Technical Note 69

Aggregate for sprayed bituminous surfacing

The requirements of AS 2758.2 - 2009

1.0 Background to AS 2758

Australian Standards are prepared by committees of industry representatives who contribute their expert knowledge to ensure the information contained in a Standard reflects the best technical, scientific and system knowledge available.

In the case of AS 2758, Aggregates and rock for engineering purposes, a set of Standards has been developed to ensure uniform material compliance is identified and specified, thus minimising the risk of a failure in a project. AS 2758 comprises seven individual standards, viz:

AS 2758.0	Part 0 Definitions and classification
AS 2758.1	Part 1 Concrete aggregates
AS 2758.2	Part 2 Aggregate for sprayed bituminous surfacing
AS 2758.4	Part 4 Aggregate for gabion baskets and wire mattresses
AS 2758.5	Part 5 Coarse asphalt aggregates
AS 2758.6	Part 6 Guidelines for the specification of armourstone
AS 2758.7	Part 7 Railway ballast

This technical note provides background knowledge of the requirements when supplying aggregates for sprayed bituminous surfacing.

Aggregate produced from rock, gravel, metallurgical slag or synthetic materials may be used provided the particular criteria set out for the aggregate are met. AS 2758.2 sets out the requirements for the quality of a material source and the properties required of the coarse aggregate.

This Standard sets out best practice criteria as known at the time of publishing and should not be regarded as a stand-alone material works specification. Most Australian state road authorities have their own specification for aggregates supply into bituminous sealing works. These specifications will, in most instances, show material attributes that are either the same as or similar to those designated in the Australian Standard AS 2758.2.

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2.0 Aggregate/Bitumen Sealing Application

Aggregates are used in combination with bitumen in various sealing applications, including:

- Prime Seal Single Coats (Single/single, Single/double and Double/double)
- Reseal
- Strain Alleviating Membrane (SAM)
- Strain Alleviating Membrane Interlayer (SAMI)

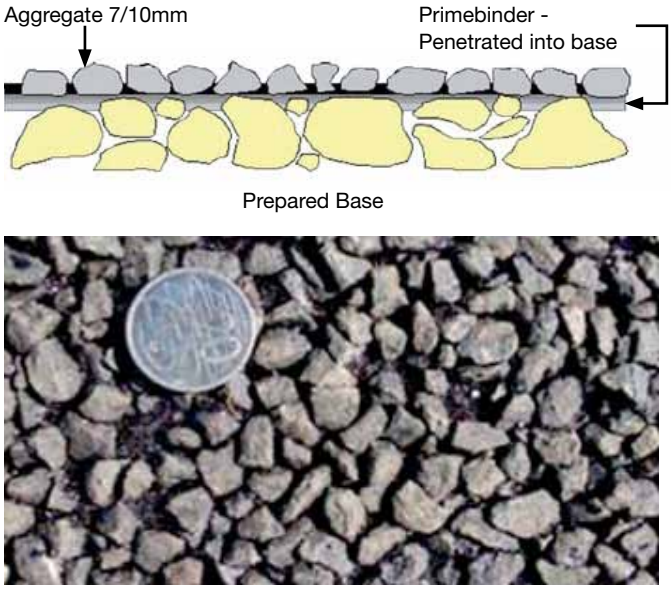

Figure 1: Typical primer seal layout

A Primer Seal provides a light weatherproof wearing surface which allows the pavement to be trafficked early, sometimes immediately after construction.

Seal coats consist of a sprayed application of bituminous binder which is then evenly coated with a select crushed aggregate that is compacted into its final position by rolling. The bitumen provides waterproofing for the surface of the underlying base and acts as an adhesion agent for the aggregate.

The aggregate wearing course then provides skid resistance under the abrasive action of traffic. It also provides protection for the bitumen from weathering and ultra violet light which causes the bitumen to "dry out" and thus accelerates aging of the bitumen. Seal coats rely on support from pavement materials beneath and must be compatible to ensure adhesion of the seal with the underlying layer interface and for aggregate retention. In general, single aggregate particles of 5, 7, 10 or 14mm are used.

