



Technical
Note 74

Aggregate for Gabion Baskets & Wire Mattresses

*The requirements of
AS 2758.4 - 2000*

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 for aggregates for use in gabion baskets and wire mattresses.

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 2758.4 sets out the requirements for the quality of a material source and the properties of the rock.

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 industry procedures will include their own specification for aggregates supply into gabion and mattress works. These specifications will, in most instances, specify material attributes that are either the same as or similar to those designated in AS 2758.4.

Applications for gabion baskets and wire mattresses include, but are not restricted to:

- Retaining walls
- Culvert protection
- Wing walls
- Bridge abutment protection
- Landscaping
- Erosion control

Gabion baskets are rectangular (box like) wire baskets of various sizes that are filled with hard rock material to provide a secure, sound and reliable way to retain soil and earth (Figure 1). When joined together, they act as a monolithic mass for retaining-wall construction and are often used where soil retention or steep slope stability is of concern (Figure 2). The free-draining nature of this construction allows water to flow through the wall, thus minimising the build up of pressure behind that may lead to failure of the structure. Gabion baskets have been used in a variety of ways throughout Australia since the wwⅡ, but have been used worldwide for over a century.

Wire mattress cages are of similar construction to gabion baskets, but they are of lower profile for use on flat or sloping sites to cover more ground surface area (Figure 3). They usually contain larger sized rock than that used in gabion baskets and are used as an alternative to traditional armour rock to protect against soil erosion and scour (Figure 4). Enclosing the rock in a wire cage assists in increasing the shear capacity of the rock layer while allowing convenient and predictable construction procedures. Mattresses are primarily used where long-term scour is an issue.

Large size aggregates are used in baskets and mattresses to provide mass whilst allowing suitable drainage through coarse packing of the large particles. The flexible nature of both basket and mattress structures means that they generally do not require extensive foundation treatments prior to construction. Thousands of gabion and wire mattress projects have been successfully completed throughout Australia since their introduction.

Manufacturers provide extensive instructions for the filling, lacing and use of their products to ensure appropriate site practices. Poorly made baskets may burst, while rock of poor condition may deteriorate, which will affect the reliability of the structure.

Gabion baskets and mattresses come in a variety of sizes depending on particular project needs. The easiest way to differentiate between gabion basket and mattress structures is that the former tend to be used on steep slopes to hold material behind them in place, whereas mattress structures can be seen as a bed-like construction on top of a near-horizontal surface to protect it against erosion and other environmental forces.

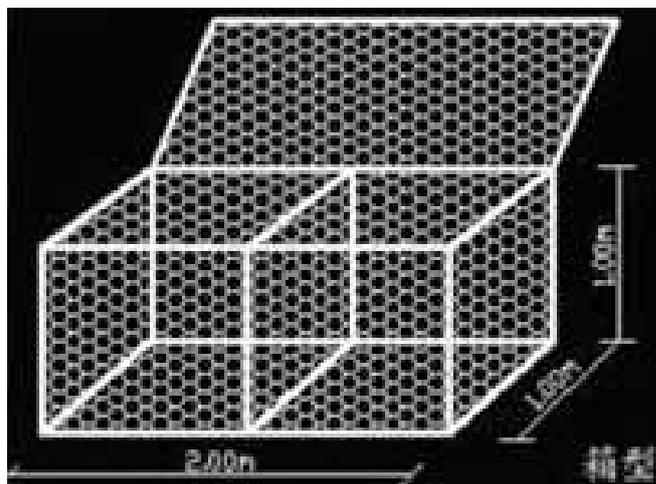


Figure 1: Typical gabion basket



Figure 2: Typical gabion wall application

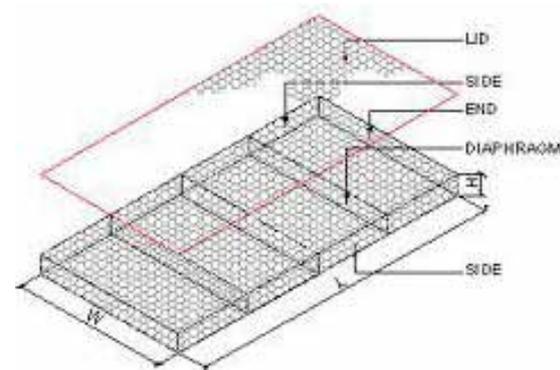


Figure 3: Typical gabion basket and wire mattress



Figure 4: Typical wire mattress

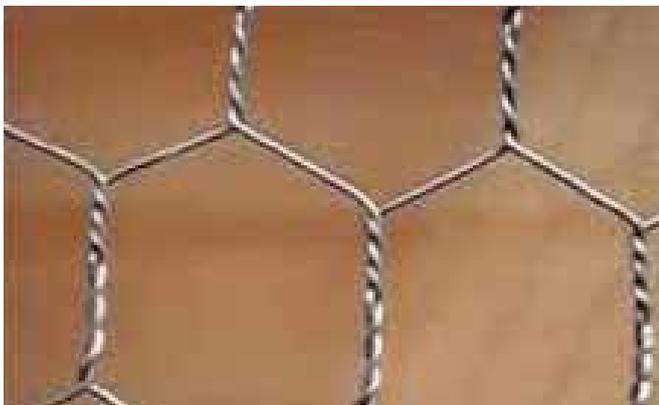


Figure 5A: Example of weave structure



Figure 6 Filled basket



Figure 5B: The lacing process



Figure 7: Diagram showing rock- on-rock contact and transfer of load at these points

