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Using High Friction Surface Treatments to Reduce Traffic Accidents

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By

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Title

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Abstract

This paper introduces a process for:

- Calculating the change in braking distance from the use of properly designed, specified and applied High Friction Surface Treatments.
- Comparisons are made between naturally occurring aggregates and the Calcined Bauxite used in the High Friction Surface Treatments in terms of surface friction and Polished Stone Values,

Examples are described where:

- The material has performed well above its Internationally stated capabilities.

The report concludes that when a properly designed, specified and applied High Friction Surface Treatment is used on a suitable road surface with a high incidence of traffic accidents that an immediate reduction in traffic accidents should be expected.

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References

1. An Analysis of the Use of Anti-Skid Surfacing as an Accident Remedial Measure on Trunk Roads in Greater London – London Accident Analysis Unit, 1988
2. Friction Survey of SH2 Under the Petone Overbridge – P.F. Stewart, Opus NZ, 1999 & 2001
3. MUARC Accident Threshold Presentation
4. Austroads Guide to Engineering Practice Series, Part 4, Treatment of Crash Locations.

Using High Friction Surface Treatments to Reduce Traffic Accidents

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 is designed to reduce road injury and ultimately save lives. 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 (HFST) at critical locations.

2. Background

Improvements in binder technology have increased the reliability and effectiveness of High Friction Surface Treatments by:

- Ensuring the retention of a high surface texture (macrotexture), and;
- Enabling a more fluid binder to be used which penetrates into the surface voids of asphalt improving the bond strength between the HFST and the asphalt wearing course.

The term ‘skid resistance’ is often used to describe a road surface. 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 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. High Friction Surface Treatment should therefore impart the friction and texture required to achieve maximum contact with the vehicle tyres.

3. What is a High Friction Surface Treatment

A High Friction Surface Treatment is one that delivers a high friction on opening to traffic and maintains that high level of friction for a minimum of 10 years. To enable the maintenance of a high level of friction the aggregate must have a very high Polished Stone Value (PSV) or Polished Aggregate Friction Value (PAFV) and a low Aggregate Abrasion Value (AAV) or Los Angeles Abrasion Value (LA) to ensure reduced wear and polish.

Research has shown that it is the exposed surface aggregate rather than the type of material used that imparts frictional resistance. This means that an open graded asphalt or a sprayed seal will produce the same level of surface friction if the same aggregate from the same source has been used, the mix type is actually there to impart other properties such as spray and noise reduction, fatigue strength, etc.

The properties of the aggregate are the mechanism that imparts the surface friction, the level of friction is identified by the laboratory test for PSV this test ranks and enables an aggregate with a high PSV to be identified. The higher the PSV the longer the aggregate will take to polish. Some aggregates have been found to withstand the effects of polishing, such as Calcined Bauxite which has been artificially hardened in a furnace at a temperature in excess of 1600^{O} C. This hardening effect causes the crystals to become reorientated and extremely hard enabling them to withstand the effects of wearing and polishing by the traffic.

A High Friction Surface Treatment is therefore a material that uses a binder that is very strong and tenacious, broadcast with an aggregate such as a PSV certified Calcined Bauxite, in a location where immediate high levels of friction are required.

4. High Friction or High Polish Resistance

There are some people who believe that an aggregate with a high PSV will provide a long lasting friction resistant surface material. This unfortunately is not the case naturally occurring aggregates have been used to improve the level of surface friction on the road but the friction life has been minimal. Figure 1 indicates the test results from a number of trials where various aggregates have been used to improve the longevity of the surface friction. The graph also indicates the wide difference between a road surface with a High Friction Surface Treatment and one with an aggregate with a High PSV.

The information in Table 1 indicates the likely friction life from an aggregate with a known PSV. This is not saying that in other areas where there are less applied stresses to the road surface by the vehicle tyres that other aggregates with a lower PSV cannot or should not be used.

