

Technical Specification

**Transport and Main Roads Specifications
MRTS43 Supply of Armourstone**

July 2022

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Contents

- 1 Introduction1**
- 2 Definitions of terms1**
- 3 Referenced documents2**
- 4 Standard test methods2**
- 5 Quality system requirements3**
 - 5.1 Hold Points, Witness Points and Milestones 3
 - 5.2 Production procedures 4
 - 5.3 Conformance requirements 4
 - 5.4 Testing frequency 4
- 6 Quarry registration4**
- 7 Material5**
 - 7.1 Armourstone 5
 - 7.1.1 *General*5
 - 7.1.2 *Hand specimen properties*5
 - 7.1.3 *Armourstone sample properties*6
 - 7.1.4 *Bulk sample properties*6
 - 7.1.5 *Armourstone sizing*6
- 8 Compliance testing.....8**
 - 8.1 General 8
 - 8.2 Visual assessment of stockpiles 8
 - 8.3 Stockpile lot sizes and testing frequency 8
 - 8.3.1 *General*8
 - 8.3.2 *Minimum frequency of testing*8
 - 8.3.3 *Maximum lot size*9
- 9 Stockpile sites9**
 - 9.1 Site details 9
 - 9.1.1 *General*9
 - 9.1.2 *Location*9
 - 9.1.3 *Size* 10
 - 9.2 Construction standard 10
 - 9.2.1 *General* 10
 - 9.2.2 *Stockpile site* 10
- 10 Delivery of armourstone to stockpiles 10**
- 11 Supplementary requirements 10**

1 Introduction

This Technical Specification applies to the supply and delivery of armourstone, and the construction of stockpile sites for the storage of armourstone.

This Technical Specification should not be applicable to general rock fill, drainage rocks, erosion protection stones and similar applications. Only natural armourstone is considered, and man-made 'blocks' such as concrete blocks or tetrahedral blocks are not considered in this Technical Specification.

The aim of this Technical Specification is to ensure armourstone has the required strength and durability characteristics. It addresses only the supply of armourstone and neither the design, nor construction details for the use of armourstone, are covered.

This Technical Specification is based on BS EN 13383-1:2013 and BS EN 13383-2:2013.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

2 Definitions of terms

The terms defined in MRTS01 *Introduction to Technical Specifications* apply to this Technical Specification. Additional terminology relevant to this Technical Specification is defined in Table 2 below.

Table 2 – Definitions of terms

Term	Definition
Acid igneous rock	An igneous rock containing more than 65% SiO ₂ typically consisting of quartz, feldspar and biotite among others. Includes rhyolite, rhyodacite, dacite, tuffs (of same composition), granite, adamellite and granodiorite.
Aggregate	A sample of crushed rock (typically < 13.2 mm fraction, with the same colour, texture and lithology as full-size armourstone blocks available from the quarry).
Armourstone	Rock of sufficient strength and durability for applications requiring material typically ranging from several kilograms to many tonnes. Armourstone is used to provide erosion protection breakwaters, sea revetment walls, riverine protection walls, groynes and riprap.
Breakwater	Is constructed in open seas to protect calm conditions for vessel berthing inside a harbour.
Coarse grading	A grading range with a nominal upper limit of less than 25 kg.
Geological material group	A unique category selected based on material classification, geological processes and material properties. Materials of one group may grade into another in the one quarry site; however, each source will be classified, based on the predominant material group.
Groyne	A low wall or sturdy barrier constructed out into the sea from a beach to protect from wave or current action or stabilise coastal erosion and drifting.
Heavy grading	A grading range with a nominal upper limit of greater than 500 kg.

Term	Definition
Intermediate igneous rock	An igneous rock containing between 54% and 65% SiO ₂ typically consisting of plagioclase, amphibole, pyroxene and nil or minor quartz. Including trachyte, trachyandesite, andesite, diorite, tuffs (of same composition), syenite and diorite.
Light grading	A grading range with a nominal upper limit of 25 kg to 500 kg.
Metamorphic rock	A rock derived from a pre-existing rock by mineralogical, or structural changes in response to changes in the temperature and/or pressure. Including hornfels, quartzite, metagreywacke, greenstone and amphibolite.
QRS	Quarry Registration System as defined in MRTS50 <i>Specific Quality System Requirements</i> .
Riprap	A structure built in inland water bodies or estuaries to protect the banks from wind-driven wave erosion.
Riverine walls	Constructed in riverbanks to protect the banks from flood or current-induced erosion.
Sea wall or revetment wall	Constructed to protect coastal areas from erosion or undermining.