The selection of the aggregate size depends on volume and composition of traffic, design life of the seal, noise level requirements, skid resistance characteristics, water spray and life- cycle costing. Generally, the life of a seal is between six and twelve years and is a function of the materials used, including the aggregate and bitumen combination(s). Correct choice of these materials is essential to match the loading and environmental conditions.

Reseals are applied directly over an existing sealed surface when the pavement requires remedial works, with aggregate size being selected on the basis of what will fit in the spaces between the aggregate in the existing seal. In this way aggregate interlock is achieved and the reseal will remain in service longer. The reseal aggregate may be smaller or larger than that in the original seal. Planning and consistent material properties are essential to ensure the correct aggregate size is available otherwise the reseal may not work as the aggregates will not interlock adequately.

Polymer or scrap rubber modified binders may be used where improved elastic behaviour of the seal is required.

A Strain Alleviating Membrane (SAM) is a single-layer seal in which a modified polymer or rubber binder is used with a single layer of aggregate. Binder is applied in a thicker layer than those used for conventional seals.

SAM seals are used to reduce reflection cracking, for waterproofing pavements and particularly bridge decks, and for improving stone retention in high traffic stress areas.

A Strain Alleviating Membrane Inter-layer (SAMI) is an application of modified binder, a single layer of aggregate, spread and rolled. SAMI is generally used as an intermediate layer to which an asphalt overlay will be applied. It is designed to alleviate tensile strains developed in underlying layers and therefore reduce the likelihood of fatigue failure in the overlay. SAMI is commonly used on already cracked pavements and generally use either 10 or 14mm aggregate.

Slurry Seals are usually used to improve ride quality of rural or lightly trafficked urban roads.

3.0 Aggregate properties and the test methods specified in AS 2758.2

3.1 General

AS 2758.2 outlines the test requirements for aggregates for sprayed bituminous surfacing. Each aggregate property is covered in a separate section of the Standard as follows:

- Section 8 Dimensional requirements designated as Grading, Shape (either by Misshapen Particle test or Flakiness Index test), Average Least Dimension and crushed particles.
- Section 9 covers Durability requirements designated as Wet Strength and Wet/Dry Strength Variation, Los Angeles Value, Sodium Sulfate Soundness and Unsound and Marginal Stone Content.

Note: Each Road Authority has, over time, adopted a test or series of tests for the aggregates available in its particular area. These have been based on test results and observed durability of aggregate in service.

- Section 10 outlines the requirement for weak particles.
- Section 11 covers the resistance to stripping of aggregates.
- Section 12 addresses frictional characteristics and refers to notes in Appendix A.

All tests referred to in AS 2758.2 are covered in the AS 1141 series of test methods. In some work specifications or Road Authority supply documents, the test methods stipulated may be from that Road Authority's own set of test methods. In general, however, these methods will be very similar to those specified in AS 1141.

3.2 Test methods and their purpose in the Standard

AS 2758.2 outlines the test requirements for aggregate for sprayed bituminous surfacing. Each aggregate property is covered in a separate section of the Standard as follows:

Dimensional requirements (Section 8)
The most ideal sealing aggregate would consist of particles of identical shape and size, made out of a hard and durable stone free from dust or deleterious matter with very few flat or elongated particles.

Grading (Clause 8.1)
Grading or Particle Size Distribution (PSD) is determined when a sample is tested in accordance with AS 1141.11.1 and AS 1141.11.2. Tables 1, 2 and 3 give the material sizing and acceptable tolerances for oversize and undersize.

The test for grading of the larger fractions, (greater than 75 µm) is carried out by sieving a sample in accordance with the requirements of AS 1141.11.1. This process is where an aggregate sample is shaken through a nest of standard sieve sizes from largest down to smallest. The result is generally reported as the percentage passing each individual sieve size. This test can be performed in either a dry state (a 'dry grading') or by wetting and washing (a 'wash grading').

The 75 micron (µm) size test is performed by wetting the sample to loosen and separate the very fine material from the bulk. The sample is then washed over a 75 µm sieve that (due to the delicacy of the sieve cloth) is protected during the test by the use of a larger sized sieve. This test can be either part of the AS 1141.11.1 test or as an individual test in accordance with AS 1141.12.

