Guidance Note on Surface Dressing Aggregates

1 INTRODUCTION

There are three types of aggregates used for surface dressing:

Crushed rocks
Crushed gravels
Artificial aggregates

The requirements for single size aggregates to be used in surface dressing in the UK are specified in BSEN 13043:2002 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas which is the European harmonised specification replacing 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 6682-2:2009 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 6682-2:2009 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, 6th edition published in January 2008.

The principal factors are the road hardness measured by a Hardness Probe(1), 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 BSEN 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

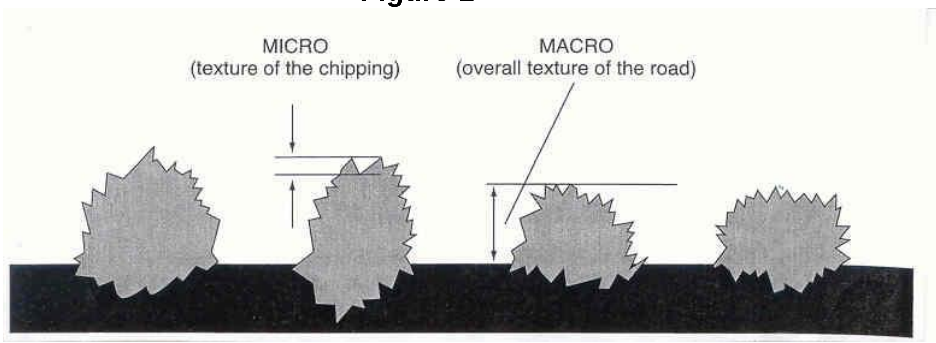
Freshly laid surfaces using almost any type of aggregate will initially provide similar resistance to skidding. Some aggregates however quickly polish under the action of traffic which reduces the resistance to skidding. Aggregates which quickly polish under the action of traffic tend to have low PSV’s 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 50 - 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[(2)].

Figure 1[1]



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. 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.

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.

[1] 5th Edition Shell Handbook, Dr. John Read & Mr David Whiteoak

5 FLAKINESS INDEX FI

This test is described in BSEN 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. Shape is also important to ensure good embedment into the road surface. For example a cubical chipping will give better embedment than a flaky chipping and will also give better texture depth and interlock (mosaic).

Figure 2[2]

6 AGGREGATES ABRASION VALUE AAV

This test is described in BSEN 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.

7. AFFINITY TO SURFACE DRESSING BINDER

Three methods are described in BSEN 12697-11 which determines the affinity between aggregate and bitumen with or without adhesion agents. The procedures give an indirect measure of the binder’s ability to adhere to the aggregate. The procedures can also be used to evaluate the effect of moisture on the binder-aggregate combination.

Rolling bottle method, not appropriate for abrasive aggregates

Specified quantities of sieved aggregate and bitumen are mixed together and allowed to cool at ambient on a metal plate or silicone paper. The cooled sample is split into three test portions which are added to part water filled test bottles. A glass rod is placed in each bottle before being topped up with water and sealed. Test

[2] European Aggregates Standard Flakiness Sieve

bottles are placed on a roller at a speed of rotation. After 6 hrs of rolling the test bottles, the aggregates are tipped into a bowl with fresh water and visually inspected for the level of bitumen coating coverage to the nearest 5%. The aggregate and water is returned to the test bottle and replaced on the roller for a further 18 hrs. A further visual estimate is made of the level of coating after a total of 24 hrs rolling. Optional observations can be made at 48 and 72 hours using the same process if required. Results are expressed as average bitumen coverage to the nearest 5 % for each rolling time

Static test method, can cope with high PSV aggregate

A specified mass of sieved aggregate is mixed with 4% binder by mass of aggregate, if complete coating is not achieved the binder can be increased until complete coating is achieved. Coated particles are placed in a flat container coated to cool. Sufficient water is added to the container to completely cover the coated particles and allowed to stand for 48 hrs at 19°C, other immersion times and temperatures can be used.

The water is decanted from the container and the particles allowed to dry, each particle is inspected for incomplete coating. If more than three particles have incomplete coverage repeat the test on three further samples. Results are the number of aggregate particles with incomplete bitumen coverage, or average of four where tested. A visual estimate can be made of the level of bitumen

Boiling water method

Can be used for any binder-aggregate combination, however, it is a more specialist test requiring skilled operatives and the use of chemicals which implies extra health & safety considerations.

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_{50}. 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** – $MSSC_{50}$. Department of Transport Advice Note HA/36/87 established that there is a rough relationship between SFC_{50} 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_{50}.