3 Referenced documents

The requirements of the referenced documents listed in Table 3 below apply to this Technical Specification. Where there are inconsistencies between this Technical Specification and the referenced documents, the requirements specified in this Technical Specification shall take precedence.

Table 3 – Referenced documents

Reference	Title
AS 2758.6	<i>Aggregates and rock for engineering purposes, Part 6: Guidelines for the specification of armourstone</i>
CIRIA C683	<i>The Rock Manual: The use of rock in hydraulic engineering (2nd edition)</i>
EN13383-1	<i>Armourstone, Part 1: Specification</i>
EN13383-2	<i>Armourstone, Part 2: Test Methods</i>
MRTS01	<i>Introduction to Technical Specifications</i>
MRTS04	<i>General Earthworks</i>
MRTS05	<i>Unbound Pavements</i>
MRTS50	<i>Specific Quality System Requirements</i>
MTM	Materials Testing Manual , Transport and Main Roads
Quarry Registration System QRS1 to QRS6	Quarry Registration System , Transport and Main Roads

4 Standard test methods

The standard test methods given in Table 4 shall be used in this Technical Specification.

Further details of test numbers and test descriptions are given in Clause 4 of MRTS01 *Introduction to Technical Specifications*.

Table 4 – Standard test methods

Property to be tested	Method No.
Degradation Factor	Q208B
Micro-Deval abrasion loss (Resistance of Coarse Aggregate to Degradation (by Abrasion in the Micro-Deval Apparatus))	Q229B
Particle density (SSD)	AS 1141.6.1
Petrographic assessment of aggregates	Q188
Point Load Strength Index	AS 4133.4.1
Random stratified sampling	AS 1289.1.4.2
Size distribution	Q232
Size distribution and shape – armourstone	Q232
Sodium Sulphate Soundness	AS 1141.24
Susceptibility of large armourstone to breakdown – drop test	Q231
Uniaxial Compressive Strength	AS 4133.4.2.2
Water absorption	AS 1141.6.1
Wet strength	AS 1141.22
Wet / dry strength variation	AS 1141.22

5 Quality system requirements

5.1 Hold Points, Witness Points and Milestones

General requirements for Hold Points, Witness Points and Milestones are specified in Clause 5.2 of MRTS01 *Introduction to Technical Specifications*.

The Hold Points, Witness Points and Milestones applicable to this Technical Specification are summarised in Table 5.1. There are no Witness Points defined.

Table 5.1 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness Point	Milestone
6	1. Use of quarry		Submit Quarry Registration Certificate (seven days)
			Submit armourstone production procedure (seven days)
8.1			Submit sample of armourstone (14 days) for testing)
8.3		Construction of armourstone stockpiles for visual assessment	

5.2 Production procedures

Production procedures which are required to be submitted by the Contractor to the Administrator in accordance with Clause 6 of MRTS50 *Specific Quality System Requirements* are listed in Table 5.2.

Table 5.2 – Construction procedures

Clause	Procedure
6	Armourstone production procedure including material quality management plan (MQMP)

5.3 Conformance requirements

The conformance requirements which apply to lots of work covered by this Technical Specification are summarised in Clauses 7 and 8.

5.4 Testing frequency

The minimum testing frequency for work covered by this Technical Specification is specified in Clause 7.3.

6 Quarry registration

Armourstone shall be supplied by a quarry registered and operated in accordance with the Department of Transport and Main Roads Quarry Registration System (QRS) requirements. The current *Quarry Registration Certificate*, including its *Registered Testing Frequency Schedule*, shall be submitted to the Administrator at least seven working days before a material's supply or use. **Milestone** If the quarry is registered under the QRS for products other than armourstone, interim registration may be provided if the proposed product can be shown to comply with the requirements for this Technical Specification. Interim registration shall lapse after one year, at which time the quarry is expected to have achieved registration for armourstone.

Material from a quarry shall be neither supplied, nor used in the Works without written permission of the Administrator. **Hold Point 1**

The Contractor shall notify the Administrator within three working days of any change to the *Quarry Registration Certificate*, including its *Registered Testing Frequency Schedule*. **Hold Point 1** shall be re-applied.

For each quarry that will supply material(s) to be used in the Works, the Contractor shall prepare a procedure for armourstone production in accordance with Clause 6 of MRTS50 *Specific Quality System Requirements* and detail the following for each nominated material:

- a) area (for example, face number, bench number and reduced level) of the quarry from which the material in the lot will be won
- b) production process to be used, including methods of winning the material
- c) procedures for stockpile management and traceability as part of lot control and, as applicable, stockpile subplot control, and
- d) quality control procedures as a part of material quality management plan (MQMP).

