

# Guidance Note on Surface Dressing Aggregates

## 1 INTRODUCTION

There are three types of aggregates used for surface dressing:

**Crushed rocks**

**Crushed gravels**

**Artificial aggregates**

Pending the introduction of European standards, the requirements for single size aggregates to be used in surface dressing in the United Kingdom are specified in BS EN 13043:2002 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas which is the European harmonised specification which replaces British Standard 63 Part 2. Nominal sizes, normally used in this country are 2.8/6.3, 6.3/10, 8/14, 14/20 mm.

BS EN 13043:2002 has a corresponding Published Document PD 6682-2:2002, this document gives guidance on the use of the standard and in Table 4 gives the preferred grading requirements for the different sizes. Annex A of the PD 6682-2:2002 gives an example specification for surface dressing aggregate with suggested values for aggregate physical properties.

The correct size of chipping for use in a surface dressing on any particular section of road should be determined in accordance with the recommendations contained in Road Note 39, 6<sup>th</sup> edition published in January 2008.

The principal factors are the road hardness measured by a Hardness Probe<sup>(1)</sup>, the number of commercial vehicles carried each day, total traffic volume, traffic speed and altitude above sea level.

Size is not the only consideration, and other qualities required for surface dressing chippings are listed below, the values required being dependent upon the circumstances at each site:

- (a) **Resistance to fragmentation**
- (b) **Resistance to polishing**
- (c) **Satisfactory shape**
- (d) **Resistance to abrasion**
- (e) **Affinity to surface dressing binder**

These Qualities are measured and expressed in the following terms, as detailed in British Standards or elsewhere and described in the following pages:

- (a) Los Angeles Test, a maximum value of 30 would normally be specified
- (b) Polished stone value – **PSV**

Values of 45 to 70, depending on the risk rating of the site.

- (c) Flakiness index – **FI**  
A maximum flakiness index of 20 would normally be specified.  
A flakiness index of 20 is practically impossible to achieve for 2.8/6.3mm therefore a maximum of 25 is recommended.
- (d) Aggregate abrasion value – **AAV**.  
Values of less than 10 are usually specified in accordance with PD 6682-2 in line with the Highways Agency design manual.
- (e) The immersion tray test – degree of binder adhesion expressed as a percentage (not applicable to emulsified binders)

## 2 **LOS ANGELES TEST**

With the implementation of harmonised European Standards, the Los Angeles Test has replaced the Ten Percent Fines Value test as a measure of rock “strength”. The test procedure is given in BS EN 1097 Part 2 and measures an aggregate’s resistance to fragmentation rather than its compressive strength.

The test procedure is to place an aggregate sample in a revolving steel drum along with a charge of large steel balls. By carrying out a grading of the sample before and after the prescribed test period, a determination of the degree of fragmentation created during the test can be established and is reported as the Los Angeles Value.

## 3 **POLISHED STONE VALUE PSV**

Freshly laid surfaces using almost any type of aggregate will initially provide similar resistance to skidding. Some aggregates however quickly polish under the action of traffic which reduces the resistance to skidding. Aggregates which quickly polish under the action of traffic tend to have low PSV’s whilst those that resist polishing tend to have a high PSV. It should be noted some high PSV aggregates can also experience rapid polishing resulting in lower in-situ PSV measured by SCRIM or grip tester. Conversely, some lower PSV aggregates can out perform their laboratory PSV result. This factor is very much dependent on the geology of the aggregate and is often termed ePSV or effective PSV of the aggregate.

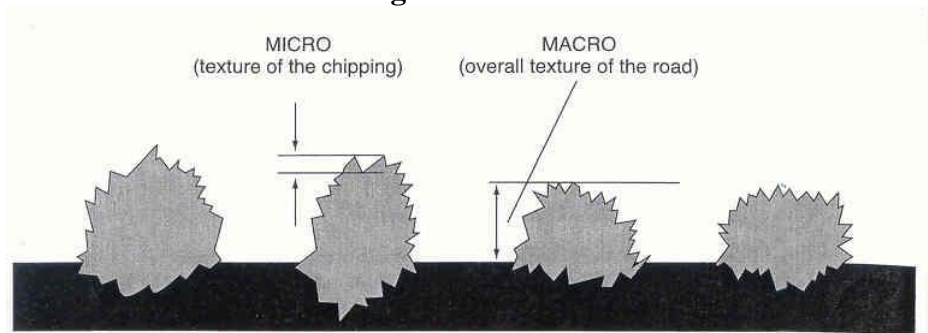
The PSV test attempts to reproduce in the laboratory the polishing effect of vehicle tyres on aggregates. In order to carry out this test which is described in BS EN 1097 Part 8, 6.3/10 mm sized samples of the aggregate to be tested are prepared in a curved mould and set in epoxy resin. The prepared samples are then mounted on the circumference of a wheel as shown in Figure 1, the wheel is then rotated, and a loaded rubber wheel is applied to the samples. Water and coarse emery is then fed between the samples and the rubber wheel for a given time. The samples are then washed and the process repeated using emery flour and water for a further period of time. The samples are then subjected to a pendulum test; see Figure 2, where a

