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The performance of alternatives to traditional high friction surfacings

M Militzer (TRL), P Sanders (TRL) and
A Premathilaka (CH2M)

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Executive Summary

The expected lifetime of High Friction Surfacing (HFS) materials is reported to be between 4 and 8 years (RSTA/ADEPT, 2011). However, it has been suggested that their deterioration can be more rapid and long term maintenance cost is higher than expected. Consequently, Thin Surface Course Systems (TSCS) with high PSV natural aggregate have been used, as a departure from standards, to achieve skid resistance at some high stress or high traffic locations where HFS would usually be specified. The long term in-service performance of these high PSV surfacings on high stress sites is however not well understood.

TRL was therefore commissioned by Highways England to gain a better understanding of the performance of high PSV surfacings. In particular, to determine whether these surfacings achieve a similar skid resistance performance to conventional HFS and whether they retain their skid resistance to a sufficient extent to allow their use as an alternative HFS without requiring a departure.

This report provides details of measurements that were undertaken to assess the skid resistance performance of high PSV surfacings. The results are compared to the Investigatory Levels (IL) of skid resistance required for each specific site, and also to the skid resistance that would be required for 'high-risk' sites where HFS incorporating Calcined Bauxite is conventionally used. For comparison, various high risk sites with HFS using Calcined Bauxite were included in the survey programme. These were categorised by their visual condition to form a baseline for the comparison with skid resistance values achieved by high PSV surfacings.

Within this report, Thin Surface Course Systems with high PSV (≥ 68) natural aggregate, and other proprietary products that may have the potential to be used in place of traditional HFS surfacings, are referred to as Alternative High Friction Surfacing (AHFS). Traditional HFS surfacings incorporating Calcined Bauxite and resin binders are termed Calcined High Friction Surfacing (CHFS).

Information on the AHFS materials currently available and information on site location and date laid was initially sought through a request to the Mineral Products Association (MPA), which was then circulated to its members. The information gained was supplemented by a similar enquiry to existing contacts at a number of local authorities in the form of a questionnaire. In addition, records of departures granted for the use of AHFS on the Strategic Road Network (SRN) were obtained directly from Highways England.

From the information obtained on AHFS sites, those for inclusion in the measurement programme were selected primarily based on the level of detail for their site location. The selection process also aimed to ensure that sites could be surveyed successfully and that they included a good range of road type, level of traffic, material and age. From the data available, 18 sites located in Sussex, Staffordshire, Derbyshire and Leicestershire were included in the survey programme.

It was found that the majority of the AHFS sites performed above the required IL, but did not achieve the same level of skid resistance as a conventional HFS utilising Calcined Bauxite aggregates.

In terms of long term performance it was found that the three sites available on the SRN had generally performed at or above IL within the first year after installation, but showed a rapid decrease to values below the IL in the following years.

Of the 50 high risk CHFS sites, the majority were found to be in a satisfactory condition and provided sufficient skid resistance, i.e. above the Investigatory Level. The visual condition classification showed that even a fairly simple and somewhat subjective approach can give an indication on the likely skid resistance performance of a high risk site. Sites in a poor visual condition are most likely to require some sort of treatment in order to meet the skid resistance requirements.

In summary, AHFS can provide sufficient skid resistance on high risk sites, but provides generally lower skid resistance values than CHFS. It should also be noted, that most of the sites available for testing were exposed to fairly low traffic levels and had all but one site had been installed within the past five years. It is therefore not possible to draw robust conclusions regarding the long term performance of AHFS materials. AHFS materials may, therefore, be suitable for some high risk sites but a better understanding of the parameters influencing the skid resistance performance is needed to enable suitable sites to be identified.

Several road authorities also noted that, the change in colour offered by CHFS surfacings could have an awareness raising effect to road users at high risk sites, and that this could be considered as part of the material selection process.

1 Introduction

HD36/06: Surfacing materials for new and maintenance construction (HD36 Surfacing materials for new and maintenance construction., 2006), and accompanying advice notes, give guidance on the polish resistance of aggregate used in new surface course construction (Table 3.1 of HD36). Sites where there is more stress imparted to the surface (gradients bends and approaches to junctions, roundabouts and pedestrian crossings), especially those carrying large volumes of traffic, require aggregate with higher resistance to polishing in order to maintain skid resistance above the investigatory level (IL) set out in HD28 (HD28/15 Skidding resistance, 2015). These sites are collectively referred to as high risk sites and attract an IL of ≥0.50 SC(50).

Polish resistance is measured using the Polished Stone Value (PSV) test (BSI, 2009) and within the UK, natural aggregate is available with PSV up to, or just above, 68. Where the traffic level or traffic induced stress is very high, it is expected that surfaces using natural aggregate with even the highest PSV will not be able to retain sufficient skid resistance in service to meet the required IL. In these locations it is recommended that a High Friction Surfacing (HFS) is used. In HD36 where "HFS" is specified it means, according to Note 4, "specialised high friction surfacing, incorporating Calcined Bauxite aggregate and conforming to Clause 924 of the Specification" (Manual of Contract Documents for Highway Works (MCHW), Volume 2, Series NG 0900, 2008)".

Any HFS system must be in compliance with the Specification for Highway Works (SHW) Clause 924 (Manual of Contract Documents for Highway Works (MCHW), Volume 2, Series NG 0900, 2008). This clause gives guidance and requirements on High Friction Surfacing regarding aggregate properties, installation and quality procedures, system coverage and guarantee. It states that any high friction surfacing system in use should be certified by the British Board of Agrément (BBA) and the Highways Authorities Product Approval Scheme (HAPAS) and shall only be installed by a BBA approved installer.

The expected lifetime of HFS is reported to be between 4 and 8 years (RSTA/ADEPT, 2011). However, it has been suggested that their deterioration can be more rapid and long term maintenance costs higher than expected. Consequently, Thin Surface Course Systems (TSCS) with high PSV natural aggregate have been used, as a departure from standards, to achieve skid resistance at some high stress or high traffic locations that would normally require HFS.

It has been shown that thin surface course systems, especially those using small coarse aggregates, can achieve higher skid resistance than hot rolled asphalt using aggregate of the same PSV; this is the basis of the guidance published in IAN 156/12. However, the long term in-service performance of high PSV surfacings, laid by departure from standards on the Strategic Road Network (SRN) at high stress sites, is not well understood.

TRL was therefore commissioned by Highways England with the aim of gaining a better understanding of the long term performance of high PSV surfacings. In particular, to determine whether they retain their skid resistance to a sufficient extent to allow their use as an alternative to HFS using Calcined Bauxite, without requiring a departure.

This report provides details of measurements that were undertaken to assess the skid resistance performance of high PSV materials. The results are compared to the

Investigatory Levels (IL) defined in the skid resistance standard HD28, and also to the performance of sites where HFS incorporating Calcined Bauxite had been used.

Within this report, Thin Surface Course Systems with high PSV (≥ 68) natural aggregate, and other proprietary products that may have the potential to be used in place of traditional HFS surfacings, will be referred to as Alternative High Friction Surfacing (AHFS). Traditional HFS surfacings incorporating Calcined Bauxite and resin binders will be termed Calcined High Friction Surfacing (CHFS).

2 Data Collection

Information on the availability and use of AHFS was initially sought through a request to the Mineral Products Association (MPA), which was then circulated to its members. A copy of the request is provided in Appendix A, with information being sought on materials currently available and details of where and when the materials had been laid. The information gained was supplemented by a similar enquiry to existing contacts at a number of local authorities. The questionnaire used is provided in Appendix B. In addition, records of departures granted for the use of AHFS on the SRN were obtained directly from Highways England.

All the information obtained was compiled into a database which was then used to identify sites where skid resistance measurements would be made and for subsequent data analysis.

2.1 Currently available materials

AHFS materials are supplied by a small number of manufacturers as proprietary products; details of those currently available are provided in Table 2-1. None of the materials are as yet certified by the BBA.

Table 2-1 Currently available AHFS products

Manufacturer	Product
Aggregate Industries	SuperFlex72
Lafarge Tarmac	Ulticolour Bauxite
Steelphalt	Steelstop

Superflex72 is an Aggregate Industries' high friction surfacing product which is referred to, in marketing material, as providing sufficient friction in highway use. Aggregate Industries claim that results from GripTester measurements have shown that this product achieves skid resistance values equivalent to SCRIM values in excess of 0.55 and that these levels can be maintained over a long period of time. SuperFlex 72 products laid by Aggregate Industries are given a 10 year SCRIM warranty (Aggregate Industries, 2014).

Lafarge Tarmac's Ulticolour Bauxite product utilises bauxite aggregates in combination with a clear polymer binder. Lafarge Tarmac state that Ulticolour Bauxite aims to provide a coloured and textured surface in order to improve visibility and skid resistance at high risk sites. According to Lafarge Tarmac the product "has comparable anti-skid properties to conventional anti-skid surfacing products but typically lasts three times longer. As a result it offers lower whole life costs and avoids resurfacing delays as well as the risk of accidents and costly legal claims" (Lafarge Tarmac, 2014). In an article Lafarge Tarmac claims a life time of ten to twelve years for their product. The product was first installed in Leicestershire (Mann, 2014).