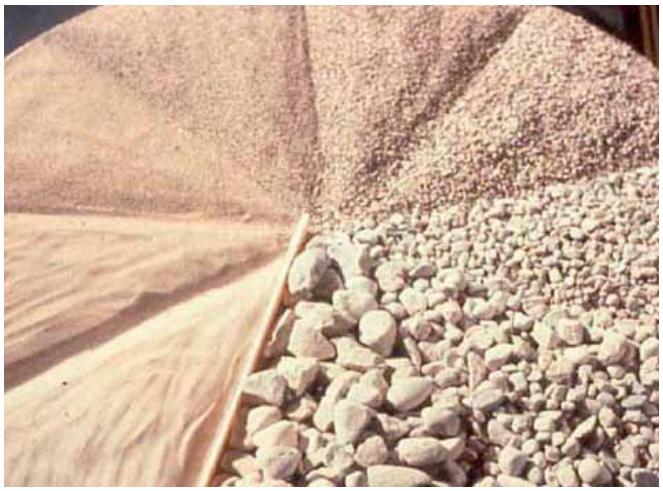

Figure 2: A sample graded into its individual sizes

Grading of aggregate is the most commonly requested test within this industry. The purpose of the test is to determine the varying amounts of material contained in standard size segments. For sealing works, the grading is an important factor in the final surface of the pavement and contributes to providing a smooth ride with low noise characteristics. This being the case, the aggregate for sealing is called single-sized aggregate as approximately 60% of the aggregate mass lies within one particular sieve size.

Single-sized aggregates will pack more efficiently in a seal application, and hence provides a more uniform pavement surface under vehicular traffic.

Shape (Clause 8.2)
The two methods specified for evaluating shape are: Particle Shape by Proportional Caliper and Flakiness Index. Particle shape samples are tested in accordance with AS 1141.14 the Misshapen Particle test. This test is carried out on sample fractions of material larger than 9.5mm and proportions representing fractions of greater than 10% of the sample.

The test is performed using a purpose-made proportional caliper, or vernier caliper, that can measure the length, width, and thickness of a stone. Calculations are then carried out to determine the various relationships of the pieces. The length to width and width-to-thickness ratio of each test particle is measured to determine if it is 'elongated', 'flat' or both. The proportion of Flat, Elongated or Flat-and-Elongated Particles is reported and a weighting factor is applied to provide an estimated measure of the proportion of misshapen aggregate particles in the sample when tested to either a 3:1 or 2:1 ratio. The Standard specifies a requirement of less than 10% for a ratio of 3:1 and less than 35% for a ratio of 2:1.

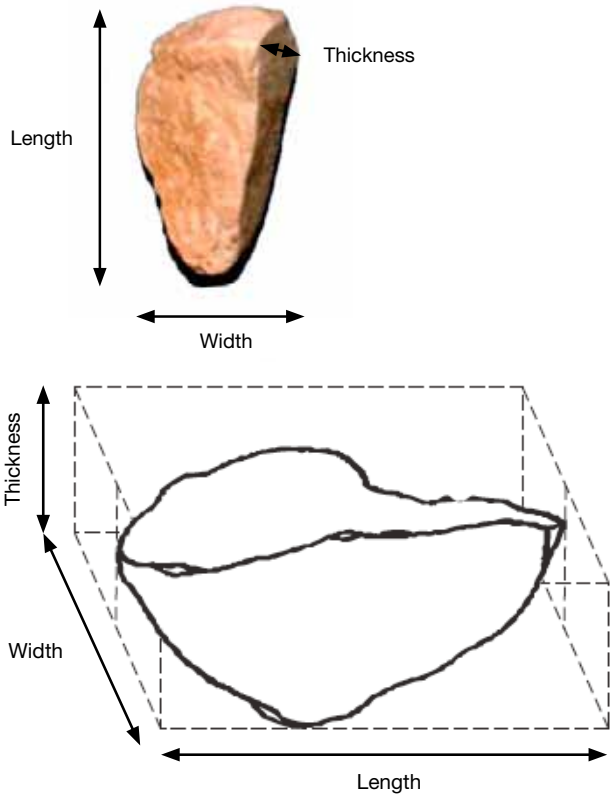

Figure 3: Standard stone dimensions

Flakiness Index Samples are prepared and tested in accordance with AS 1141.15. The various fractions of the sample are between 26.0 and 4.75mm and must represent more than 5% of the sample to be tested.