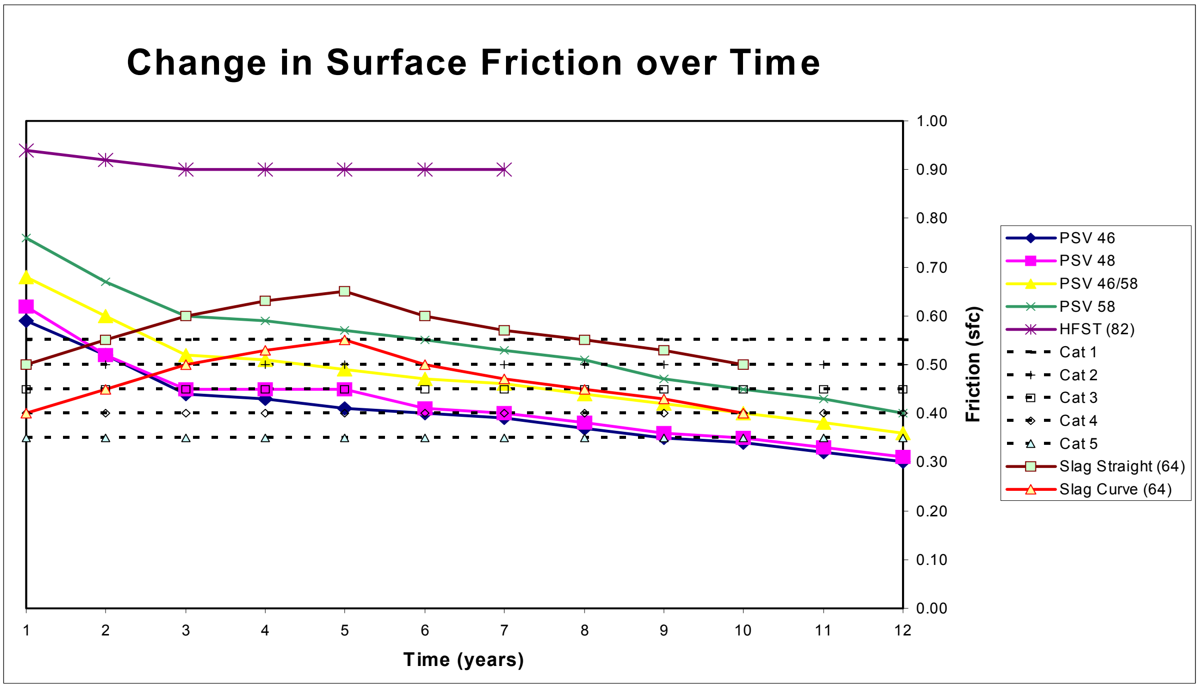
5. HFST Material Properties

The material when applied to the road surface as a High Friction Surface Treatment shall provide an immediate improvement to the macrotexture and the surface friction to ensure that reductions to accident type and severity are immediate.

The main requirements of a High Friction Surface Treatment, other than the high level of friction designed to reduce the incidence of skidding accidents is one of an initial improvement and maintenance of an appropriate surface texture (macrotexture) to ensure maximum contact between the tyre and the road surface on a wet road.

Maintenance of macrotexture is harder to achieve with softer naturally occurring aggregate as the action of the traffic wears the components of the aggregate away, the properties of a high PSV Calcined Bauxite are more consistent and therefore produce an aggregate with not only a high PSV but also one with a very low AAV or LA which ensures that the loss of surface texture is minimal.

Figure 1: Change in Surface Friction over time.



Information obtained from several VicRoads Reports

Table 1: Indicative friction life of aggregate with a known PSV / PAFV

Aggregate PSV / PAFV	Traffic Volumes Veh/lane/day	Indicative Friction Life			
		Curves radius < 100m	Controlled Intersections, Pedestrian Crossings, Roundabouts	Tight Curves <250 m radius	Other Intersections
48	5000	NS	NS	NS	3 to 6
	10000	NS	NS	NS	1 to 3
52	5000	NS	NS	3 to 6	6 to 8
	10000	NS	NS	1 to 3	3 to 6
56	5000	NS	3 to 6	6 to 8	8 to 10
	10000	NS	1 to 3	3 to 6	6 to 8
60	5000	3 to 6	6 to 8	8 to 10	10 to 13
	10000	1 to 3	3 to 6	6 to 8	8 to 11
80	5000	>15	>20	>20	>20
	10000	>15	>20	>20	>20

NS – Aggregate not expected to have a suitable friction life

5.1 Binder Properties

The binder used in a High Friction Surface Treatment needs to be strong enough to resist removal of an aggregate with a high PSV, whilst being fluid enough to penetrate into the surface voids of the substrate and the surface of the exposed aggregate for a veneer and broadcast aggregate treatment type.

Several binders have been tested under actual road conditions as a veneer and broadcast application of these the most successful has been the thermosetting 2 component amine based Epoxy resin. This binder is tenacious, hard but flexible and is capable of penetrating into the surface voids of a road surface material.