The armourstone production procedures shall be submitted to the Administrator at least seven days prior to the commencement of armourstone production for the Works. **Milestone**

7 Material

7.1 Armourstone

7.1.1 General

Armourstone shall only be produced from naturally-occurring hard rock quarry with acid igneous, intermediate igneous or metamorphic rock material group. The source rock properties of armourstone are specified in Table 7.1.1.

The quality of the armourstone shall be determined via several tests as detailed below. The testing requirements for armourstone can be divided into two fundamental categories, either source rock properties or product properties. Thus, during testing, < 13.2 mm fraction samples shall be used for source rock tests, while the product properties use the full-size specimens. It is generally not practical to crush armourstone to produce a < 13.2 mm particle size; hence, it is best to resort to a sample of crushed product from the same lot or shot number which has the same colour, texture, lithology and look at the product material. In the case of petrographic analysis, at least three hand specimens collected for each of the different lithologies shall be analysed.

Table 7.1.1 – Properties for Class A and Class B armourstone

Source Rock Property	Test Method	Class A	Class B
Petrographic assessment of aggregates	Q188	Report	Report
Particle density (SSD) (t/m ³)	AS 1141.6.1	≥ 2.60	≥ 2.50
Water absorption (%)	AS 1141.6.1	≤ 2.0	≤ 3.0
Wet strength (kN)	AS 1141.22	≥ 175	≥ 150
Sodium Sulphate Soundness (over five cycles)	AS 1141.24	< 6	< 9
Micro-Deval Abrasion Loss (%)	Q229B	< 10	< 15
Point Load Index Test (MPa)	AS 4133.4.1	4	3
Uniaxial Compressive Strength (MPa)	AS 4133.4.2.2	100	75
Wet / Dry strength variation (%)	AS 1141.22	≤ 45	≤ 40
Degradation factor	Q208B	≥ 50	≥ 40
Product Properties	Test Method	Class A	Class B
Mean Breakdown (%)	Q231	≤ 10	≤ 15
Size ratio (> 3.0)	Q232	≤ 5	≤ 15

The test properties have been divided into Class A and Class B armourstone. Class A armourstone shall be used on the outside of the works or outer zones which may be exposed to wave action and may also be used for internal works. Class B armourstone shall only be used for internal works or inner zones or core areas which are not subject to wave action.

7.1.2 Hand specimen properties

7.1.2.1 Petrographic assessment of aggregates

The samples collected for petrographic assessment of aggregates should be hand specimens chipped from several large armourstone blocks, such that they represent the full range of rock materials likely to be supplied from the quarry as armourstone. The petrographic analysis shall be undertaken in accordance with Test Method Q188 *Petrographic assessment of aggregates* and the petrographic

assessment report shall include comments on the lithology, both primary and secondary mineralogical assemblage, weathering state, secondary mineral content and clay content. A minimum of three petrographic analyses shall be undertaken, and more, if more than three rock (lithological) types are present in the quarry.

7.1.3 Armourstone sample properties

7.1.3.1 Particle density and water absorption

It is not practical to use full armourstone samples for this test and, hence, representative source rock aggregate samples shall be used to assess this material property.

7.1.3.2 Wet strength and wet / dry variation

This test must be carried out on a representative 9.5 mm to 13.2 mm particle size sample fraction. Tests based on other particle size sample fractions shall not be accepted. Samples used for such testing shall be typical of the material to be used for armourstone.

7.1.3.3 Degradation factor

Degradation factor tests shall be carried out on fractions from 2.36 mm to 13.2 mm.

7.1.4 Bulk sample properties

7.1.4.1 Particle shape

The particle shape shall be determined on armourstone using Test Method Q232. One sample piece of each type of armourstone shall be provided for the test from each 100 pieces or part thereof of that type delivered to the site. Essentially, 20 to 100 'typical' specimens of the lot are selected and placed on a flat surface, such that the longest linear dimension of the stone is horizontal and the shortest dimension near-vertical. The longest horizontal dimension (the length) shall then be measured, as well as the shortest dimension normal to the longest line (the thickness). The length / thickness ratio shall then be determined. The percentage of particles with a length / thickness ratio < 3, 3 – 5, and > 5 shall be reported.