The test is performed using a measuring gauge that has standard sized slots which the sample pieces either pass through or are retained. The result is based on a combined calculation of that which passes through the slots versus that which is retained on the gauge. The Standard sets a level of less than 35% of flaky particles.

Figure 4: The Flakiness Index test gauge and Flakiness Index test slotted sieves

Average Least Dimension (Clause 8.3)
Average Least Dimension (ALD) is a most important test when supplying sealing aggregates. The test result is used to assess the final aggregate/bituminous binder matt of the pavement surface which is done via the aggregate spread rate. This allows for the determination of the amount of aggregate required to cover a given pavement area and is size dependant. The three methods of obtaining a result are shown in AS 1141.20.1, AS 1141.20.2 and AS 1141.20.3.

The 20.1 method is used for larger sized aggregate such as 20, 14 and 10mm.

The accuracy of the result is based on 2mm slot variations due to aggregate size.

The 20.2 method is used for the smaller sized aggregates such as 7 and 5mm. This form of the test is based on 1mm slot variations as the smaller size packs differently and gives a closer surface matt in the field.

The above two methods rely on passing the sample through a series of slots with the aggregate piece lying on its flattest side during the process. In this way particles are passed along the test equipment until they are retained at a given slot width. Once retained the amount is recorded against that slot size and a multiplying factor is applied. The average least dimension of the sample is obtained from calculating an average of these figures.

The 20.3 method is a calculation method for the ALD and is referred to as the nomograph method. It calculates the median size and ALD of an aggregate and is applicable for aggregates 7mm and greater based on grading data.

Figure 5: Differing styles of ALD measuring devices, the one on the bottom is the more commonly used

A change in grading during quarry aggregate production can affect the ALD result. The coarser the grading result of the produced aggregate, the higher the ALD result will be; and conversely, the finer the grading, the lower the ALD result.

A change in result can have an effect on cover rate requirements as the design will be based on a submitted result prior to delivery. Quarries must carefully consider their test result history so that designers are given relevant information.

Calculation of the design aggregate application rate is based on determining the amount of aggregate needed to create an even, single coat of aggregate on the pavement surface. It requires that the user consider the conditions of the surface being sealed as well as the conditions to which it will be subjected, all of which are important.

While many design methods are available, the following provides a good starting point and covers most situations:

$C = (1 - 0.4V) \times H \times G \times E$

Where:

C = Cover Aggregate (kg/m^2)

V = Voids in Loose Aggregate (%)

E = Wastage Factor (%)

H = ALD (mm)

G = Bulk Specific Gravity

Aggregate with 100% angular faces

Aggregate with some non-angular faces

Fractured Faces

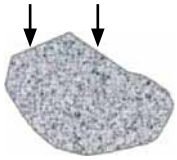

Figure 6: Examples of river gravel crushed faces

Crushed Particles (Clause 8.4)

The test for crushed particles is performed in accordance with AS 1141.18 and is a simple visual test used when selecting either river gravels or conglomerates for use in sealing projects.

The test is performed to ensure that these types of aggregate have been mechanically altered by means of crushing to have a percentage of broken faces that will enhance their bond with the bituminous binder in a surface sealing application. The broken surfaces of the aggregate help to improve the skid resistance of the pavement wearing course and subsequently the ability of vehicles to stop suddenly if required, eg in adverse weather conditions. Some authorities do not allow the use of round aggregates despite the achievement of sufficient crushed faces due to previous stripping or skid resistance issues with rounded aggregate particles.

3.2.2 Durability Requirements (Section 9)

General

The aggregate in a sealed pavement must be durable, as it is in direct contact with the wheels of vehicular traffic and is loaded constantly on an ongoing basis. Sealing aggregates are also exposed to a range of atmospheric and other cyclic conditions which threaten to break them down while in service. They therefore need to be durable to achieve the required pavement design life of up to 20 years in some cases.

