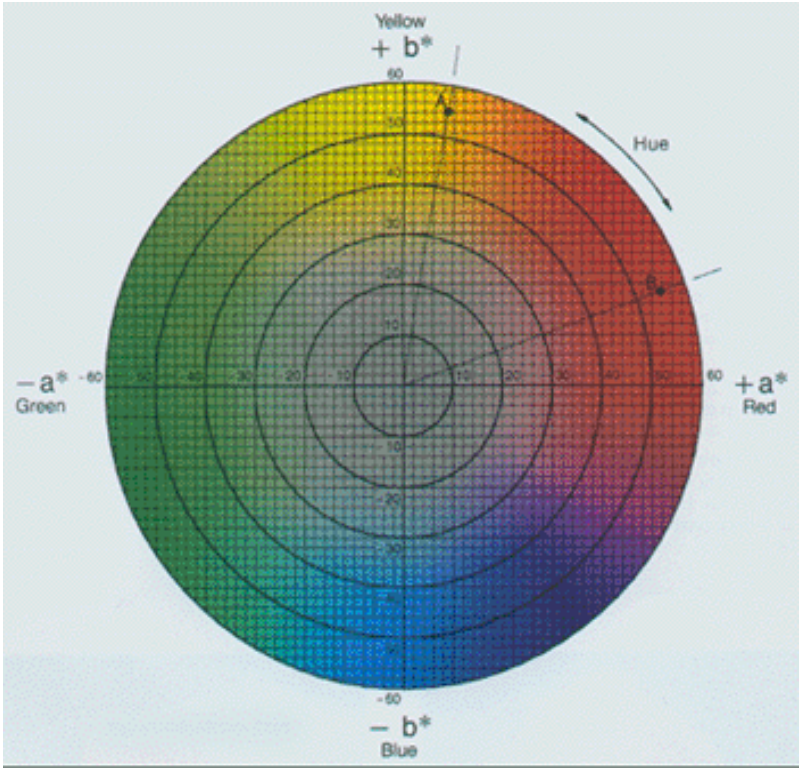



Figure 5: CIELAB 1976 Colour Change Chart

Colour is assessed before and after laboratory wear testing including a visual assessment of the effects of wear, which provide an indication of the colour change over time such as:

- Changes in the Luminance value indicate a change in the brightness of the surface.
- Comparative ΔE values which are based on a colour difference scale and can provide an indication of overall colour change of a surface.
- Change in Hue (colour of the surface) which is indicated by the ‘a’ and ‘b’ scales reduction in ‘a’ represents a move to less red more green appearance, where as a reduction in ‘b’ represents a move to less yellow and more blue in colour.

During comparative trials on Synthite materials it was noted that coloured coatings on the calcined bauxite had worn off exposing the buff coloured aggregate underneath rendering the “colour” impact almost useless. The Synthite product, although showing slight surface wear did not give the differential colour appearance of an exposed aggregate surface.

Like the high friction surface treatment the Coloured Surface Treatment also suffers from there being no standard specification for on road applications on which to compare the colour retention or provide direction in terms of colour, texture and friction requirements over time.

## 4. SAFETY FROM THE USE OF HIGH FRICTION AND COLOURED SURFACE TREATMENTS

Currently in Australia and New Zealand there are no recognised specifications for a High Friction or Coloured Surface Treatment, most are based on company information, individual prejudice and limited knowledge. A number of State Road Authorities have developed their own versions of a High Friction Surface Treatment specification and some have included reference to Coloured Surface Treatments. Whereas some have followed the UK Highways Authority and specified the technical requirements from the Highways Authority Product Approval Scheme (HAPAS) and the British Board of Agreement (BBA) test protocol, others have followed their own procedure.

Several of the State specifications have correctly identified binder properties to ensure that the binder has sufficient strength to ensure maximum adhesion of the also specified Calcined Bauxite however they have left out the properties of the substrate.

In many instances specifiers have over looked simulative laboratory scuffing and wear tests which can provide advance wear and erosion test information in regards to the suitability of a product. The scuffing test simulates the action of traffic on the bonding strength between the binder and the aggregate which relates directly to wear and to the reduction in surface texture and possible reduction in surface friction and colour retention.

There have been many case studies conducted which indicate the ability of a High Friction Surface Treatment to reduce the severity and number of crashes and Coloured Surface Treatments to improve travel time and reduce speed.

## 5. CONCLUSIONS

Does Friction and Colour equal safety?

The basic difference between High Friction Surface Treatment and a Coloured Surface Treatment is the location of the individual treatment; a High Friction Surface Treatment would only be used where an accident investigation has identified a need for the maintenance of a higher level of surface friction, whereas a Coloured Surface Treatment may be used at specific locations for delineation or over long lengths of the road network, especially if the particular lane is for the exclusive use of that type of road user.

Where properly designed and applied high friction surface treatments have been applied the outcome from a safety point of view has improved. Evidence indicates that nose to tail crashes have been reduced by more than 40% at approaches to traffic light controlled

intersections. In other areas where coloured surface treatments have been applied to differentiate between pedestrian, cyclist, bus and tram the reduction in traffic / pedestrian accidents have been measured at greater than 60%.

From this it is clear that the application of a properly designed and applied High Friction Surface Treatment or a Coloured Road Surface Treatment does improve safety.

However, there are various forms of surface treatments that purport to be capable of producing a long term increase in surface friction or the retention of colour. Clearly the data provided in this report indicates that there is a great deal of miss understanding in the road surfacing fraternity and the line marking industry and that prejudice and the making of unsubstantiated claims is hurting the most vulnerable, the road user.

This lack of knowledge or prejudice ultimately leads to inappropriate material being applied to specific locations with the belief that what they are doing is economically justifiable. Case studies have indicated where naturally quarried aggregates have been used with limited effect after a very short period of time, the use of a properly designed and applied High Friction Surface Treatment using Calcined Bauxite or Coloured Surface Treatment using Synthite has provided the travelling public with increased awareness and reduced incidence of traffic crashes.

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