Steelphalt has developed a range of asphalt products incorporating electric arc furnace (EAF) carbon steel slag which is a by-product of the manufacture of steel by the electric arc furnace process. EAF steel slag is a strong, dense, non-porous aggregate that is cubical in shape, has high resistance to polishing and has an affinity to bitumen (MPA, 2015). Steelphalt products make use of steel slag and it is also used in their High Friction Surfacing product Steelstop instead of Calcined Bauxite.

Information provided by the Local Authorities showed that in addition to these proprietary products, Stone Mastic Asphalt (SMA) utilising high PSV 10mm natural aggregate has also been installed in lieu of CHFS on high risk sites. It is for that reason that these sites were included in the survey programme and their results are presented within the AHFS results.

2.2 Site selection

To enable a comparison between the two types of high friction surfacing materials, a sufficient number of sites had to be identified in order to obtain meaningful data from the skid resistance surveys.

From the information obtained on AHFS sites, those for inclusion in the measurement programme were selected based on the level of detail for their site location, and the ability to include the sites in efficient test routes. The selection process also aimed to ensure that sites could be surveyed successfully and that they included a good range of road type, level of traffic, material and age.

From the data available, 14 sites located in Sussex, Staffordshire, Derbyshire and Leicestershire were included in the survey programme. These sites were selected on the basis outlined above, but the logistics of the possible survey programme within the context of the project budget were also taken into account. Surveys were undertaken on the following dates:

Table 2-2 AHFS Survey Dates

Survey Area	Survey Dates	Number of Sites
Staffordshire	27 / 28 October 2014	6
Sussex	29 / 30 October 2014	8
Derbyshire / Leicestershire	16 / 17 March 2015	2

It has to be noted that the survey dates are not compliant with the survey season set out in HD28. The skid resistance data collected can however still give an indication of the general performance of the sites tested. Details of the surveyed sites are provided in Appendix C.

To enable a comparison between the AHFS sites and sites surfaced with CHFS, several CHFS sites in the vicinity of TRL's Crowthorne office were included in the survey programme, as listed in Appendix D. The sites included a range of high risk site categories and also surfaces in various levels of condition; this enabled analysis of their skid resistance compared to their condition. The site selection was also based on sites surveyed by Evans (2006).

2.3 Skid Resistance Surveys

Skid resistance surveys were undertaken using the Highways England Skid Resistance Development Platform (SkReDeP); a sideways-force measurement device. Measurements were made at a speed of 50 km/h and at high resolution, using the 1m averaging capability of SkReDeP, as many of the sites were relatively short. For the surveys, the lane carrying the highest volume of heavy vehicles was surveyed in order to obtain data for where polishing stresses would be highest.

For the AHFS sites, control sections before and after the surfacing were surveyed to allow a comparison with a conventional surfacing material. For sites where the exact start and end point of the AHFS surface was not clearly identifiable, only data for the clearly defined high risk site, e.g. 50m before a pedestrian crossing, were used in the subsequent analysis.

For the CHFS sites, video images of the surfacings were also recorded to enable an assessment of their condition.

2.4 HAPMS

In order to get a better understanding about the performance of high PSV surfacing materials, skid resistance data over several years is needed. However, skid resistance data from previous years could not be obtained for the local authority sites. For sites on the SRN previous years' skid resistance data were extracted from the Highways England's pavement management system (HAPMS).

Furthermore site categories and Investigatory Levels for those sites were also extracted from HAPMS in order to assess to what extend the set ILs were being achieved.

3 Analysis

3.1 Skid Resistance Surveys

The skid resistance data collected were analysed to compare the performance of both types of HFS material against the Investigatory Level that would typically be set for high risk sites (SC(50) ≥ 0.50). All the sites surveyed were classified by surface type and site category/IL. In some cases the site category and IL assigned to the AHFS sites was lower than the typical IL for high risk sites; in these cases the performance of the materials at these sites were still compared to a high risk category IL of 0.5.

For sites on the SRN, the site categories and ILs from the HAPMS database were aligned with the survey data. For the remaining non-HA network sites, site categories were assigned based on the road layout and geometry in accordance with HD28/04 and IAN98/07.

According to HD28/04, Investigatory Levels for event sites are generally set for a minimum length of 50m. For this analysis, 10m sections within each site were analysed and compared against the IL in order to obtain more detail on the range of skid resistance achieved.

The current performance was then assessed for each HFS material type by comparing the distribution of achieved skid resistance values to site category, age and traffic level according to the data available.

3.2 Visual Condition Survey of CHFS

In addition to analysing the skid resistance data for the CHFS sites, their condition was also assessed. This evaluation was based on video images and notes taken at the time of the skid resistance surveys.

The classification of condition was based on the basic seven point scale of condition inspection criteria reported in Appendix R of TRL report TRL 176 (Nicholls, 1997). Table 3-1 shows the condition categories and their descriptions.

This categorisation is not based on threshold values but on a simple evaluation based on the visual impression of a surface. Evans (2006) showed that the categorisation based on the percentage of defaults is linked to the skid resistance of the surface.

This work aimed to investigate whether an even more simplified categorisation of condition can still be related to the skid resistance present. Examples of the different visual condition categories are given in Table 3-2.

For the analysis the average skid resistance value for each 10m section was used. However, the classification according to the condition was based on the overall appearance of the surface. Therefore the same condition category is assigned to each 10m section of the surface.

Table 3-1 CHFS condition categories (Nicholls, 1997)

Category			Description
Satisfactory	A	Excellent	No discernible faults (like new)
	B	Good	No significant fault (although not a brand new look)
	C	Moderate	Some faults, although insufficient for serious problem
	D	Acceptable	Several faults - usually just acceptable
Unsatisfactory	E	Suspect	Seriously faulted, still serviceable in short term (will last a bit longer)
	F	Poor	Requires remedial treatment (need significant repair, basically too late)
	G	Bad	Total degradation, needs immediate replacement

3.3 Statistical Analysis

Statistical analysis was undertaken on the resulting distributions of skid resistance for the different surfacing types to determine whether they were statistically significantly different.

'Hypothesis testing - two population means', as specified in Fleming and Nellis (2000), was used for this analysis. According to Fleming and Nellis (2000), for sample sizes greater than 30, the Z-Test is appropriate for this testing and was therefore used. The analysis was based on a confidence interval of 95%.

Table 3-2 Visual Condition Examples

Satisfactory	**A - Excellent** No discernible Faults (like new).		
	B - Good No significant fault (although not a brand new look).		
	C - Moderate Some faults, although insufficient for serious problems.		
	D - Acceptable Several faults – usually just acceptable.		
Unsatisfactory	**E - Suspect** Seriously faulted, still serviceable in short term (will last a bit longer).		
	F - Poor Remedial treatment (need significant repair, basically too late).		
	G - Bad Total degradation, needs immediate replacement.		

4 Results

This section provides and discusses the results obtained from the analysis of the skid resistance measurements on both the Alternative and Calcined Bauxite high friction surfacing sites.

4.1 Local Authorities Survey Results

CH2M obtained information from Government Authorities, County Councils, City Councils and Borough Councils regarding their use and experience of Alternative High Friction Surfacing.

In total, eight questionnaires were completed resulting in 35 sites being listed as areas where AHFS has been used as a replacement for CHFS. For these sites detailed information regarding location was provided. However, performance and experience related information were not provided with the same level of detail. In addition to the questionnaire, comments on experience with the use of CHFS and AHFS were given. In total four Councils returned detailed comments which are provided anonymously below.

Council 1

Council 1 responded that high PSV surfacing was used but not as a first choice alternative to HFS. It was used where there was either an existing grey HFS and the road was about to be resurfaced, or to address a casualty cluster site where HFS could not be provided in the first instance because of the existing condition of the road. Where the colour impact of HFS was considered to be an important factor, e.g. on the approach to crossings, etc., no AHFS was used. So far only a few locations have been resurfaced with AHFS and information for these sites was not easily accessible as the Council have not formally monitored their performance since laying (1 has only just been completed).

Council 2

Council 2 historically placed CHFS on approaches to pedestrian crossings and approaches to roundabouts as a matter of course on new build and maintenance works. The amount of HFS laid was substantial and the seemingly short life of the CHFS materials, along with a lack of routine maintenance and repair of CHFS, meant that it has tried to change direction a little.