Gabion baskets and wire mattresses are manufactured from steel wire that is heavily galvanized or plastic coated to minimize the risk of rusting and degradation of the wire. Protection of these (or other) coatings is important since the service life of the basket or mattress depends on the durability of the wire and thus its ability to hold the rock together. The durability of the rock used will also determine the life of these structures.

The galvanizing process used is generally a proprietary process designed by the manufacturer or supplier. Some authorities nominate specific requirements for galvanizing which will have a direct affect on the life of the baskets in-service.

Baskets and mattresses obtain their strength from the way in which the wire is woven and twisted (Figure 5A & 5B). For baskets, additional strength is provided by the inclusion of transverse diaphragms. The weave structure is such that unravelling is prevented should a wire break and the aggregate placed into the basket or mattress will be retained.

Basket and mattress structures are designed to withstand differential settlement and to be porous to prevent the build up of hydrostatic pressure.

To reduce the risk of damage to the wire, the rock material is generally placed by hand against the base and walls of baskets. Mechanical equipment is then used to complete the filling. Similarly, when filling mattresses by mechanical means, care should be taken to avoid abrasion of the wire coating.

When sampling aggregate for use in baskets and mattresses, care is necessary to ensure that the samples represent the whole mass of the material to be supplied.

Sampling is carried out in accordance with AS 1141.3.2 rather than the more commonly used AS 1141.3.1. This particular sampling method takes into account that the material being sampled is typically larger than 63mm nominal size. Samples are to be obtained by a competent person and in accordance with Section 6 of the procedure specified AS 1141.3.2.

As basket and mattress structures rely on aggregate interlock to distribute service loads, the quality of the rock used and the way in which the rocks interact is very important (Figure 6). Point-to-point contact of rock surfaces must be maintained and anything that affects this important feature may lead to problems in the structure (Figure 7). AS 2758.4 requires rock used in these structures to have a consistent size and shape to promote interlocking and to have appropriate durability. Should the selected rock have a tendency to break down due to the presence of weak particles or have micro internal cracking, this can initiate a breakdown of particles and a weakening of the structure.

4.0

Aggregate properties and the test methods specified in AS 2758.4

4.1 General

AS 2758.4 outlines the test requirements for aggregates for use in gabion baskets and wire mattresses. Each aggregate property is covered in a separate section of the Standard as follows:

- Section 7 Dimensional Requirements
- Section 8 Durability Requirements designated as Wet Strength and Wet/Dry Strength Variation, Los Angeles value and unsound and marginal stone content
- Section 9 Requirement for weak particles

All tests referred to in AS 2758.4 are covered in the AS 1141 series of test methods. In some work specifications or supply documents, the test methods stipulated may be different from those in this standard. In general however, these methods are very similar to those specified in AS 1141.

4.2 Test methods and their purpose in the Standard

4.2.1 Dimensional Requirements (Section 7)

General

The ideal rock for gabion and mattress applications would consist of particles with a range of sizes and degree of angularity that would allow them to pack and interlock easily (Figure 8). They would need to be of hard and durable stone, from a suitable rock source, free from adhering dust or deleterious matter, and including very few flat or elongated particles.

Grading (Clause 7)

Grading or Particle Size Distribution (PSD) is determined when a sample is tested in accordance with AS 1141.11.1. Table 1. That Standard gives the material sizing and acceptable minimum mass requirements of test portion for sieving.

The test for grading is carried out by sieving a sample in accordance with the requirements of AS 1141.11.1. In this process an aggregate sample is shaken through a nest of selected 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').

For gabion baskets, the rock size shall be a minimum of 100mm and a maximum of 250mm.

For mattresses, the rock size shall be a minimum of 75mm and the maximum size shall be 2/3 the thickness of the designed mattress thickness or 250mm, whichever is the lesser.

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.



Figure 8: A sample of typical Gabion or Mattress rock.

4.2.2 Durability Requirements (Section 8)

General

The aggregate used in gabion-basket and wire-mattress construction must be durable, as it is exposed to a range of atmospheric and other cyclic conditions which threaten to break it down while in service. That aggregate therefore needs to be sufficiently durable to meet the required in-service life of the structure.

AS 2758.4 outlines a range of test methods that can be used to determine the potential durability of an aggregate in a given exposure condition. Two options are provided but only one is required to be nominated in any given works specification.