pendulum with a standard rubber slider is swung over the sample under controlled conditions. The polished stone value is measured by the degree of retardation of the pendulum caused by the friction between the rubber pendulum and the sample.

Although this test is reasonably reproducible for a given sample of aggregate, aggregates from a quarry or gravel pit vary and for this reason the polished stone value of a particular aggregate should refer to the mean of the three most recent consecutive results carried out in the previous six months, or by the average range of values excluding the maximum and minimum values. In this way an aggregate may be referred to as having a PSV of 55 – 60 or 60 – 65. At sites carrying high volumes of heavy commercial vehicles, where there are tight bends, steep gradients, and where there are traffic lights at junctions or pedestrian crossings, PSV's 65 -70 are often specified. At sites carrying up to 750 commercial vehicles per lane per day on main line sections of motorway and other dual carriageways, where heavy braking and turning is unlikely to occur, a PSV of about 55 should normally be satisfactory and on single carriageway minor roads of similar character, a PSV of about 50 is normally acceptable.

In general terms, as the volume of heavy commercial vehicles increases and events such as junctions, bends and gradients are present, higher polished stone values are necessary to maintain a satisfactory resistance to skidding under dry conditions. The maintenance of skidding resistance under wet and dry conditions is also dependent upon surface texture (see Figure 3) and vehicle tyre treads<sup>(2)</sup>.

**Figure 3<sup>1</sup>**



#### **4 AVAILABILITY OF HIGH PSV AGGREGATES**

At the present time, only a limited number of quarries in the United Kingdom consistently produce chippings for surface dressing with an accepted PSV of 68 or above, and four or five produce surface dressing aggregates with a PSV of 65 or above. Calcined bauxite imported from Guyana and China have been shown to have PSV's of about 70, but they are significantly more expensive than the best surface dressing chippings available within the United Kingdom. In spite of this, their use at the limited number of sites where they are needed to maintain satisfactory levels of skidding resistance can be justified in accident reduction terms. On the other hand, the use of aggregates with PSV's in excess of those required to meet particular site conditions cannot be justified in financial terms and also represent a waste of a scarce national resource.

<sup>1</sup> 5<sup>th</sup> Edition Shell Handbook, Dr. John Read & Mr David Whiteoak

In recent years, the demand for high PSV chippings exceeded the supply and it seems likely that this will continue to be the case in the foreseeable future as commercial traffic volumes grow. Unless the PSV selected is kept to the minimum level necessary for particular site conditions, there will be a shortage for some sites requiring higher levels of PSV, these then having an unacceptable accident risk under wet conditions.

## 5 FLAKINESS INDEX FI

This test is described in BS EN 933 Part 3. In the test a flake sieve consisting of steel rods of specified dimensions is used in order to determine the percentage by weight of flaky chippings. This characteristic is important in surface dressing because after initial rolling and compaction by traffic, individual chippings will tend to lie on their longest dimension and a flaky chipping will not stand above the binder film to the same extent as a more cubically shaped chipping.

Figure 4<sup>2</sup>



Flakiness Sieve

## 6 AGGREGATES ABRASION VALUE AAV

This test is described in BE EN 1097 Part 8 and is used to simulate the abrasion caused by traffic on chippings in a road surface. In the test, nominal 10/14 mm chippings are mounted in a shallow tray and subjected to wear by means of a lapping machine fed with sand as the abrasive, at a constant speed, for a given time. The percentage loss in weight on the sample at the end of this period is used to calculate the abrasion value.