7.1.4.2 Breakdown

The breakdown shall be determined on armourstone using Test Method Q231. One sample piece of each type of armourstone shall be provided for the drop test for each 100 pieces or part thereof of that type delivered to the site. Essentially, 20 to 100 'typical' specimens of the lot are selected and then weighed. After weighing, each armourstone is then lifted 3.0 m and dropped onto a test area. The largest remaining fragment of each armourstone is weighed and examined for cracking, and percentage breakdown is determined.

7.1.5 Armourstone sizing

7.1.5.1 General

The sizing requirements for armourstone cover a very wide range: hence, sizing requirements may extend well beyond those included in this Technical Specification. The sizing requirements shown are only a selection of 10 potential gradings. If different gradings are required, these should be defined in the project documents, specifically Clause 2.1 of MRTS43.1 Annexure, and be compliant with the requirements of BS EN 13383-1.

An alternative method for specifying size requirements is included in Clause 7.1.5.4.

7.1.5.2 Nominal, minimum, and maximum masses

For each respective armourstone size, the armourstone shall comply with the armourstone size requirements given in Table 7.1.5.2, unless otherwise specified in the project documents.

Table 7.1.5.2 – Standard armourstone sizes

Armourstone size (kg)	Absolute minimum mass (Extreme Lower Limit (ELL))	Nominal minimum mass (Normal Lower Limit (NLL))	Nominal maximum mass (Normal Upper Limit (NUL))	Absolute maximum mass (Extreme Upper Limit (EUL))
60 to 300	30	60	300	600
40 to 200	20	40	200	400
20 to 300	7.5	20	300	600
10 to 60	5	10	60	120
10.0 to 15.0	5.0	10.0	15.0	30.0
6.0 to 10.0	3.0	6.0	10.0	20.0
5 to 40	2.5	5	40	80
3000 to 6000	1.5	3.0	6.0	12.0
1000 to 3000	0.5	1.0	3.0	6.0
300 to 1000	0.15	0.30	1.0	2.0

7.1.5.3 Size limits

The limits for each armourstone size are specified in Table 7.1.5.3.

Table 7.1.5.3 – Armourstone size limits

Stone size limits (%)	Limit type	Value
Stone larger than absolute maximum mass	Maximum	< 3
Stone between nominal maximum mass and absolute maximum mass	Maximum	28
Stone between nominal minimum mass and nominal maximum mass	Minimum	58
Stone smaller than nominal minimum mass	Maximum	10
Stone smaller than absolute minimum mass	Maximum	< 2

7.1.5.4 Alternative size requirements

These size requirements may be more suitable for materials to be used for underlayer and core and stone shall have essentially two characteristics, the size and the width of the size limits.

Ten nominal grading envelopes are covered by this Technical Specification in Clauses 7.1.5.2 and 7.1.5.3, but designers may choose other requirements which shall be defined in the Works documents, using the width of the size limits specified in Table 7.1.5.4.

If different gradings are required, these should be defined in the project documents and be compliant with the requirements of BS EN 13383-1.

Table 7.1.5.4 – Armourstone: Width of size limits

Armourstone size – width of size limits	Property	Limit	Typical use
Narrow or single size	D85/D15	< 1.5	Outer zone of breakwaters and revetments
Wide	D85/D15	1.5 – 2.5	Filter armour, riprap, minor revetments
Very wide	D85/D15	2.5 – 5.0	Breakwater core material, riprap.

8 Compliance testing

8.1 General

The Contractor is responsible for carrying out sufficient testing to ensure that the armourstone complies with the standards and requirements of this Technical Specification, including registration of the quarry as an armourstone source in the QRS. If the quarry is not registered, an interim registration (for not more than one year) may be granted, provided the quarry can demonstrate compliance with this Technical Specification.

Compliance testing of armourstone shall be undertaken for each lot. Initially, all stockpiles shall be visually inspected for compliance. Samples for compliance testing shall be randomly selected (random stratified sampling) from the stockpile lot. A stockpile lot shall be an essentially homogeneous portion of armourstone from the same source and having the same nominal size. A new stockpile lot shall apply when there is a change in any of these characteristics.