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 RELATIONSHIP BETWEEN $MSSC_{50}$, PSV AND COMMERCIAL TRAFFIC LEVELS

Figure 7.3.1 of Road Note 39 (6^{th} 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 3[3]

Site category	Site description	IL	Minimum PSV required for given IL, traffic level and type of site Traffic (cv/lane/day) at design life									
			0-250	251-500	501-750	751-1000	1001-2000	2001-3000	3001-4000	4001-5000	5001-6000	Over 6000
A1	Motorways where traffic is generally free-flowing on a relatively straight line	0.30	50	50	50	50	50	55	55	60	65	65
		0.35	50	50	50	50	50	60	60	60	65	65
A2	Motorways where some braking regularly occurs (eg. on 300m approach to an off-slip)	0.35	50	50	50	55	55	60	60	65	65	65
B1	Dual carriageways where traffic is generally free-flowing on a relatively straight line	0.3	50	50	50	50	50	55	55	60	65	65
		0.35	50	50	50	50	50	60	60	60	65	65
		0.4	50	50	50	55	60	65	65	65	65	68+
B2	Dual carriageways where some braking regularly occurs (eg. on 300m approach to an off-slip)	0.35	50	50	50	55	55	60	60	65	65	65
		0.4	55	60	60	65	65	68+	68+	68+	68+	68+
C	Single carriageways where traffic is generally free-flowing on a relatively straight line	0.35	50	50	50	55	55	60	60	65	65	65
		0.4	55	60	60	65	65	68+	68+	68+	68+	68+
		0.45	60	60	65	65	68+	68+	68+	68+	68+	68+
G1/G2	Gradients >5% longer than 50m as per HD	0.45	55	60	60	65	65	68+	68+	68+	68+	HFS
		28	0.5	60	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS
		0.55	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
K	Approaches to pedestrian crossings and other high risk situations	0.5	65	65	65	68+	68+	68+	HFS	HFS	HFS	HFS
		0.55	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
Q	Approaches to major and minor junctions on dual carriageways and single carriageways where frequent or sudden braking occurs but in a generally straight line	0.45	60	65	65	68+	68+	68+	68+	68+	68+	HFS
		0.5	65	65	65	68+	68+	68+	HFS	HFS	HFS	HFS
		0.55	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS
R	Roundabout circulation areas	0.45	50	55	60	60	65	65	68+	68+	HFS	HFS
		0.5	68+	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
S1/S2	Bends (radius <500m) on all types of road, including motorway link roads; other hazards that require combined braking and cornering	0.45	50	55	60	60	65	65	68+	68+	HFS	HFS
		0.5	68+	68+	68+	HFS	HFS	HFS	HFS	HFS	HFS	HFS
		0.55	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS	HFS

Minimum Polished Stone Value of Chippings
(Ref: Fig 7.3.1. Design manual for Roads and Bridges)

Note: Designers should always ensure that they are using the current version of this table www.standardsforhighways.co.uk/dmrb/vol7/section5/hd3606.pdf.

[3] Reproduced with kind permission of TRL

10 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 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.

11 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.

12 COLOUR

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

The “Directory of Quarries & Quarry Equipment” published by the Quarry Managers Journal Limited, 7 Regent Street, Nottingham, NG1 5BY, can be helpful in identifying the sources of coloured aggregates.

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.

13 SELECTION OF SURFACE DRESSING AGGREGATES

There is a need to exercise practical engineering judgment 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 and PD 6682, particularly with regard to dust content.

BS EN 13043 also recommends that, for surface dressing, the fines content should be *f*1 (i.e. not more than 1% passing through the 0.063 mm sieve). Some contractors might consider this level of fines (filler) to be too high for chippings from some sources and for some uses. Where this is the case a contractor may require a fines category of *f*0.5. It is recommended that contractors should demonstrate that chippings have adequate durability for the intended use, following the guidance in PD 6682-2. In many cases aggregates will require washing to achieve this fines category.

It is equally important that similarly high standards for the storage and handling of surface dressing chippings is adhered to too minimise dust generation and for careful pre-sweeping of roads before the application of emulsion binder.

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

BS 598 – 112: 2004 Method for the use of road surface hardness probe

Hardness Probe Suppliers

CNS Farnell (Engineering Test Equipment) Ltd
Elstree Business Centre Elstree Way, Borehamwood, Hertfordshire, WD6 1RX Tel:020 8238 6900

Materials Testing Equipment Limited. Gilwilly Industrial Estate, Penrith, Cumbria. CA11 9BQ Tel: 01768 865302
http://www.materialstestingequip.com/contact.htm

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

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

UK ROADS BOARD, Well-maintained Highways, Code of Practice for Highway Maintenance Management.
http://www.ukroadsliaisongroup.org/en/UKRLG-and-boards/uk-roads-board/wellmaintained-highways.cfm

APPENDIX A

FEEDBACK ON THIS DOCUMENT

Any observations, feedback or complaints ***relating to the content of this document*** **or the process described** herein should be addressed (using the form below) to:

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Issue Identified:

Suggested Action:

Name:

Organization:

Address:

Contact details:

Date:

APPENDIX B

DOCUMENT CONTROL

Issue Statement

Issue 5	2008
Issue 6	2011
Issue 7	2014

REVISION LIST – AMENDMENTS MADE IN THIS ISSUE

Revision	Page
Section 7 – Binder Aggregate affinity testing has been significantly re-written.	4
Figure 3 – minimum PSV of chippings introduced.	7