This binder has been found to be suitable for the retention of the high PSV aggregate on an asphalt and concrete substrate, and once it has cured is impervious to the effects of fuel spillage, however during the curing period certain fuels may cause a softening effect on the binder which would lead to the loss of aggregate for the veneer and broadcast system.

The single layer of binder should be fluid enough to penetrate into the matrix of the substrate enabling a high bonding strength, added to this the broadcast aggregate has time to become embedded in the binder before the binder has cured.

5.2 Aggregate Properties

The aggregate to be used as a High Friction Surface Treatment shall have a PSV result 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 potential life of a surfacing aggregate as detailed in table 1 suggests that natural quarried aggregates and to some extent the various types of slag aggregate have a limited friction life. To ensure that a consistent level of friction is maintained the aggregate is usually defined as being a Calcined Bauxite. This material was chosen as it is consistently hard and durable with a PSV greater than 70 and an AAV / LA less than 5.

6. Specification requirements

Currently in Australia and New Zealand there are no recognised specifications for a High Friction 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. 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, where as 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 mixed and applied material.

In some instances specifiers have over looked simulative 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. Without a simulative laboratory test the material would have to undergo extensive field trials to confirm the wheel path evaluations after 2 or 3 years of exposure to traffic.

This complete system, once set has the ability to withstand adhesive failure from the plucking out of the broadcast aggregate and the delamination of the binder from the 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.

7. Braking Distance

The widely known Haddon Matrix indicates that the road environment (21%) either on its own or combined with human (73%) and vehicle (6%) influences the outcome of traffic accidents. Over the past several decades road safety initiatives have targeted human and vehicle changes to reduce the road toll. The outcome from these initiatives have considerably reduced the road toll, however it is the 21% of accidents influenced by the road environment that should be investigated next.

The road surface properties that influence the interaction between the vehicle and the road are friction and texture, by improving the level of surface friction a considerable reduction in braking distance is achieved, whereas improvements to the road surface texture ensures maximum contact between the road surface and the vehicle tyre is maintained even when the road is wet.

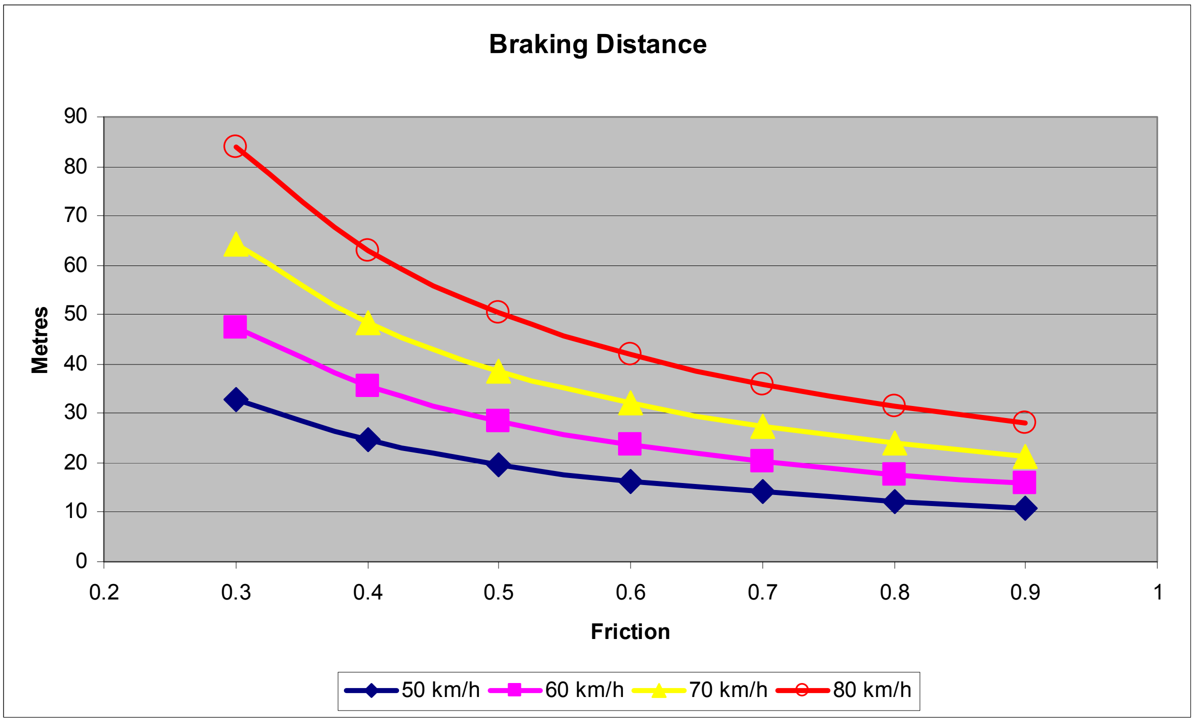
The formulas used for calculating the outcome from the interaction between the vehicle and the road surface are widely known and in their basic form can be described as:

- Reaction distance = $(0.7 * V)$
- Braking Distance = $V^2 / (254 * \mu)$
- Stopping Distance = $(0.7 * V) + V^2 / (254 * \mu)$
- Threshold Speed = $\sqrt{(254 * d * \mu)}$

Where:
V = Vehicle velocity in Km/h
d = distance in metres
μ = Road Surface Friction

The reaction time is dependant on the attentive reactions of the driver and can be included in the human element of the Haddon Matrix, equally the total stopping distance includes the reaction time and is therefore included in the Human and Road environment elements. This report is primarily based on what we as road engineers can do to improve the road surface to reduce the stopping distance and therefore the speed on impact.

Figure 2: Braking Distance in relation to Friction and Speed



The braking distance is based on vehicle speed and the road surface friction, figure 2 indicates the likely braking distance where the speed at application of the brakes and the surface friction is known.

8. Threshold Values between Fatality and Injury

Recent research undertaken by MUARC has indicated that there is a correlation between the speed of impact and the consequence of a crash becoming a personal injury or a fatality. The following table (table 2) indicates the likely speed range over which the crash has a higher risk of becoming a fatality.

The threshold speed, indicated in the figure 3 schematic, is the speed of one vehicle relative to another or in this instance the speed of a vehicle on one surface material against the speed of a vehicle that has already completed braking and has stopped on a High Friction Surface Treatment. It too is based on the speed of the vehicle when the brakes are applied and in this basic form is based on the friction levels being constant or the use of the average friction level.

Table 2: Human Tolerance to Impact

Collision between a Car and	Speed (km/h)
Pedestrian	20 – 30
Motorcyclist	20 – 30
Tree	30 – 40
Car (Side Impact)	50
Car (Head-on Impact)	70

MUARC Presentation

Earlier in the report reference was made to the use of a surface material that contained an aggregate with a High Polished Stone Value (HPSV) rather than a High Friction Surface Treatment (HFST) which uses a Calcined Bauxite.

Figure 3: Threshold Speed

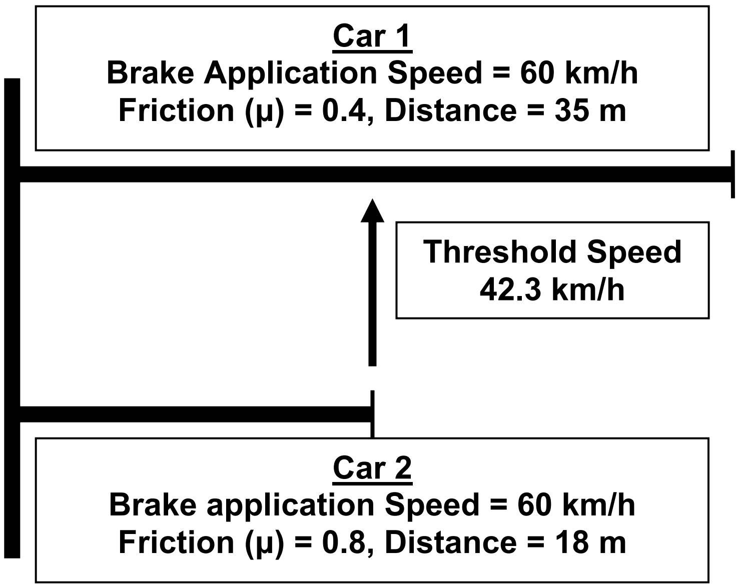


Table 3 indicates the relative threshold speed values between a HFST with an average friction value of 0.8 and a HPSV material with a friction value of 0.6. An investigation conducted earlier indicated that friction results at some high stress locations such as approaches to traffic light controlled intersections; pedestrian crossings, etc had measured friction results at or below a friction level of 0.4. To provide a comparison between the HFST and a Low Surface Friction Material (LSFM) a friction level of 0.4 has been adopted, which is not unrealistic. Using this friction level the threshold speed variation data has been calculated and included.