The maintenance works now focus on providing the required DMRB design standards for PSV on the classified roads; hence this tends to remove the need for CHFS on the approaches to roundabouts. For pedestrian crossings the re-application of CHFS is still intended, even where there has been a low or improved accident record - otherwise lowering the standard of provision would have to be justified if CHFS was replaced with a 68+ PSV material. In terms of high risk sites, one example was given where design / risk assessments were undertaken on a sharp bend on a 50mph site and which resulted in providing a 68 PSV Thin Surfacing Material (40mm thickness of 14mm natural aggregate) to Clause 942 in place of the existing HFS.

Council 3

Council 3 has in the past applied CHFS at the approaches to urban traffic signals (pedestrian crossings / junctions) and rural accident black-spots (tight corners – 90 degrees or less). Degradation of the surface course was experienced. It is assumed that this was primarily caused by the binder failing to adhere the CHFS to the surface. In the last 12 months, 2 urban sites within the area have been resurfaced – 1 site was a traffic signal refurbishment with pedestrian controlled signals and the other was public realm works. It was decided to use a high PSV pre-coated 14mm chipping in an HRA surface course without the use of CHFS prior to the pedestrian signals.

Council 4

Council 4 commented that the approach of using AHFS was adopted over recent times in response to a concern about overuse of CHFS and the increased cost, both in capital costs and in whole life terms. The Council estimates around 25% additional costs initially for CHFS, with an expectation of around half the life span of a TSCS.

4.2 Skid Resistance Surveys

4.2.1 Alternative High Friction Surfacing

In total, data were collected from 4075 m of AHFS, 3373 m were characterised as high risk sites with an IL of at least 0.5.

The overall performance of the AHFS materials is shown in Figure 4-1, which provides the distribution of 10m skid resistance values for the lengths surveyed. Figure 4-1 shows that the skid resistance values measured on high risk sites range between 0.39 and 0.71, the range of measurements on lower risk sites was between 0.45 and 0.67. An average value of 0.54 was observed for both high and low risk sites with the majority of measurements falling above 0.50 SC(50). In order to draw any reliable conclusions, further analysis is necessary.

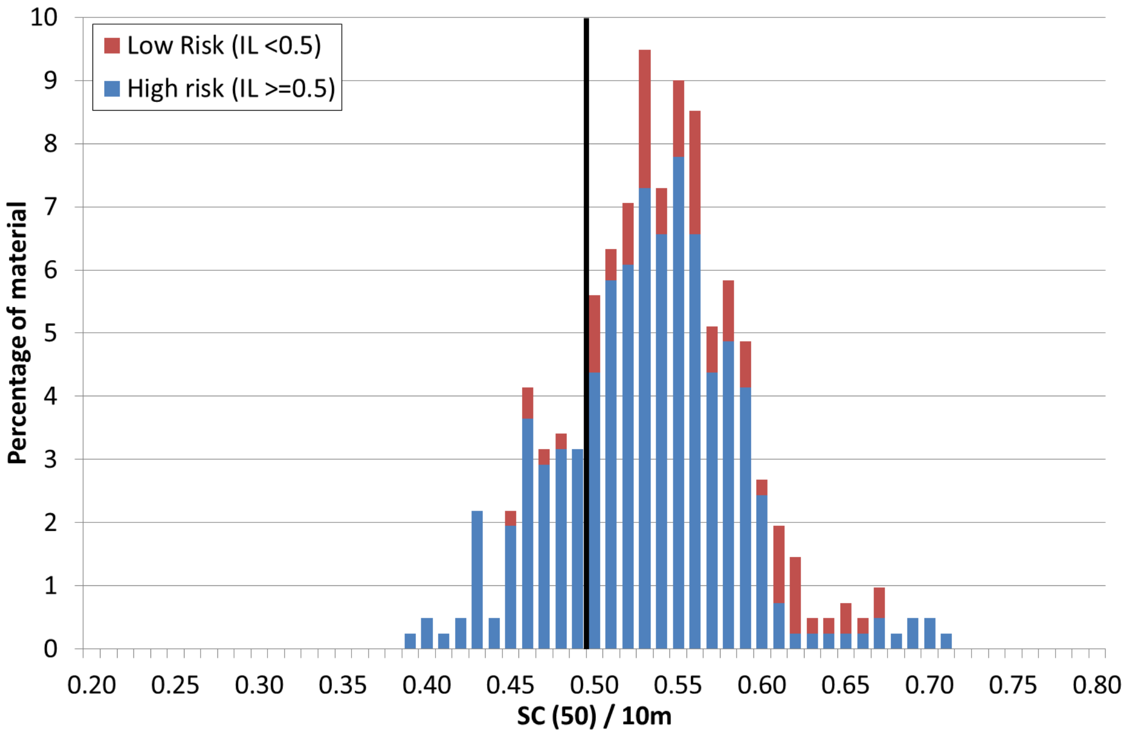


Figure 4-1 Skid resistance measurements – AHFS

Despite the sites providing a mix of site categories, category S2 (bends on single carriageways) forms a high percentage of the survey length. This is due to this site category being assigned to longer lengths than, for example, approaches to pedestrian crossings or junctions. Therefore the majority of the data (approximately 63%) was collected from category S2 sites which therefore have the major impact on the distribution in Figure 4-1. It is therefore sensible to review the data for each site category as presented in Table 4-1.

Table 4-1 AHFS survey results by site category

	Site Category											
	S2		Q		K		R		C		B	
Averaging length	**10m**	**Section**[1]	**10m**	**Section**	**10m**	**Section**	**10m**	**Section**	**10m**	**Section**	**10m**	**Section**
Data points	250	12	35	7	43	8	34	2	25	4	10	2
Avg. SC(50)	0.54	0.53	0.52	0.52	0.50	0.51	0.58	0.57	0.54	0.56	0.55	0.56
<0.5 SC(50)	16%	25%	48%	43%	44%	38%	0%	0%	4%	0%	40%	50%
≥0.5 SC(50)	84%	75%	52%	57%	56%	62%	100%	100%	96%	100%	60%	50%

[1] A continuous length with a single site category assigned

For all the site categories covered by the surveyed sites the majority of the skid resistance measurements are above IL. However, for category K, Q and B the proportion above IL is considerably lower than for the S2 lengths. This may give an indication that the level of stress for the sites assessed, and therefore the polishing effect on the aggregate at these locations, is greater than experienced on the bends assessed. Further analysis was completed to determine whether the results could be linked to a particular material, age of the surface or traffic level.

The level of detail for the date the materials were laid varied from site to site, but in most cases only the year of installation was provided. Therefore, only approximate age at the time of the survey could be estimated. As all but one site were less than 4 years old a detailed analysis based on age alone was not considered to be robust, particularly as some of the sites may not yet have reached an equilibrium level of skid resistance.

In addition to the age, traffic levels for each of the sites were obtained from the Department for Transport website (DfT, 2013); from the count points the Annual Average Daily Traffic (AADT) for ‘All Motorized Vehicles’ and ‘HGVs’ were extracted.

The performance of the sites, in both directions if applicable, was then compared against the total HGV passes over the estimated age at the time of the survey.

For the different bands of traffic level, a similar average skid resistance value was measured, resulting in similar proportions of sections meeting the IL. It was therefore found that, for the surveyed sites, comparing the traffic level to the skid resistance performance does not produce any clear correlation.

Besides age and traffic level, an analysis based on material type was undertaken. Within the data, three different materials were available for analysis. Material 1 and 2 are bitumen based materials using a natural, high PSV aggregate. Material 3 utilises Calcined Bauxite aggregates but it is considered in this analysis as it is specified as a non-conventional Calcined Bauxite high friction surfacing product using a polymer binder. A summary of the information obtained for each site is provided in Table 4-2.

Table 4-2 AHFS survey results by site

Site	Date laid	Age (yrs)	All Vehs (AADT)	HGVs (AADT)	Material	Dir.	Site Cat.	Length (m)	IL	Avg. SC(50)	10m Sections ≥ 0.5 (SC(50))	10m Sections < 0.5 (SC(50))
1	2014	0.0	N/A	N/A	2	EB	K	45	0.50	0.52	100%	0%
2	2013	1.0	14,583	489	2	NB	K	50	0.50	0.49	20%	80%
						SB		50	0.50	0.48	40%	60%
3	2013	1.0	9,075	801	2	NB	S2	175	0.50	0.51	50%	50%
						SB		105	0.50	0.53	100%	0%
4	2011	3.0	11,298	500	2	NB	K	50	0.50	0.54	100%	0%
6	2011	3.0	10,737	207	2	WB	K	70	0.50	0.56	100%	0%
						EB		50	0.50	0.50	80%	20%
7	2011	3.0	14,751	321	2	NB	K	40	0.50	0.45	0%	100%
						SB		70	0.50	0.46	0%	100%
9	2011	3.4	5,000	218	1	NB	S2	655	0.50	0.53	70%	30%
						SB		669	0.50	0.54	94%	6%
10	2014	0.0	12,750	624	1	NB	S2	104	0.50	0.50	64%	36%
						SB		111	0.50	0.48	42%	58%
11	2012	2.2	14,693	320	1	WB	Q	50	0.50	0.53	100%	0%
							R	230	0.45	0.59	100%	0%
							C	50	0.40	0.64	100%	0%
						EB	Q	50	0.50	0.59	100%	0%
							R	110	0.45	0.55	100%	0%
							C	70	0.40	0.54	100%	0%
13	N/A	N/A	25,099	1335	1	NB	Q	86	0.50	0.59	100%	0%
14a	2011	2.9	25,099	1335	1	NB	S2	67	0.50	0.54	100%	0%
						SB	S2	56	0.50	0.51	100%	0%
14b	2011	2.9	25,099	1335	1	NB	S2	240	0.50	0.54	100%	0%
							C	90	0.40	0.51	89%	11%
						SB	S2	270	0.50	0.55	100%	0%
							C	60	0.40	0.54	100%	0%
15	2011	2.9	25,099	1335	1	NB	Q	60	0.50	0.47	0%	100%
						SB		70	0.50	0.44	0%	100%
17	2001	14.0	12,591	311	3	WB	S2	90	0.5	0.63	100%	0%
						EB		90	0.5	0.64	100%	0%
18	2013	2.0	38,173	1648	3	NB	B	92	0.4	0.55	60%	40%