The chosen method 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 and confusing for specifiers in 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 2758.4 are:

- Wet Strength and Wet/Dry Strength Variation (AS 1141.22)
- Los Angeles value (AS 1141.23) and unsound and marginal stone content (AS 1141.30.1). Course aggregate quality assessed by visual comparison.

Wet Strength and Wet/Dry Strength Variation (Clause 8.3)

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 (Figure 9). The test is performed on aggregate in both the wet and dry condition. 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.

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 gabion and wire mattress aggregate, AS 2758.4 requires the wet strength to be not less than 100 kN and the wet/dry variation to not exceed 35%.



Figure 9: A Wet/Dry sample under test in a compression machine

Due to the size of the rock used in gabion baskets and wire mattress construction, the test is generally performed on a sample sized to $-19.0 +13.2\text{mm}$ or to $-19.0 +9.5\text{mm}$. Testing should be carried out on material from a quarry source that represents that being crushed and supplied to a particular project. Results obtained from normal quarry production can be acceptable for the source of supply should supply be coming from that area of the quarry.

Los Angeles Value and Unsound and Marginal Stone Content (Clause 8.4)

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 steel drum loaded with steel balls and sample aggregate (Figure 10). A bar across the drum interrupts the flow pattern of the steel balls, ensuring that they perform a crushing/impact process on the aggregate sample and do not just roll around the drum during rotation. The drum is rotated for 500 revolutions and through this action fine aggregate particles are generated from the sample. The sample is then sieved over a 1.7mm test sieve and the loss is expressed as the percentage LA abrasion loss. A high value may indicate a weak material which could degrade in service.

Table 2 in AS 2758.4 gives a range of acceptable LA test results based on rock type and class of aggregate.

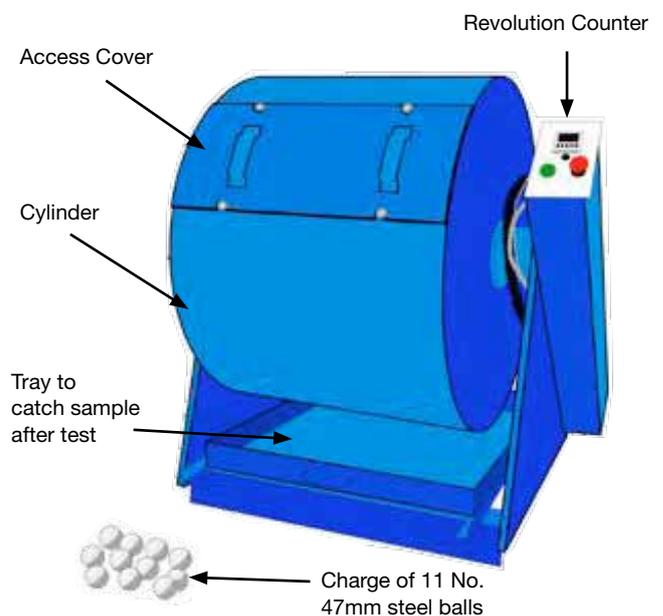


Figure 10: Typical Los Angeles test machine layout

Unsound and Marginal Stone Content

This test is performed in accordance with AS 1141.30.1. It is necessary that the unsound and marginal stone has been defined and is visibly distinguishable from sound rock within the same deposit. Unsound and marginal stone is likely to have poor durability in-service and is therefore unsuitable for use in Gabion and mattress applications. The difference between sound and unsound aggregate is normally determined visually and may be identified according to colour or texture. AS 1141.30.2 gives the procedure for preparation of the reference specimens used for this comparison. It is critical that the reference samples are prepared by an experienced person so that they accurately represent the rock source and location from which they are obtained.

The test is performed on a sample of aggregate retained on a 4.75mm sieve. The sample is checked firstly for soft material which is removed. The remainder of material 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. The mass of these unsound particles is expressed as a percentage of the total sample mass. Samples are then generally kept so they can be used at a given rock deposit for visual comparison with future production.

It is noted in AS 2758.4 that some rock sources contain deleterious secondary minerals or exhibit other properties, which may affect the long-term durability. Table B1 of Appendix B in that Standard gives values to take into account when assessing for unsound and marginal stone content.

3.2.3 Weak Particles (Section 9)

The weak particle test is performed in accordance with AS 1141.32. The test involves soaking a sample of aggregate for a given period of time to remove any clay lumps and then, by using finger pressure on each individual aggregate piece, from the remaining sample, checking for pieces that are easily broken. These are the weak particles in the sample.

Once separated, the percentage of these weak particles within the test sample can be determined. AS 2758.4 specifies that there shall not be more than 1% of weak particles in any sample tested.

This test ensures that only minimal soft and weak material is used in Gabions basket and wire mattress construction. This is important since the breakdown of aggregate can affect the integrity of this particular type of structure.

4.0

Conclusion

Aggregates that satisfy the requirements of AS 2758.4 are likely to be suitable for use in either Gabion basket or wire mattress structures provided they are consistently supplied and regular sampling and testing is undertaken to ensure those properties remain compliant with this Standard, relevant works specifications or industry requirements.