AS 2758.2 outlines a range of test methods that can be used to determine the potential durability of an aggregate in a given exposure condition. Three options are provided but only one is required to be included in any given works specification.

The chosen methods should be that which most suits local experience for the particular rock source selected. It has been a common error by specifiers to select more than one of the test sets. This can result in unnecessary testing and provide results that are not relevant for the area in which the aggregate is to be used, eg some durability tests are commonly required in New South Wales but not in other states and vice versa.

The recommended durability test options in AS 2758.2 are:

- Wet Strength and Wet/Dry Strength Variation (AS 1141.22)
- Los Angeles Value (AS 1141.23) and Sodium Sulfate Soundness (AS 1141.24)
- Los Angeles Value (AS 1141.23) and Unsound and Marginal Stone content (AS 1141.30.1)

Wet Strength and Wet/Dry Strength Variation (Clause 9.2)

This test is performed in accordance with AS 1141.22 and is a basic aggregate crushing test. It is performed by taking a measured quantity of sized aggregate and subjecting the sample to a force within a confined space. The test is performed on aggregate in both wet and dry conditions. The aim is to obtain, by crushing, 10% of produced fines in order to ascertain the strength of the aggregate in both wet and dry conditions and to determine the percentage variation between the aggregate's strength in the two conditions.

Figure 7: A Wet/Dry sample under test in a compression machine

The strength of the aggregate is defined as the crushing force which, when applied to a known mass of the aggregate, will produce fines amounting to 10% of the mass of the dry test portion. The wet test is performed on a sample of the same size as that for the dry test but it is soaked for 24 hours then towel dried to Saturated Surface Dry Condition (SSD), and crushed. This allows an understanding of the change in strength between the dry and wet states, thus identifying any sensitivity to water. This test is used widely in New South Wales and Queensland, particularly, as a measure of aggregate durability.

For sealing aggregate, AS 2758.2 requires the wet strength to be "not less than 100 kN" and the wet/dry variation "shall not exceed 35%". Generally, the smaller sized aggregates produce a higher strength value due to the packing nature and void characteristics of the particles in the test mould and better shape aggregates also achieve a greater strength as aggregate corners are not removed during crushing.

Los Angeles Value and Sodium Sulfate Soundness (Clause 9.3)

Los Angeles Value (LA)
The Los Angeles (LA) test is performed in accordance with AS 1141.23 and is a dry abrasion test. It is performed in a rotating drum loaded with steel balls. A bar across the inside of the drum interrupts the flow structure of the steel balls and ensures they perform a crushing/impact process and do not just roll around the drum during rotation. The drum is rotated for 500 revolutions and through this action fine particles are generated from the interaction of the steel balls and the aggregate. After completion of the test the sample is sieved over a 1.7mm sieve and the % loss is expressed as a % LA abrasion loss. A high % LA abrasion loss may indicate a weak material which may degrade in service.

Table 5 in AS 2758.2 gives a range of acceptable LA test results based on rock type and class of aggregate.

Sodium Sulfate Soundness
The Sodium Sulfate Soundness (SSS) test is performed in accordance with AS 1141.24 and is used to determine an aggregate's ability to resist weathering. This test accelerates the normal weathering process by increasing the frequency and severity of the aggregate's exposure to a sulfate-rich environment. Some rock types may experience uncontrolled expansion and rapid deterioration in such an environment, and these rock types are not recommended as sealing aggregate.

This test is performed by placing aggregate samples in a salt water solution and then drying the sample in an oven. The process is repeated 5 times in 5 days and allows salt crystals to enter any cracks or micro-cracks present in the aggregate and as the salt crystals grow they expand and break down the aggregate. Poor quality material will disintegrate into grain- sized particles and will show the degree of weathering that can be expected if that aggregate was placed in such an in-service exposure.

This test is a good indication of aggregate durability when the material is to be exposed to ground water or near salt water such as areas within the coastal zone.

The maximum allowable weighted average loss is 12%.