As stated in Clause 2.1 of Annexure MRTS43.1, a preliminary sample consisting of at least the minimum number of specimens is to be tested in accordance with Test Method Q232 Table 2 of each size class of armourstone to be used in the Contract. Samples shall be made available to the Administrator at least 14 days before the material is to be used. **Milestone**

8.2 Visual assessment of stockpiles

During visual assessment of stockpiles, the frequent, spacing and continuity of rock fabric elements shall be noted and reported. These include details of cleavage planes, foliation, joints, fractures, and breaks, as well as evidence of alteration including chloritization, and iron staining. **Witness**

8.3 Stockpile lot sizes and testing frequency

8.3.1 General

Each individual stockpile lot shall be clearly delineated by one of the methods below:

- a) a separate stockpile shall be formed for each stockpile lot of the same material type, or
- b) material of the same type shall be added to a single stockpile incrementally, such that a portion representing a discrete stockpile lot is added, tested, and found to be conforming before the next portion, representing the next stockpile lot, is added. Non-conforming stockpile lots shall be removed from the stockpile prior to the addition of further portions.

Testing shall be undertaken for each armourstone source.

8.3.2 Minimum frequency of testing

Testing frequencies for the armourstone source rock tests and product tests shall comply with the requirements of Table 8.3.2(a) and Table 8.3.2(b) in this Technical Specification.

Table 8.3.2(a) – Minimum testing frequencies for armourstone source rock tests

Property	Test Method	Minimum Frequency of Testing
Degradation factor	Q208B	Minimum testing frequencies shall be in accordance with Clause 8.1.1 of MRTS50 <i>Specific Quality System Requirements</i> .
Micro-Deval Abrasion Loss	Q229B	
Particle density (SSD)	AS 1141.6.1	
Petrographic assessment of aggregates	Q188	
Point Load Index Test	AS4133.4.1	
Sodium Sulphate Soundness	AS1141.24	
Uniaxial Compressive Strength	AS4133.4.2.2	
Water absorption	AS 1141.6.1	
Wet Strength	AS 1141.22	
Wet / Dry Strength Variation	AS 1141.22	

Table 8.3.2(b) – Minimum testing frequencies for armourstone product tests

Property	Test Method	Minimum Frequency of Testing
Size distribution	Q232	1 per lot
Mean breakdown	Q231	
Size ratio (<3.0)	Q232	

8.3.3 Maximum lot size

The maximum lot size for source rock tests shall be in accordance with Clause 8.1.1 of MRTS50 *Specific Quality System Requirements*, or up to 5000 tonnes of each product size.

9 Stockpile sites

9.1 Site details

9.1.1 General

If a position is stated in Clause 3.1 of Annexure MRTS43.1, the stockpile site shall be so located. If a position is not stated, the stockpile site shall be located to suit the construction program and to comply with the requirements specified in Clauses 9.1.2 and 9.1.3 in this Technical Specification.

9.1.2 Location

The stockpile site shall be located on firm, well-drained, even ground and shall be located:

- a) at least one metre from any property boundary
- b) at least three metres from any road, railway, structure, watercourse, underground and overhead services, and
- c) clear of any proposed works or accommodation works.

Additional restrictions to the location of the stockpile site shall apply as stated in Clause 3.2 of the Annexure MRTS43.1.

9.1.3 Size

The size of the stockpile site shall depend on the quantity and size of armourstone to be stored and shall comply with the requirements in Table 9.1.3.

Table 9.1.3 – Stockpile size restrictions

Requirements	Limits (metres)
Height of stockpile (maximum) or one armourstone height	2
Distance between the edge of a stockpile and the edge of the stockpile site (minimum)	1
Distance between stockpile sites (minimum)	2
Maximum stockpile mass (or lot size)	5000 tonnes

9.2 Construction standard

9.2.1 General

Stockpiles shall be constructed to the standard stated in Clause 3.1 of Annexure MRTS43.1 and shall either the standard listed in Clauses 9.2.2, or that described in Clause 3.2 of Annexure MRTS43.1.

9.2.2 Stockpile site

Stockpile site shall consist of the following Works:

- a) clearing, grubbing, compacting, and trimming of the natural ground over the full area of the stockpile site in accordance with MRTS04 *General Earthworks* and the site environmental management plan (EMP) if available
- b) installation of any necessary drains, and
- c) construction of access tracks.

10 Delivery of armourstone to stockpiles

Prior to commencement of delivery of armourstone to any stockpile site, the Contractor shall obtain the Administrator's authorisation to place armourstone on the stockpile site. **Hold Point 2**

Placement of armourstone on stockpile sites shall be carried out in a manner which ensures that segregation of particles and other deleterious effects are avoided and shall proceed in an orderly sequence.

11 Supplementary requirements

The requirements of MRTS43 are varied by the supplementary requirements given in Clause 4 of Annexure MRTS43.1.