Figure 4-2 shows the skid resistance for each of the investigated materials. The results show that, overall, material 1 and 2 provide lower levels of skid resistance than material 3. Material 2 also shows a slightly lower peak in its distribution compared to material 1. Both materials have skid resistance values between approximately 0.4 and 0.6. Material 3 achieves the highest skid resistance values with the largest proportion lying between 0.6 and 0.7.

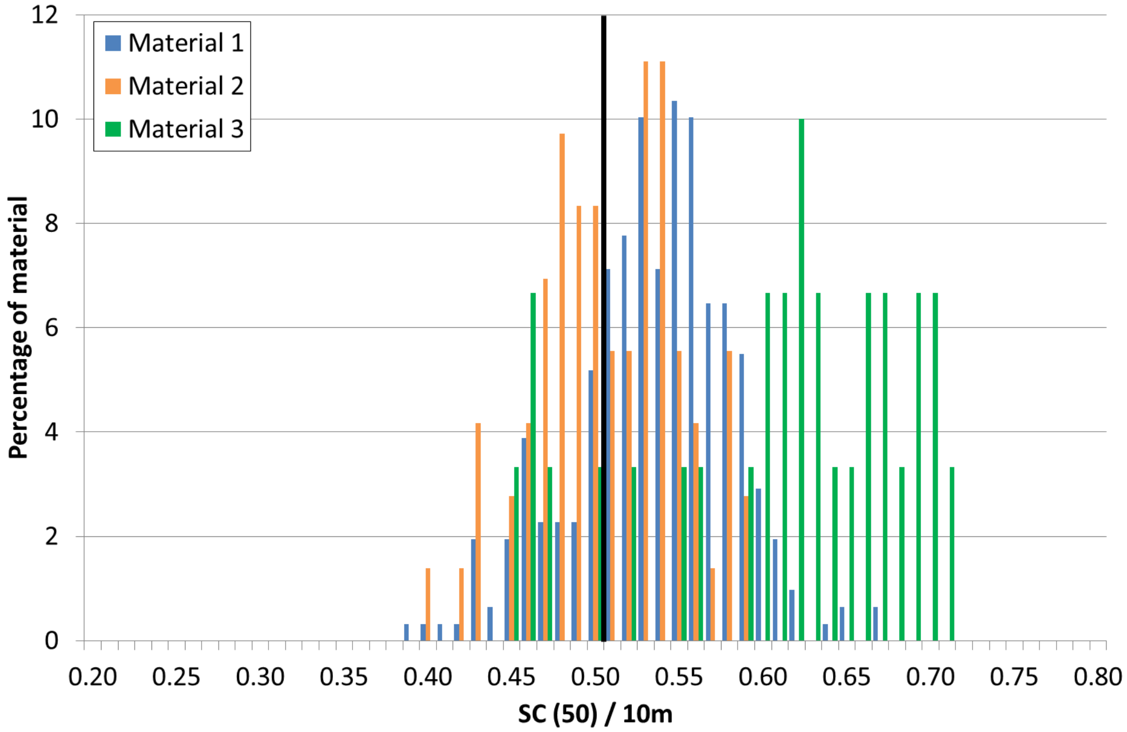


Figure 4-2 Survey results by material

This analysis shows a clear differentiation in skid resistance results between natural aggregates and Calcined Bauxite aggregates. The percentage of measurements meeting the required IL for high risk sites (IL ≥ 0.50) also varies for the three materials, as shown in Table 4-3.

Table 4-3 Overall performance of each material

	Material					
	1		2		3	
Averaging Range	**10m**	**Section**	**10m**	**Section**	**10m**	**Section**
Data points	250	13	72	10	27	3
Average	0.53	0.50	0.51	0.51	0.60	0.61
< 0.50 SC(50)	20%	46%	39%	30%	14%	0%
≥ 0.50 SC(50)	80%	54%	61%	70%	86%	100%

However, there is an indication about the performance of the different aggregates used. Sites surfaced with Calcined Bauxite show the highest percentage, with 86% of the 10m sections meeting 0.50 SC(50). Materials using natural aggregates, material 1 and 2, show a lower percentage meeting 0.50 SC(50).

4.2.2 Calcined Bauxite High Friction Surfacing

In total 50 Calcined Bauxite HFS locations were surveyed, including 18 approaches to pedestrian crossings (PDX), 26 approaches to roundabouts (RDB) and junctions (JCT), and 6 bends. Table 4-4 provides a summary of the sites, a detailed site list is provided in Appendix D. All of the CHFS materials tested were located on high risk sites with an IL of 0.50 or greater. The resulting measurements have therefore been compared to an IL of 0.50.

Table 4-4 CHFS survey locations

No	Road		Town	Site Locations
1	A4	London Road	Reading	EB/WB – PDX and JCT approaches
2	Woosehill Spine Road		Wokingham	EB/WB - PDX approaches
3	B3430	Nine Mile Ride	Bracknell	EB/WB - Bends
4	A3095	Marshall Road	Sandhurst	NB/SB – RDB and JCT approaches
5	A30	London Road	Camberley	EB/WB – PDX and JCT approaches

The results of the survey are presented in Figure 4-3, showing the distribution of skid resistance values based on 10m averaging lengths. Skid resistance values range from 0.34 to 0.75, with a peak in the distribution occurring between 0.55 and 0.6.

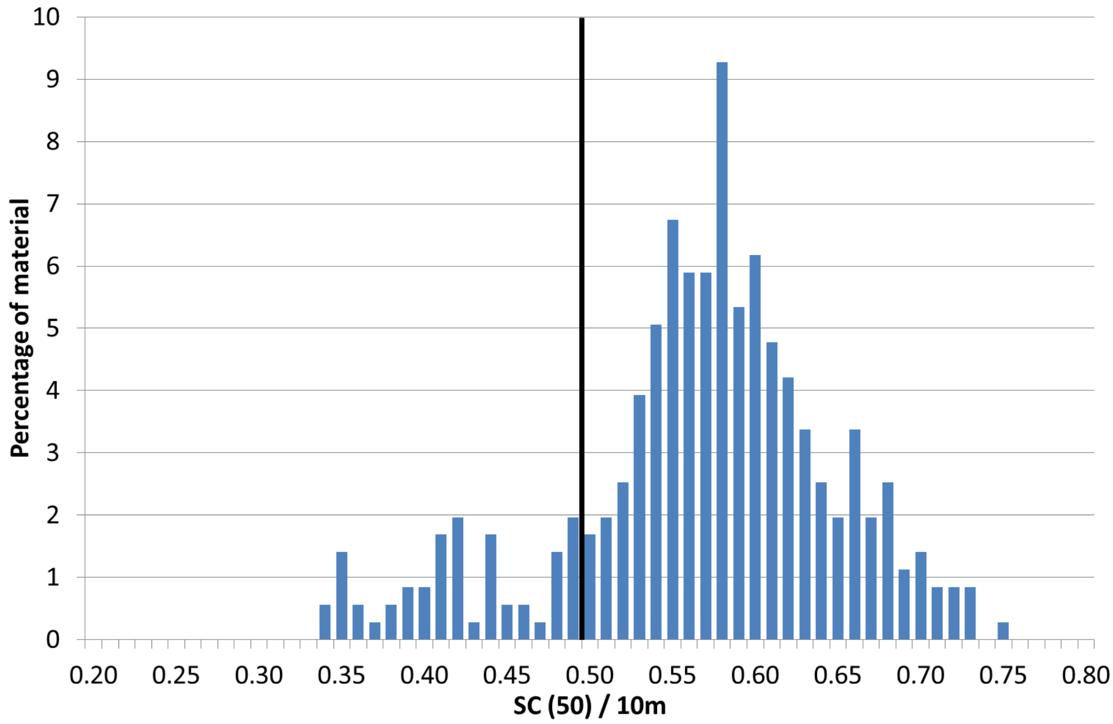


Figure 4-3 Survey results for CHFS

As the values are widely spread the influence of the surface condition was investigated; it could be expected that the lower skid resistance values are associated with surfaces in poor condition.