Los Angeles Value and Unsound and Marginal Stone Content (Clause 9.4)

Unsound and Marginal Stone Content
This test is performed in accordance with AS 1141.30.1. It is necessary that the unsound rock has been defined and is visibly distinguishable from sound rock within the same deposit. The difference may be according to colour or texture. AS 1141.30.2 gives the procedure for preparation of the reference specimens used for the comparison. It is critical that the reference samples are prepared by an experienced person.

The test is performed on a sample of aggregate retained on a 4.75mm sieve. The sample is checked firstly for soft material. The remainder is then washed and the sample is visually examined and compared to the reference specimens and any unsound particles are separated from the rest of the sample. Their mass is expressed as a percentage of the total sample mass. Samples are generally then kept so they can be used at a deposit for visual comparison with future production.

Table 6 in AS 2758.2 gives the list of acceptable limits based on class of aggregate and amount of testing carried out.

3.2.3 Weak Particles (Section 10)
The Weak Particle test is performed in accordance with AS 1141.32. The test involves removal and recording of suspect weak particles, soaking the sample of aggregate for a given period of time and then by using finger pressure on each individual piece, checking for pieces that are easily broken.

Once separated, the percentage of weak particles can be determined. AS 2758.2 specifies that there shall not be more than 1% of weak particles in any sample.

This test ensures that soft material is not used in a sealing project as the breakdown of particles early in the life of a seal damages the bitumen and also changes the integrity of the aggregate surface matt of the pavement.

3.2.4 Resistance to Stripping (Section 11)
This test is performed in accordance with AS 1141.50 and is used to assess the adhesion between sealing aggregates and bituminous binders. The aggregate may be tested with or without a pre-coating agent and is generally performed on a 14mm aggregate.

The binder used should be from the source proposed for the project and include any adhesion agents. If the class of bitumen or adhesion agents are not specified the test is carried out using Class 170 bitumen as the standard bitumen.

In cases where a new source of aggregate of unknown performance is to be evaluated the Standard suggests a range of test conditions, viz:

- As received
- Clean and Dry
- Saturated Surface Dry

The test involves heating a sample of bitumen and spreading it into a film onto a metal plate and allowing it to cool. Aggregate particles are then embedded into it, orientated in a way similar to how they would place on the pavement. After curing at temperature and cooling in water for a period, each particle is pulled from the plate and checked for adhering binder.

Depending on the amount of adhering binder on the aggregate a decision is made as to whether the aggregate particle is "completely stripped, partly stripped or not stripped".

The Standard AS 2758.2 sets a limit of "not more than 10% stripped particles" when tested in the "as received but dried to constant mass" condition. It must be noted that for the test method in AS 1141.50, the "as received "condition includes aggregate that has been pre-coated.

Figure 8: The commencement of aggregate stripping from a pavement surface

Figure 9: Polishing machine

Figure 10: Friction pendulum

3.2.5 Frictional Characteristics (Section 12)
This section of AS 2758.2 provides no specification details, it only points to a guidance note in Appendix A of the Standard.

Frictional characteristics of aggregate are expressed as the aggregate's ability to resist polishing. This is determined by testing an aggregate sample by the method described in AS 1141.40, AS 1141.41 and AS 1141.42. The result is reported as a Polished Aggregate Friction Value (PAFV) or a Polished Stone Value (PSV).

The tests involve preparing sample plates of aggregate that are then subjected to continual passes of rubber tyres that simulate traffic movement and loading. The sample plates of aggregate are also subjected to the addition of an abrasive material to simulate wear on the aggregate. After the period of polishing is completed, the plates are removed and subjected to a frictional pendulum test to ascertain the final frictional characteristic value and polishing resistance.

The Standard does not specify limits for PAFV or PSV as there are a wide range of factors that influence the requirement. They include such things as road geometry and traffic volumes. The results however for this test are expressed against a standard aggregate material with a PAFV of 50 (Panmure Basalt).

In most situations the road authority specifies the required PAFV or PSV.

4.0 Conclusion

Coarse aggregates that satisfy the requirements of AS 2758.2 are likely to be suitable for use in sealing applications provided they are consistently supplied and regular sampling and testing is undertaken to ensure those properties remain compliant with this Australian Standard document and relevant works specifications.