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<sup>2</sup> European Aggregates Standard Flakiness Sieve

## 7. IMMERSION TRAY TEST

The immersion tray test is not applicable to emulsion binders. This test has two objectives. The first is to determine the compatibility of the aggregate and binder selected for the dressing, and the second is to indicate the quantity of adhesion agent required to improve the bond between chipping and binder to an acceptable level. The test, which is described in Road Note 39, consists of applying a film of the binder at a thickness of about 1½ mm onto a small tray and allowing it to cool to about 20° C. It is then immersed in water to a depth of 25 mm, the water having previously been heated to 20°. Six or more pieces of aggregate, usually of 14 mm nominal size, are then applied to the binder film under water and lightly pressed into the binder film. After 10 minutes, the tray of binder is removed from the water tank and the chippings carefully removed and the percentage of binder retained on the chippings is visually assessed and recorded. The new European standard BS EN 12697 Part 11, Affinity to bituminous binders covers the testing specification.

Where good adhesion between chippings and binder is not indicated by this test and cut back binder is to be used, adhesion can be improved by one or more of the following methods:

- (a) chemically coating the chippings,
- (b) spraying adhesion agent on top of the binder film before the chippings are applied to the road surface,
- (c) adding an adhesion agent to the binder in the spray tanker before spraying commences, or
- (d) heating the chippings before application to the binder film.

It is most important that after coating, chippings are free flowing and this is far more important than a requirement that the chippings should be not less than 90% coated. Many different grades of binder have been used but it is recommended that a binder of 40/60 Pen is used. As a rough guide 0.5%-1% of bitumen by weight should be enough to provide a satisfactory coating but it is necessary to ensure that the binder applied to the chippings has not been burnt or carbonised. They should not be used with emulsions as this will seriously delay the break of the emulsion resulting in an unstable dressing during its early life.

Coating chippings with a chemical designed to enhance adhesion has been used successfully. The presence of the coating cannot, however, be visually detected. As with coated chippings, their use is not recommended with emulsion binders as this will seriously delay the break of the emulsion.

Applying a fine spray of adhesion agent directly onto the binder film onto the road immediately before the chippings are applied is probably the most effective method other than precoating of chippings and applies the adhesion agent only at the point where it is required. It is also possible to start and stop the operation quickly as circumstances demand.

Adding adhesion agents to bitumen tankers before spraying commences is expensive – some £15 per thousand litres treated at 2000 prices. The agent has to be added to the tanker and circulated for a minimum of 20 minutes, thus losing productive time. The effectiveness of some adhesion agents added to binders in this way diminishes quite rapidly with time and treated binders lose some of the effect when used on the following day. The adding of adhesion agent will also lower the viscosity of the treated binder.

## 8 TEXTURE AND RESISTANCE TO SKIDDING

Methods for measuring texture depth are given in BS EN 13036-1. While the PSV of the aggregate in a surface dressing plays a significant part in the resultant levels of skidding resistance, the texture of the surface as a whole is also important. As traffic speeds increase, surface texture becomes more important, because, under wet conditions, the texture provides a space into which water can be displaced as vehicle tyres pass over the surface. In this way contact is maintained between the chippings in the road surface and vehicle tyres. Tyres with poor treads on roads with very smooth textures can, under wet conditions, result in aquaplaning, ie the vehicle ceases to respond to steering or braking. Good textures are required on roads where vehicle speeds are likely to exceed 50 km per hour.

Prior to 1990, the traditional way of measuring texture was by spreading a known volume of sand, of a standard grading, in a circle on a dry road surface until it could be spread no further, as the sand filled the texture on the road surface. The texture depth was then expressed as a relationship between the volume of sand and the area of the patch. Under this method, known as the **sand patch test**, large diameter circles indicate poor texture, while on a road with a good texture, sand patches are relatively small, although to measure the texture depth accurately it is sometimes necessary to alter the volume of sand. The test method for this particular test has now been amended to use glass beads instead of sand and hence is simply known as the Patch Test.

The fact that this method of measuring texture was slow led the Department of Transport's Research Laboratory to develop the **high speed texture meter (HSTM)**. This apparatus consists of a trailer which can be drawn behind a vehicle travelling at normal traffic speeds. Lasers and microprocessors continually record details of the road texture and other characteristics including gradient, crossfall and curvature. Texture measurements resulting from the high speed texture meter are not identical to those measured using the patch method, but they do provide a reliable comparison between different textures, and the speed at which the apparatus operates allows regular monitoring of the texture of the most heavily trafficked roads.

A less versatile, and consequently cheaper, mini laser texture meter has also been developed by the TRL. This apparatus measures the average **Sensor Metered Texture Depth (SMTD)** over 50 metre test lengths.

At the present time the Patch Test is the only test contractually acceptable in the case of dispute.