The performance of each site was also analysed by site category and the results are shown in Table 4-5. The results from this analysis show that a greater percentage of materials laid on category S2 sites were above the IL of 0.5 than those laid on category Q and K sites. This difference in performance could be related to the expected manoeuvres and, therefore, polishing imparted to the surface at these locations. Manoeuvres carried out at category S2 sites are likely to be turning whereas the majority of manoeuvres on category Q and K sites are likely to be braking. The difference in vehicle behaviour could therefore create different polishing and deterioration effects.

Table 4-5 Overall survey results for CHFS by site category

	Site Categories					
	S2		Q		K	
Averaging range	**10m**	**Section**	**10m**	**Section**	**10m**	**Section**
Data points	71	6	208	30	102	15
< 0.5 SC(50)	3%	0%	17%	14%	18%	13%
≥ 0.5 SC (50)	97%	100%	83%	86%	82%	87%

4.3 Visual Condition Survey of CHFS

In order to assess this impact, all sites were categorized as satisfactory (A-D) or unsatisfactory (E-G), based on the approach outlined in section 3.2. The same condition category was assigned to each 10m length of a site which enabled the range of skid resistance values within each condition category to be assessed.

Figure 4-4 shows the results of this analysis, displaying the distribution of condition categories within the survey results. Two separate distributions can be seen in the data, one for surfaces in a satisfactory condition with a peak around 0.58 and another for those in unsatisfactory condition with a peak around 0.42.

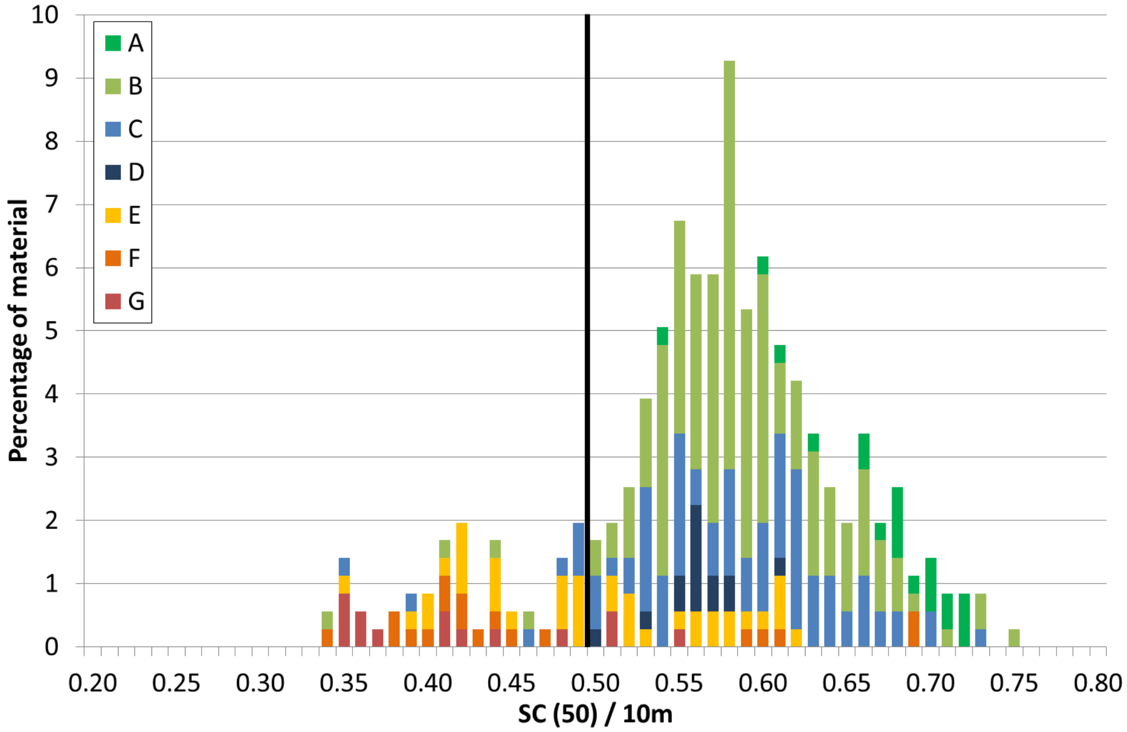


Figure 4-4 CHFS results by condition classification

Figure 4-4 also shows the wide distribution of skid resistance values within each condition category. This probably indicates that, in reality, more than one condition category occurred within each site; for example a site categorised overall as condition E (unsatisfactory) could still contain 10m lengths in a higher condition category and with higher skid resistance values.

Visual observations indicated that such lengths usually occurred near the start of a site where stress levels could be expected to be lower. Similarly, some satisfactory sites had defects towards the end of the site where stress levels may be higher.

It should also be noted that the condition in the near-side wheelpath, where the skid resistance measurements were conducted, may not have matched the overall condition of the site.

However, the average performance for each condition category shows that the skid resistance declines with progressing deterioration of the surface. This is also shown when analysing the percentage of sites that met the assigned IL, shown in Table 4-6.

Table 4-6 CHFS survey results by condition category

	Visual Condition per 10 m section	
	Satisfactory A-D	**Unsatisfactory E-G**
Number of Sites	41	9
Average SC	0.59	0.48
< IL (0.5)	6 %	62 %
≥ IL (0.5)	94 %	38 %

4.3.1 Verification of visual condition survey results

In order to validate this further, the results of the visual survey for each site were compared to the SC(50) values in more detail.

- The visual condition survey detected all sites which performed below IL (i.e. < 0.5).
- No site was falsely classified as satisfactory. All sites classified as satisfactory performed above IL based on the average value for the site.
- Two sites were classified as unsatisfactory that performed above IL. However, more than 20% of the sites' 10m values were below IL.
- Two sites that performed fully above IL, average and 10m values, were classified as unsatisfactory. It was found that for these sites, the CHFS was almost stripped off completely and that the skid resistance performance resulted from the underlying asphalt surface, as shown in Figure 4-5.

This verification shows that the visual condition survey did not overestimate the performance of the surfaces when compared with the skid resistance measurements and is therefore a failsafe approach. It generally confirms the measurements, is sufficiently accurate to capture failures and identifies good performing sites appropriately. In addition it showed that failing sites can be detected earlier than by reviewing skid resistance data alone.

Figure 4-5 Visually unsatisfactory CHFS

4.4 Performance Comparison of AHFS and CHFS

This section compares the performance of AHFS and CHFS so that conclusions about the suitability of using AHFS at high risk site locations can be made.

Figure 4-6 shows the distribution of skid resistance values on non-High Friction Surfacing sites (asphalt sections before and after the AHFS sites), AHFS sites and CHFS site, based on 10m values.

The distribution shows a clear differentiation between the three different surface types. Compared to both HFS types, non-HFS surfacings show lower SC values ranging from 0.31 to 0.73 with the peak occurring at around 0.47.

Both High Friction Surfacing distributions have the distribution peak above 0.5 with CHFS recording the highest peak at around 0.58. However, CHFS also shows the widest spread of SC values, ranging from 0.31 to 0.75; the CHFS peak in the lower SC range can be attributed mainly to CHFS in unsatisfactory condition.

The graph also shows that there is significant overlap in the skid resistance levels measured for each of the surface types, particularly between 0.5 and 0.6.

