

Aggregates —

Part 7: Armourstone — Guidance on the use of BS EN 13383

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Foreword

This Published Document has been prepared under the direction of Subcommittee B/502/4, Aggregates for unbound and hydraulically bound materials. It is one of nine parts that give guidance on the use and application of a series of European Standards for aggregates. These European Standards were prepared by CEN/TC 154, Aggregates and have been adopted as British Standards. Conflicting British Standards relating to aggregates will be withdrawn in June 2004.

This part of PD 6682 gives guidance on the use of BS EN 13383 which specifies requirements for armourstone. BS EN 13383 supersedes the conflicting recommendations for armourstone in BS 6349-1:2000 which will be amended to remove these conflicting recommendations at the latest by June 2004.

NOTE 1 Users of BS 6349-1:2000 should contact BSI Customer Services for confirmation of amendment.

BS EN 13383 specifies requirements that differ from those found in the CIRIA/CUR manual on the use of rock in coastal and shoreline engineering [1]. The CIRIA/CUR manual will be amended to remove these conflicting recommendations.

NOTE 2 Users of the CIRIA/CUR manual should contact the Construction Industry Research and Information Association for confirmation of amendment.

Attention is drawn to the fact that BS EN 13383 fully takes into account the requirements of the European Commission mandate M125, Aggregates, given under the EU Construction Products Directive (89/106/EEC) [2].

Guidance on the other European Standards in the series is given in the following parts of PD 6682.

- *Part 1: Aggregates for concrete — Guidance on the use of BS EN 12620.*
- *Part 2: Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas — Guidance on the use of BS EN 13043.*
- *Part 3: Aggregates for mortar — Guidance on the use of BS EN 13139.*
- *Part 4: Lightweight aggregates for concrete, mortar and grout — Guidance on the use of BS EN 13055-1.*
- *Part 5: Lightweight aggregates for bituminous mixtures and surface treatments and for unbound and bound applications excluding concrete, mortar and grout — Guidance on the use of BS EN 13055-2.¹⁾*
- *Part 6: Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction — Guidance on the use of BS EN 13242.*
- *Part 8: Aggregates for railway track ballast — Guidance on the use of BS EN 13450.*
- *Part 9: Guidance on the use of European test method standards.*

This publication does not purport to include all necessary provisions of a contract. Users are responsible for its correct application.

This Published Document is not to be regarded as a British Standard.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 35 and a back cover.

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¹⁾ Both BS EN 13055-2 and PD 6682-5 are in preparation.

Introduction

This document gives guidance on the use of BS EN 13383 in the UK. BS EN 13383 supersedes the corresponding conflicting recommendations for stone for armouring in BS 6349-1.

NOTE 1 European test method standards for aggregates supersede the BS 812 test methods for aggregates recommended in BS 6349-1 for the quality testing of armourstone. Guidance on which European Standard test methods for aggregates are used for the testing of armourstone is given in Clause 5 and Clause 6.

BS EN 13383 specifies requirements for armourstone that differ from the recommendations contained in the CIRIA/CUR manual on the use of rock in coastal and shoreline engineering [1].

NOTE 2 The requirements of BS EN 13383 are particularly different from the model specification and test methods specified in Annex 1 and Annex 2 of the CIRIA/CUR manual. The recommendations in the annexes of the CIRIA/CUR manual will be updated to reflect the content of BS EN 13383.

Whilst BS EN 13383 describes armourstone in a different manner to established UK practice and in some cases uses different test methods to evaluate their properties, there is no change to the general quality of the armourstone in use in the UK. BS EN 13383, like the CIRIA/CUR manual, specifies wider gradings than BS 6349-1 for heavier armourstone because there is evidence of the satisfactory use of these grading.

BS EN 13383 is divided into 2 parts:

- *Part 1: Specification;*
- *Part 2: Test methods.*

BS EN 13383-1 specifies a range of categories for properties to enable users to select the appropriate limiting values for the wide range of armourstone produced in Europe. In most instances, provision is also made for producers to identify a declared value for properties when the value of the property is outside indicated categories.

Owing to the special functions and large sizes of armourstone materials, special test methods and sampling methods which differ from those associated with aggregates have been specified in BS EN 13383-2. A tabular summary of all sampling and testing requirements for a particular property is given informatively in BS EN 13383-2:2002, Annex G as an aid for armourstone producers and testing authorities. This summary is considered necessary because of the particularly wide range of test types, test portions and sample reduction procedures needed to accommodate armourstone tests both on individual test pieces of rock as well as on a sample selection of rocks.

An example specification listing recommended BS EN 13383 categories for particular properties is given in Annex A. It can be applied to most general uses of armourstone. For particular armourstone sources and/or end uses, specifiers may need to give requirements for additional properties. Some recommended BS EN 13383 categories for particular armourstone sources and/or end uses in the UK are given in Annex B. Where requirements vary dependent on the particular end use, appropriate values should be inserted for the particular properties.