Table 3: Threshold Speed Variation between Friction and Speed

SPEED ZONE (km/h)	THRESHOLD SPEED VARIATION	
	HFST (sfc 0.8) / HPSV (sfc 0.6) (km/h)	HFST (sfc 0.8) / LSFM (sfc 0.4) (km/h)
40	20.0	28.2
50	24.9	35.3
60	29.9	42.3
70	34.9	49.4
80	39.9	56.4
90	44.9	63.5
100	49.9	70.5
110	54.9	77.6

9. Accident Reduction

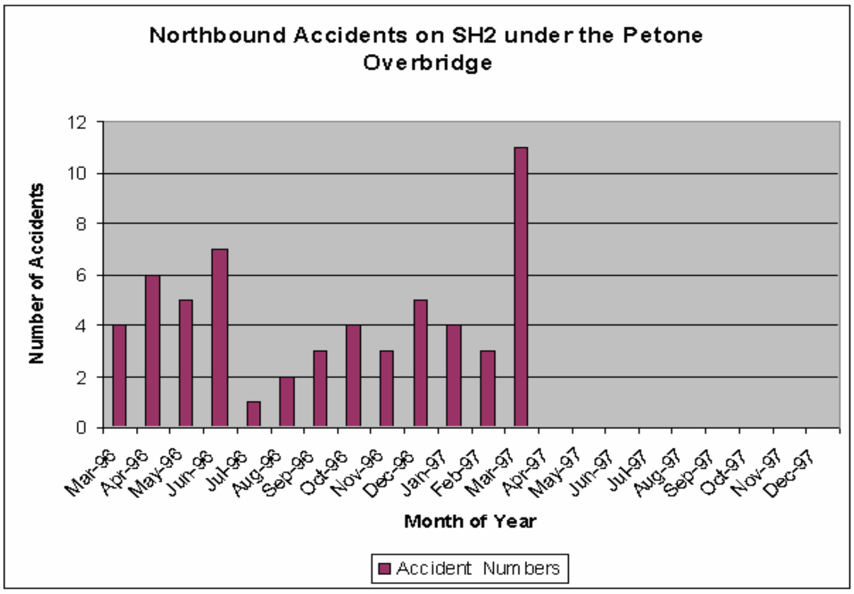
It is well documented that skidding on wet roads is far more frequent than on dry roads, it is therefore not unreasonable to suggest that the reduction in skid resistance is caused by the presence of water, so by increasing the level of skid resistance to that of a dry road a reduction in accidents can be achieved.

There have been many case studies conducted which indicate the ability of a High Friction Surface Treatment to reduce the severity and number of accidents. The references to this report indicate two such cases where properly established investigations identified that accident and in fact road surface re-treatments using natural quarried aggregates were increasing prior to the application of a High friction Surface Treatment but that immediately after the application the accident numbers reduced to zero and was maintained at this level for the monitoring period or at least the following two years.

The outcomes from the report by P. Stewart, Opus, NZ (reference 2) indicate that the site was re-surfaced 8, 4 and 2 years prior to the application of the High Friction Surface Treatment and in this period the accidents continued to occur and also at times increased. The following graph (figure 4) indicates the immediate reduction in traffic accidents reported at the site after the application of the High Friction Surface Treatment.

The recently released Austroads, “Treatment of Crash Locations” (reference 4) indicate that a non-skid surface (High Friction Surface Treatment) will produce a crash reduction of 40% for rear end accidents and 10% for loss of control accidents. The data from the described accident reduction investigations confirm this reduction.

Figure 4: Accident Reduction after application of High Friction Surface Treatment



Data from OPUS NZ Report

10. Conclusions

The use of a properly designed, specified and applied High Friction Surface Treatment has a proven record of accident reductions especially a reduction in fatalities, but it will also provide a reduction in:

- Braking distance of up to 33%;
- Speed after application of the brakes of up to 70%;
- Wet weather accidents of up to 50%;
- Rear end accidents by up to 40%, and;
- Total accidents by up to 32%.

The report also concludes that:

- There is a difference between a High Friction Surface Treatment and a surface material using a natural quarried aggregate or slag aggregate, whether the aggregate has a high PSV or not;
- The use of a High Friction Surface Treatment can greatly reduce the braking distance when compared against a natural quarried aggregate under the same high stress conditions, and;
- The Threshold Speed variation between the use of a High Friction Surface Treatment and other materials indicates that for naturally quarried aggregates and slag aggregates there is an increased risk of higher impact speeds.