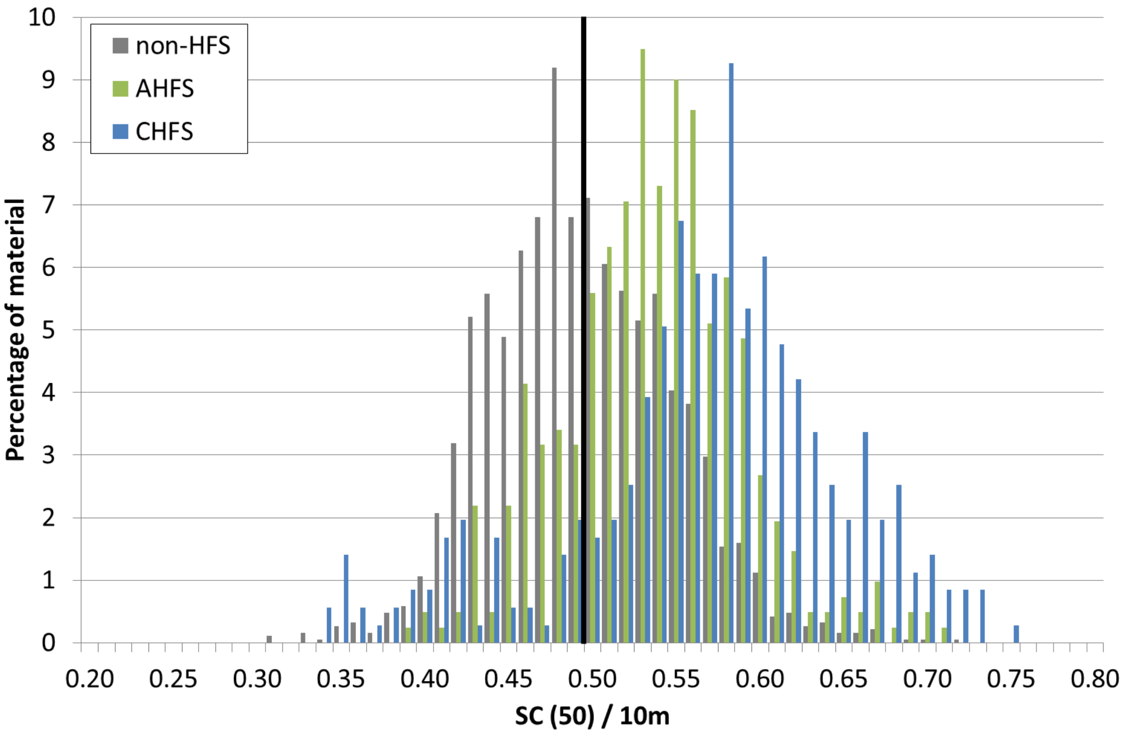
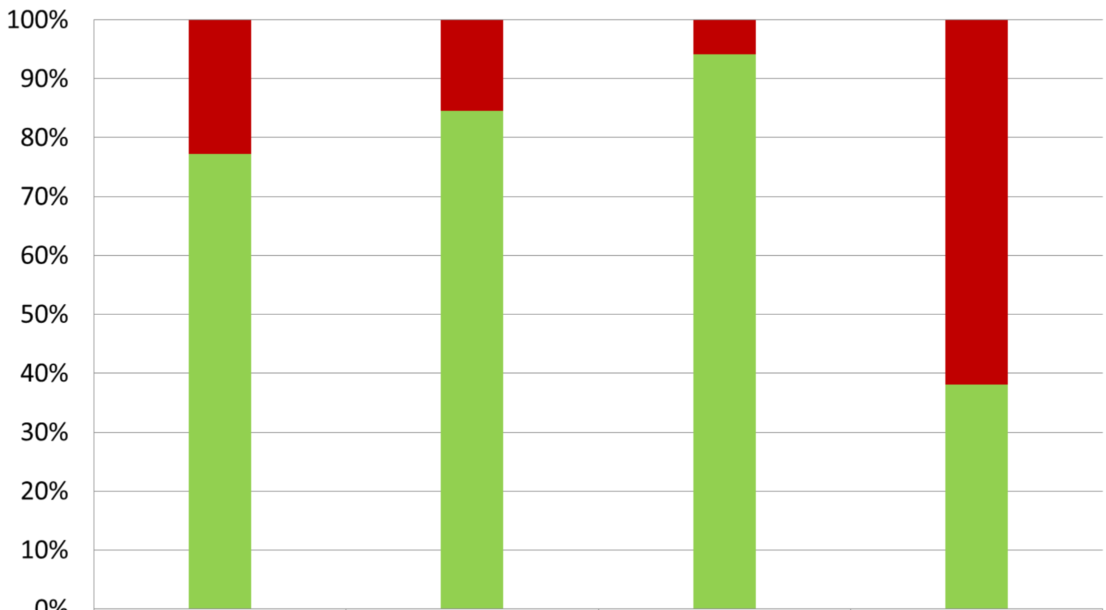


Figure 4-6 High risk sites - material performance

Taking the surface condition into consideration, the overall performance with regards to an IL of 0.5 is shown in Figure 4-7. Non-HFS is excluded as these surfaces were not laid in high risk sites and as such an IL lower than 0.5 would have been assigned to these lengths.



	AHFS	CHFS	CHFS Satisfactory	CHFS Unsatisfactory
< IL	23%	15%	6%	62%
> IL	77%	85%	94%	38%

Figure 4-7 Performance comparison for IL of 0.5

The analysis shows that most of the 10m lengths for both High Friction Surfacing types meet an IL of 0.5, but that the percentage is higher for CHFS. It is also evident that the overall better performance of CHFS is mainly due to those sites classed as being in satisfactory condition where 94% of the 10m sections meet the IL.

The sites and materials tested indicate that the performance of the surface differs with respect to the level of stress that it experiences. Site category K and Q achieve lower skid resistance values, even for surfaces relatively early in their life.

The skid resistance also depends on the material used. In general materials using a natural aggregate do not provide the levels of skid resistance expected from traditional CHFS surfacings. However, the majority of the sections tested met the required IL of 0.5. It would therefore be interesting to see how these sites perform over the coming years.

A further comparison of the AHFS and CHFS sites cannot be undertaken as different information was available for the sites surveyed. Furthermore the number of sites, the variation in traffic level and age would have to be increased in order to draw robust conclusions on the factors contributing to the overall performance of the surfacings.

The analysis undertaken however still shows the clearly higher performance of CHFS and that even CHFS is unsatisfactory condition may still provide a satisfactory level of skid resistance. The AHFS sites tested did not provide a level of skid resistance that would be typically expected from a surface classified as high friction surfacing. However an IL of 0.5 was achieved in the majority of cases and therefore these materials may still be able to provide sufficient skid resistance for some high risk sites. This assessment would require additional data to identify the specific site parameters influencing the skid resistance performance.

4.5 Statistical Analysis

The statistical analysis, as described in section 3.3, tested the difference of the sample means to determine if they were statistically significantly different. The results are shown in Table 4-7.

Analysing the distributions for non-HFS, AHFS and CHFS, it was found that for all three the samples can be considered significantly different from each other at a level of significance of 0.95.

For CHFS this analysis was carried out for the 'Satisfactory' and the 'Unsatisfactory' distribution. It was found that the samples can also be considered significantly different from each other at a level of significance of 0.95.

This gives justification for using a basic visual assessment to characterise the performance of CHFS.

Table 4-7 Results for test of statistically significant difference (X – Different)

	Non-HFS	AHFS	CHFS	CHFS Satisfactory	CHFS Unsatisfactory
Non-HFS		X	X		
AHFS	X		X		
CHFS	X	X			
CHFS Satisfactory					X
CHFS Unsatisfactory				X	

4.6 Visual Comparison

Besides the results of the skid resistance surveys it was found that, unlike high risk sites surfaced with Calcined Bauxite HFS, sites with Alternative HFS are less distinguishable from other road sections due to the lack of a difference in colour. High risk sites are therefore less easily identifiable in advance and do not have any attention raising effect. Furthermore, visual surveys are less likely to be able to provide any indication of the likely skid resistance performance of the surfaces.

Figure 4-8 shows two of the surveyed HFS sites, left showing a junction approach surfaced with AHFS and right showing an approach to a pedestrian crossing surfaced with CHFS.

Figure 4-8 AHFS (Left, A34 Weeping Cross), CHFS (Right, Woosehill Spine Rd)

4.7 Long-term performance of AHFS

From the information provided by Highways England, three sites on the SRN were identified as having been surfaced with an AHFS material. For these sites skid resistance data for the years 2012 to 2015 were obtained from the HAPMS database. Figure 4-9 shows the variation in skid resistance over this four year period.

The sites are all located on the A21 between Blue Boy's Roundabout and Forstal Farm Roundabout, Tunbridge Wells. Sites 13 and 15 are 50m approaches to non-signalised junctions, whereas site 14 is a series of bends. Site 13 had been resurfaced in one direction only, resulting in seven sections for the three sites.

It should be noted that the surveys were undertaken in different months of the year but that the data have been corrected for in year and between year variations in skid resistance due to seasonal effects; being reported as Characteristic Skid Coefficient (CSC) values obtained from HAPMS.