The skidding resistance can be assessed by measuring the **sideways force co-efficient (SFC)**. The apparatus used is the **sideways co-efficient routine investigation machine (SCRIM)**. This vehicle is a lorry with a test wheel mounted between the axles of the vehicle, at an angle of 20° to the forward direction of the vehicle. The forces acting on the wheel when the vehicle is travelling at 50 km per hour on a wet surface are used to calculate the SFC<sub>50</sub>. The wetting of the road is achieved by applying water in front of the test wheel from a storage tank mounted on the vehicle. Because the SFC of a road surface varies throughout the year, SFC measurements are taken during the summer when values are at their lowest. A series of tests are taken on each section of road to be assessed between the months of May to October. These measurements give the **mean summer sideways co-efficient at 50 km per hour – MSSC<sub>50</sub>**. Department of Transport Advice Note HA/36/87 has established that there is a rough relationship between SFC<sub>50</sub> and the portable skid resistance pendulum tester which is used for determining the polished stone value. The pendulum produces a **skid resistance value (SRV)** and SRV is approximately equal to 105 x SFC<sub>50</sub>.

A more mobile and versatile method of measuring skid resistance is by use of the Griptester. This is a trailer mounted piece of equipment having a test wheel geared down from the trailer axle; the resultant drag created on the test wheel is converted into a Gripnumber. There is a correlation between Griptester and SCRIM although, currently, SCRIM is the only contractually acceptable method of measurement.

## 9 DEPARTMENT OF TRANSPORT AND LOCAL STANDARDS OF MSSC<sub>50</sub>

In 1987, desirable minimum MSSC<sub>50</sub> levels were set down for the first time by the Department of Transport for trunk roads and motorways under their control, and this was followed a little later by advice from the Local Authorities' Association<sup>(3)</sup> on the levels appropriate for the less important roads. The values which have been indicated in these documents are described as **investigatory limits**, below which consideration should be given to the action necessary to improve the skidding resistance of the road in question. It is likely that investigatory levels are to be the subject of continual review in the light of experience and increases in traffic volumes.

## 10 RELATIONSHIP BETWEEN MSSC<sub>50</sub>, PSV AND COMMERCIAL TRAFFIC LEVELS

Figure 7.3.1 of Road Note 39 (6<sup>th</sup> edition) which is reproduced below with the permission of the TRL, shows minimum PSV requirements for different sites and commercial vehicle trafficking. Research undertaken by many highway authorities has indicated that immediately after the completion of a surface dressing, the SFC is at its maximum but that it falls over about the first 12 to 18 months but thereafter maintains a more or less constant mean summer average as long as the road remains in a satisfactory condition.

Figure 5<sup>3</sup>

IL Band	Default IL	Site categories	Site definition	Traffic (cv/lane/day) at design life									
				0 to 250	251 to 500	501 to 750	751 to 1000	1001 to 2000	2001 to 3000	3001 to 4000	4001 to 5000	5001 to 6000	Over 6000
I	0.35	A, B	Motorway (main line), dual carriageways (non-event)	50	50	50	50	50	55	60	60	65	65
Ia	0.35	A1	Motorway (main line), 300 m approaches to off-slip roads	50	50	50	55	55	60	60	65	65	65
II	0.40	C, D	Single carriageways (non-event), dual carriageways approaches to minor junctions	50	50	50	55	60	65	65	65	65	68+
III	0.45	E, F, G1, H1	Single carriageways minor junctions, approaches to and across major junctions, gradients 5-10 % >50 m (dual, downhill only), bends <250 m radius >40 mph	55	60	60	65	65	68+	68+	68+	68+	70+
IV	0.50	G2	Gradient >50 m long >10%	60	68+	68+	70+	70+	70+	70+	70+	70+	70+
V	0.55	J, K	Approaches to roundabouts, traffic signals, pedestrian crossings, railway level crossings and similar	68+	68+	68+	70+	70+	70+	70+	70+	70+	70+
VI	0.55 (20 km/h)	L	Roundabout	50-70+	55-70+	60-70+	60-70+	60-70+	65-70+	65-70+			
VII	0.60 (20 km/h)	H2	Bends <100 m	55-70+	60-70+	60-70+	65-70+	65-70+	65-70+	65-70+			

Notes:

- Where '68+' material is listed in this Table, none of the three most recent results from consecutive tests relating to the aggregate to be supplied shall fall below 68. See Paragraph 3.21.
- Throughout this Table '70+' means that specialised high-skidding resistant surfacings complying with MCHW 1 Clause 924 will be required.
- For site categories L and H2, a range is given and the PSV should be chosen on the basis of local experience of material performance. In the absence of other information, the highest values should be used.
- Investigatory Level (IL) is defined in Chapter 3 of HD 28 (DMRB 7.3.1).

***Always ensure that you are using the current version of this table – check at [www.standardsforhighways.co.uk/dmrb/vol7/section5/hd3606.pdf](http://www.standardsforhighways.co.uk/dmrb/vol7/section5/hd3606.pdf)***

## 11 STORAGE OF SURFACE DRESSING AGGREGATES

Because peak demand for surface dressing aggregates exists during the surface dressing season, it is necessary for highway authorities and contractors to take delivery of chippings over a period of months before the surface dressing season starts. For this reason, it is vital that chippings are stored in carefully selected locations, on well-drained hard-standings, free from dust of other fall-out, including leaves, and in bays where different sizes and different types of aggregates can be separated. Such storage areas should be located with easy access to main roads, and ideally at 10 or 12 mile centres for maximum efficiency. It is important that adequate space for lorries to turn and to load is available within the storage area, which should be secured against trespassers.

Even when all the above precautions have been taken, the long term storage of chippings can cause problems. Rain can wash small quantities of dust from

<sup>3</sup> Reproduced with kind permission of TRL

chippings near the top of the pile and concentrate the dust content at the bottom of the pile, contaminating these chippings and rendering them out of specification. The degree to which this happens depends very much on the nature of the chippings, but needs to be taken into account. Contamination of chippings and stockpiles can also occur when loading shovel drivers attempt to “tidy up” the site and by collecting chippings which have become deposited on the manoeuvring area of a chipping dump and replacing them on the stockpile, thus contaminate the stockpile. Loading shovel drivers should be made aware of this problem and the danger of “over handling” chippings at storage areas.

## **12 LOADING**

The more surface dressing chippings are handled, the greater the risk of abrasion resulting in an increased dust content. For this reason, mechanical loading or handling should be kept to a minimum, particularly when using high PSV aggregates, which, by their nature, are less resistant to abrasion.

## **13 COLOUR**

Surface dressing chippings are available in a wide range of colours including white, buff, grey, black, green, pink and red.

These are listed in Road Note 59 Sources of White and Coloured Aggregates in Great Britain. During the intervening time some of these sources have changed hands, whilst others have ceased production. Reference to the Directory of Quarries and Pits published by the Quarry Managers Journal Limited, 7 Regent Street, Nottingham, NG1 5BY, can be helpful in identifying whether or not the sources referred to in the Road Note are still available.

Light coloured aggregates can be an aid to safety, particularly at night in areas with a poor standard of street lighting. Colour can be used to differentiate minor roads from main roads, and through roads from housing estates or parking areas, and hard shoulders from carriageways. A careful combination of coloured aggregates can be both environmentally attractive and technically sound but, inevitably, the cost of coloured aggregates for any site will be heavily influenced by the distance between the site and the quarry.

## **14 SELECTION OF SURFACE DRESSING AGGREGATES**

There is a need to exercise engineering logic in the selection of surface dressing aggregates. There has been a temptation in recent years for some engineers to demand that surface dressing aggregates for use in their area should conform to more stringent requirements than those set out in BS EN 13043, particularly with regard to dust content. Unless that requirement is accompanied by similar extraordinary standards for the storage and handling of surface dressing chippings in perfect conditions and the pre-sweeping, or even washing, of roads before the application of binder, these requirements are illogical.

Improvement in the quality of surface dressing is much more likely to occur by greater attention to design, supervision and aftercare than to higher standards for either the aggregate or the binder used. Natural aggregates are a non-renewable resource and the best available should be regarded as a valuable national resource.

## **REFERENCES**

- 1     Hardness Probe  
      Farnell Limited of Borehamwood tel 0208238 6902  
      BS 598 – 112 : 2004 Method for the use of road surface hardness probe
- 2     TRL Research Report 296 (1991)  
      “The relation Between the Surface Texture of Roads and Accidents”  
      by P G Roe, D C Webster and G West
- 3     T R L Research Report 322 (1998)  
      “The Polished Stone Value of aggregates and in-service skidding resistance”  
      by P G Roe and S A Hartstone
- 4     Local Authorities Code of Practice for Highway Maintenance (1989)  
      Association of County Councils  
      ISBN 0 901 783 48 X