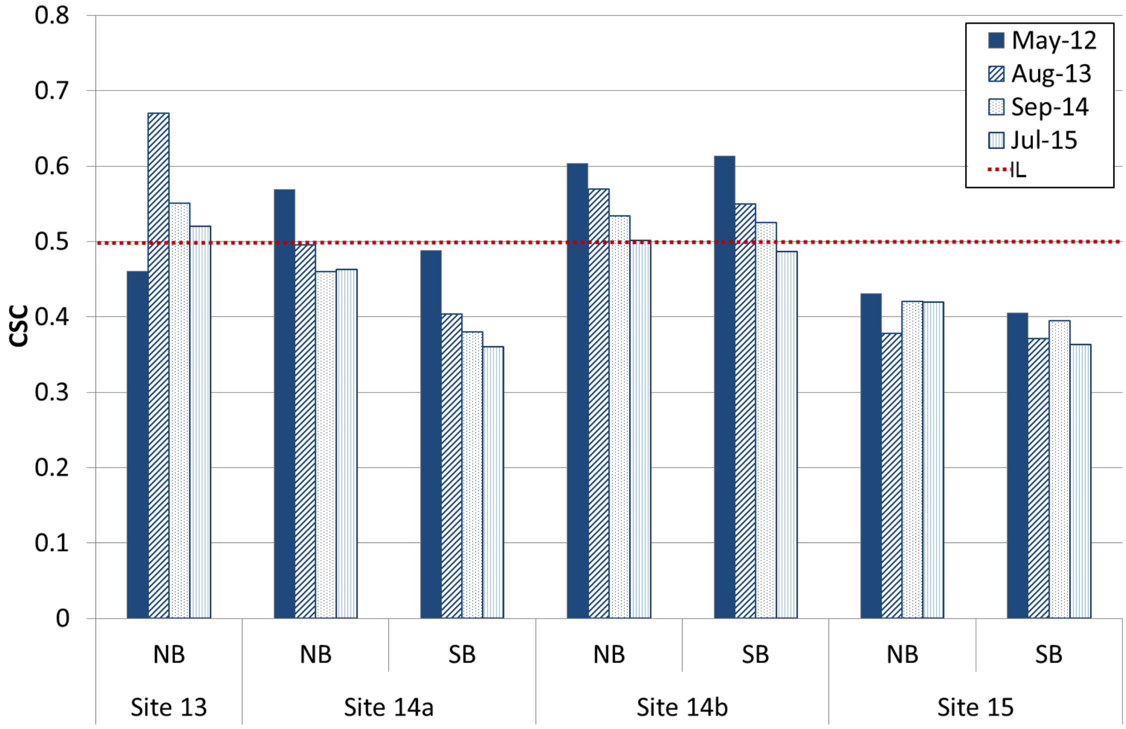


Figure 4-9 Four years performance of AHFS sites on A21

The first survey after the surfaces on sites 14 and 15 were laid was completed in May 2012, approximately 6-9 months after installation. For site 13, where no date laid information was available, the data suggest that the surface was likely to have been installed between the 2012 and 2013 surveys; however no information is available on the age of the surface at the time of the initial survey.

The data shows that four of the seven sections performed above the IL in their first year after installation. Site 13 showed the highest initial skid resistance value with 0.67. Site 14a SB and Site 15 failed to meet the required IL of 0.5 in the first year.

After the first year in service, all Sites show a decline in skid resistance values for the subsequent years. Four of the seven sections did not perform above the IL after their first year in service, with Site 15 reporting the lowest values of around 0.4 for all four years.

The CSC values reported for 2015 show that all Sites which were installed in 2011 dropped below the IL of 0.5. Site 13 showed values slightly above 0.5 but is also on a downward trend.

Overall the four year data show that two of the sites on the A21 did not provide sufficient skid resistance either during the initial period after laying or in subsequent years in order to meet the IL set according to HD28.

5 Discussion and conclusions

The aim of this work was to assess the performance of high friction surfacing materials, especially AHFS and whether they can be a suitable alternative for traditional HFS using Calcined Bauxite aggregates.

Investigations of available AHFS and CHFS materials were undertaken. For the assessment of the current performance, skid resistance surveys of AHFS and CHFS sites were carried out. The results of the study can be summarised as follows:

- a limited number of AHFS products are currently available, none of which are yet certified by the BBA;
- survey results indicate that AHFS materials do not provide as high a level of skid resistance as traditional CHFS materials, but a majority of the sites surveyed did achieve skid resistance values above the assigned IL;
- performance of AHFS varies with the assigned site category; site categories K and Q generally achieve lower skid resistance values than obtained on site category S2, even for surfaces in their initial period after laying;
- for CHFS sites, the level of stress at the site does not appear to have a significant impact on the measured skid resistance;
- performance of CHFS can be estimated from the condition of the surface; sites in an unsatisfactory condition are more likely to provide lower skid resistance levels.

In order to assess the long-term performance of AHFS, data from the annual skid resistance surveys of the SRN, available from HAPMS, were reviewed. The results of the long-term performance can be summarized as follows:

- Two of the three investigated AHFS sites reported skid resistance values above the assigned IL for the first year of service, but by the fourth year in service none of these sites met the IL.
- As data were available for only one material type on a limited number of sites and for a relatively short period of time, an overall conclusion for the general long term performance of AHFS is not feasible.
- CHFS sites reported a high percentage of skid resistance values above the IL. With increasing age and trafficking no clear reduction in skid resistance was shown. This suggests that the failure mechanism for CHFS is not due to polishing of the aggregate, but is attributable to deterioration in the overall surface condition.
- Using data available in HAPMS a calculation of the service lives of CHFS sites was not possible. However, a substantial reduction in the occurrence of sites over eight years old was observed. This could therefore be indicative of the service life of CHFS.

Analysis of current and long-term performance showed similar characteristics; namely, a reduction in performance on site category K and Q, and a greater overall performance of CHFS compared with AHFS. From the findings of this work it can be concluded that currently available AHFS products are not able to consistently achieve skid resistance levels similar to traditional Calcined Bauxite HFS and may not yet be a suitable replacement for sites where stress levels are particularly high.

Taking account of the findings from this study the following recommendations can be given;

- use of Calcined Bauxite aggregates for HFS should be continued for high risk sites,
- in order to assess the in situ performance of CHFS, the visual condition can provide an indication of the likely general level of skid resistance,
- AHFS materials may be suitable for some high risk sites but a better understanding of the parameters influencing the skid resistance performance is needed to enable suitable sites to be identified.

Acknowledgements

We would like to gratefully acknowledge the assistance of CH2M and the Mineral Product Association in identifying suitable sites and materials for testing as well as the collation of experiences from road authorities. We would also like to thank the material producers and local authorities that provided information on the location of AHFS materials.

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Appendix A Request for MPA

High PSV surfacings vs High Friction Surfacings (HFS) – performance review

New project

TRL is about to carry out a short programme of work, for the Highways Agency, comparing the performance and deterioration mechanisms of HFS with those of high PSV natural aggregate thin surface course systems.

Background

Sites where there is more stress imparted to the surface (gradients, junction approaches, roundabouts), especially those carrying large volumes of traffic, require aggregate with higher resistance to polishing in order to maintain skid resistance above the Investigatory Level (IL) set out in skid policy documentation, HD28. Polish resistance is measured using the Polished Stone Value (PSV) test and natural aggregate is available with PSV up to, or just above, 68. Where the traffic level or traffic induced stress is very high, it is expected that surfaces using natural aggregate with even the highest PSV will not be able to retain sufficient skid resistance in service to meet IL. In these locations it is recommended that a High Friction Surfacing (HFS) is used, which currently means, in practice, the use of a "specialised high friction surfacing, incorporating calcined bauxite".

The expected lifetime of HFS is reported to be between 4 and 8 years. However, it has been suggested that their deterioration is much more rapid and whole life cost is much higher than expected. Consequently, thin surface course systems with high PSV natural aggregate have been used, as a departure from standards, to achieve skid resistance at some high stress or high traffic locations that would normally require HFS. It has been shown that thin surface course systems, especially those using small coarse aggregates, can achieve higher skid resistance than hot rolled asphalt using aggregate of the same PSV; this is the basis of the guidance published in IAN 156/12.

However, the long term in-service performance of high PSV surfacings, laid at high stress sites, is not well understood.

The aim of this project is a better understanding of the long term performance of high PSV surfacings. In particular, the goal is to determine whether they retain their skid resistance to a sufficient extent to allow their use as an alternative to HFS using calcined bauxite

Request

We would like to identify the availability and use of high PSV surfacings on the network.

Please consider sending us details of materials that you offer as an alternative to cold or hot applied HFS, where they are currently in use and, if available, an indication of their performance.

As always, commercially sensitive information will not be published and all results will be made anonymous for reporting purposes.

For further information about the project please contact Fiona Coyle. fcoyle@trl.co.uk

TRL
Crowthorne House, Nine Mile Ride, Wokingham
Berkshire, RG40 3GA, United Kingdom
T: +44(0)1344 773131
F: +44(0)1344 770356
E: enquiries@trl.co.uk
www.trl.co.uk

Appendix B Questionnaire

The TRL Halcrow joint venture for transport

TRL Halcrow A CH2M HILL COMPANY

This is the Required section; please complete all this information to enable our research.

Questions regarding the Location

(Please respond for areas of Thin Course Surfacing System (TSCS) that has been used in lieu of High Friction Surfacing (HFS) Only)

	1. Road Name *e.g. Newton Lane*	2. GPS co-ordinates / Ordanance Survey Grid Reference *e.g. E: 460900, N: 300600*	3. Traffic Data *e.g. Traffic counts / AADT*
Site 1			
Site 2			
Site 3			
Site 4			
Site 5			
Site 6			
Site 7			
Site 8			
Site 9			
Site 10			

Please send responses to: helena.turner@ch2m.com by 9am on Friday 3rd October 2014

The TRL Halcrow joint venture for transport

TRL Halcrow A CH2M HILL COMPANY

This is the Optional section; please complete any questions you have information for

Questions regarding the Location

(Please respond for areas of Thin Course Surfacing System (TSCS) that has been used in lieu of High Friction Surfacing (HFS) Only)

	4. Road Geometry *e.g. Approaches to pedestrian crossings*	5. Visual Condition Inspection Results / Photographs *e.g. (share information)*	6. Any other information
Site 1			
Site 2			
Site 3			
Site 4			
Site 5			
Site 6			
Site 7			
Site 8			
Site 9			
Site 10			

Questions regarding the Material

(Please respond for areas of Thin Course Surfacing System (TSCS) that has been used in lieu of High Friction Surfacing (HFS) Only)

	7. Material / Product Name *e.g. AC 14 / 14mm SMA Tex*	8. Aggregate Size *e.g. 14mm*	9. Aggregate Source *e.g. Bardon*	10. Date of construction *e.g. 2011*	11. Contractor used for construction *e.g. Aggregate Industries*	12. Any other information
Site 1						
Site 2						
Site 3						
Site 4						
Site 5						
Site 6						
Site 7						
Site 8						
Site 9						
Site 10						

Questions regarding the Performance						
(Please respond for areas of Thin Course Surfacing System (TSCS) that has been used in lieu of High Friction Surfacing (HFS) Only)						
	13. Maintenance / Replacement History *e.g. Cat 1 in 2012; repair pothole, Cat 2.1 in 2013; repair patch*	**14. Results of Safety Audits in Accordance with 19/03** *e.g.(share audit)*	**15. Experience / Evidence of Geometry which Deteriorate Faster than Designed**	**16. Details of local PSV policy if different to IAN 156/12**	**17. Local experience of deterioration / Life Expectancy of HFS**	**18. Any other information**
Site 1						
Site 2						
Site 3						
Site 4						
Site 5						
Site 6						
Site 7						
Site 8						
Site 9						
Site 10						
Please send responses to: helena.turner@ch2m.com by 9am on Friday 3rd October 2014						

Appendix C AHFS Survey sites

Site	Location			Description provided	Material
1	U6005	Albert Road	Tamworth	Immediately off A513 Offadrive RDB	2
2	A51	Western Bypass	Lichfield	Controlled crossing NW off Bowling Green RDB	2
3	A462	Bursnips Road	Springhill	Approx 100m north of B4156 Hobnock Rd jct	2
4	A34	Stafford Road	Cannock	Controlled crossing innediately off park road roundabout	2
6	A513	Milford Road	Stafford	Area around Stockton Lane	2
7	A34	Weeping Cross	Stafford	Just south of the mini roundabouts	2
9	A285	Duncton High Street	Duncton	Series of bends 30mph speed limit	1
10	A29	Fairmile Bottom	Slindon	None	1
11	A259	Brighton Road	Lancing	None	1
13	A21 and B2244	Tollgate road, northbound approach		None	1
14a	A21	Clayhill Road to Blue Boys roundabout		None	1
14b					1
15	A21	Cuckoo Lane		None	1
17	A46	Dale Road	Rowsley	None	3
18	A6	Loughborough Road	Leicester	None	3

Appendix D CHFS Survey sites

Site	Location		Dir.	Description	Site type	Condition category		SC(50)
1	A4	London Road	EB	Bus stop North Earley	PDX	Suspect	E	0.43
2	A4	London Road	EB	Before RBT Reading Road	PDX	Acceptable	D	0.56
3	A4	London Road	EB	Sonning Lane	JCT	Moderate	C	0.68
4	A4	London Road	EB	Before RBT Pound Lane	PDX	Acceptable	D	0.56
5	A4	London Road	EB	Pound Lane	RBT	Good	B	0.61
6	A4	London Road	EB	Park View Drive	JCT	Good	B	0.67
7	A4	London Road	WB	Park View Drive	JCT	Moderate	C	0.64
8	A4	London Road	WB	Pound Lane	RBT	Good	B	0.60
9	A4	London Road	WB	After RBT Reading Road	PDX	Suspect	E	0.50
10	A4	London Road	WB	Sonning Lane	JCT	Moderate	C	0.64
11	A4	London Road	WB	After RBT Reading Road	PDX	Suspect	E	0.57
12	A4	London Road	WB	Bus stop North Earley	PDX	Poor	F	0.42
13	A4	London Road	WB	Before RBT Suttons Park	PDX	Good	B	0.63
14	A4	London Road	WB	A3290	RDB	Good	B	0.67
15	Woosehill Spine Road		SB	Old Woosehill Lane	PDX	Excellent	A	0.69
16	Woosehill Spine Road		NB	Old Woosehill Lane	PDX	Excellent	A	0.69
17	B3430	Nine Mile Ride	EB	Right Bend	Bend	Good	B	0.56
18	B3430	Nine Mile Ride	EB	Left Bend	Bend	Good	B	0.55
19	B3430	Nine Mile Ride	EB	Left Bend	Bend	Good	B	0.58
20	B3430	Nine Mile Ride	WB	Right Bend	Bend	Good	B	0.54
21	B3430	Nine Mile Ride	WB	Right Bend	Bend	Moderate	C	0.54
22	B3430	Nine Mile Ride	WB	Left Bend	Bend	Moderate	C	0.61
23	B3430	Nine Mile Ride	WB	Foresters Way	RBT	Good	B	0.53
24	A3095	Marshall Road	NB	Supermarket	JCT	Good	B	0.51
25	A3095	Marshall Road	NB	Laundry Lane	JCT	Moderate	C	0.48
26	A3095	Marshall Road	NB	Raeburn Way	RBT	Good	B	0.60
27	A3095	Marshall Road	SB	Supermarket	JCT	Good	B	0.44
28	A30	London Road	WB	High Street	PDX	Excellent	A	0.66
29	A30	London Road	WB	London Road / Middleton Road	PDX	Good	B	0.54
30	A30	London Road	WB	Lower Charles Street	JCT	Moderate	C	0.59
31	A30	London Road	WB	The Avenue	PDX	Good	B	0.56

32	A30	London Road	WB	London Road	PDX	Acceptable	D	0.57
33	A30	London Road	WB	Victoria Road	PDX	Good	B	0.54
34	A30	London Road	WB	Restaurant	JCT	Excellent	A	0.65
35	A30	London Road	WB	Rosemary Lane	JCT	Good	B	0.54
36	A30	London Road	WB	Cricket Hill Lane	RBT	Good	B	0.56
37	A30	London Road	WB	Blackbush Airport	Access	Bad	G	0.42
38	A30	London Road	WB	Hartley Witney	OB	Poor	F	0.40
39	A30	London Road	EB	Hartley Witney	OB	Suspect	E	0.40
40	A30	London Road	EB	Hares Lane	JCT	Good	B	0.45
41	A30	London Road	EB	Hulfords Lane	JCT	Good	B	0.63
42	A30	London Road	EB	A327	JCT	Suspect	E	0.53
43	A30	London Road	EB	Cricket Hill Lane	RBT	Good	B	0.56
44	A30	London Road	EB	Rosemary Lane	JCT	Moderate	C	0.58
45	A30	London Road	EB	Blackwater	PDX	Moderate	C	0.54
46	A30	London Road	EB	Victoria Road	PDX	Good	B	0.58
47	A30	London Road	EB	Frimely Road	JCT	Moderate	C	0.51
48	A30	London Road	EB	The Avenue	PDX	Moderate	C	0.50
49	A30	London Road	EB	Lower Charles Street	JCT	Moderate	C	0.59
50	A30	London Road	EB	Park Street	JCT	Poor	F	0.63
51	A30	London Road	EB	London Road / Middleton Road	PDX	Moderate	C	0.53
52	A30	London Road	EB	Caesar Camp Road	JCT	Good	B	0.67
53	A30	London Road	EB	Waterers Way	JCT	Good	B	0.56
54	A30	London Road	EB	Higgs Lane	JCT	Good	B	0.60
55	A30	London Road	EB	High Street	PDX	Moderate	C	0.53

The performance of alternatives to traditional high friction surfacings

It is the aim of this work to assess the performance of asphalt pavement surfacings utilising aggregates with high Polished Stone Values (PSVs) as alternatives to calcined bauxite high friction surfacing. This report provides details of measurements that were undertaken to assess the skid resistance performance of high PSV surfacings currently in operation on the UK road network. The results are compared to the Investigatory Levels (IL) of skid resistance required for each specific site, and also to the skid resistance that would be required for 'high-risk' sites where HFS incorporating Calcined Bauxite is conventionally used.

TRL
Crowthorne House, Nine Mile Ride,
Wokingham, Berkshire, RG40 3GA,
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

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