BS EN 13383 includes manufactured and recycled armourstone within its scope and indicates that their suitability should be assessed in accordance with the regulations valid in the place of use. However, in the UK, there are no relevant regulations for armourstone and there is no current experience of the use of manufactured or recycled materials for this purpose. Precast concrete armour units are not considered to be manufactured armourstone for the purposes of this guide.

1 Scope

This part of PD 6682 gives guidance on the use of BS EN 13383 in the UK. BS EN 13383 specifies the properties of armourstone obtained by processing natural, manufactured or recycled materials and mixtures of these materials.

2 Overview of BS EN 13383

2.1 General

In comparison with BS 6349-1 and the CIRIA/CUR manual, BS EN 13383 gives requirements for different armourstone properties, including different test methods.

The geometrical, physical (mechanical), chemical and durability requirements for armourstone that appear in BS EN 13383-1 are listed in **2.2**, **2.3**, **2.4** and **2.5**. The armourstone test methods that appear in BS EN 13383-2 and other European test method standards for aggregates are listed in **2.6**.

2.2 Geometrical requirements

Requirements for the following geometrical properties are specified for armourstone in BS EN 13383-1:2002, Clause 4:

- a) grading;
- b) shape;
- c) percentage of crushed and broken surfaces.

2.3 Physical requirements

Requirements for the following physical properties are specified for armourstone in BS EN 13383-1:2002, Clause 5:

- a) particle density, determined in accordance with a BS EN 13383-2 test method derived from a Dutch (NEN²⁾) test method;
- b) resistance to breakage determined in accordance with a BS EN 1926 compressive strength test method designed for testing armourstone;
- c) resistance to wear measured by determining the (wet) micro-Deval coefficient in accordance with a BS EN 1097-1 test method derived from a French (AFNOR³⁾) test method (and found to have good correlation with another resistance to wear method developed in the UK and published in the CIRIA/CUR manual);
- d) grouting;
- e) colour.

2.4 Chemical requirements

Requirements for the following chemical properties are specified for armourstone in BS EN 13383-1:2002, Clause 6:

- a) impurities;
- b) water-soluble constituents.

²⁾ Further information about NEN, the Netherlands national standards body, can be found on www.nen.nl.

³⁾ Further information about AFNOR, the French national standards body, can be found on www.afnor.fr.

2.5 Durability requirements

Requirements for the following durability properties are specified for armourstone in BS EN 13383-1:2002, Clause 7:

- a) dicalcium silicate disintegration of air-cooled blast-furnace slag;
- b) iron disintegration of air-cooled blast-furnace slag;
- c) disintegration of steel slag;
- d) water absorption as a screening test for the resistance to freezing and thawing and to salt crystallization;
- e) resistance to freezing and thawing using 10 large individual test pieces determined in accordance with BS EN 13383-2 derived from a Dutch (NEN⁴) test method involving 25 freeze-thaw cycles;
- f) resistance to salt crystallization determined in accordance with the BS EN 1367-2 magnesium sulfate soundness test for aggregates derived from BS 812-121;
- g) “Sonnenbrand” of basalt, a type of rock decay that can be present in some basalts, determined in accordance with a BS EN 13383-2 boiling test derived from a German (DIN⁵) test method.

2.6 Sampling and test methods

Requirements for sampling procedures are specified for armourstone in BS EN 13383-2:2002, Clause 4.

Test methods to determine the following properties are specified for armourstone in BS EN 13383-2:

- a) determination of particle size distribution of coarse gradings;
- b) determination of the mass distribution of light and heavy gradings;
- c) determination of the percentage of pieces of armourstone with a length-to-thickness ratio greater than 3;
- d) determination of particle density and water absorption;
- e) determination of resistance to freezing and thawing;
- f) determination of signs of “Sonnenbrand” and disintegration of steel slags.

BS EN 13383-1 specifies testing in accordance with European test method standards for aggregates that have not previously been used for armourstone in the UK. European test method standards for aggregates are used to determine the following properties for armourstone:

- 1) type of armourstone identified using a simplified petrographic description in accordance with BS EN 932-3;
 - 2) a sieving method for the determination of particle size in accordance with BS EN 933-1;
 - 3) resistance to wear by determination of the micro-Deval coefficient in accordance with BS EN 1097-1;
- NOTE Attention is drawn to the fact that BS EN 13383-1:2002, 5.4 specifies variations to the requirements for sample preparation given in BS EN 1097-1:1996, Clause 6.
- 4) determination of water content in accordance with BS EN 1097-5;
 - 5) resistance to salt crystallization by determination of the magnesium sulfate value in accordance with BS EN 1367-2:1998, Clause 8;
 - 6) dicalcium silicate or iron disintegration of air-cooled blast-furnace slag determined in accordance with BS EN 1744-1:1998, 19.1 and 19.2;
 - 7) determination of water-soluble constituents through the preparation of an eluate in accordance with BS EN 1744-3 and subsequent testing using methods developed for water analysis that have been adapted for use in the analysis of eluates;
 - 8) resistance to breakage by testing compressive strength in accordance with BS EN 1926:1999, Annex A.

For the convenience of the user a brief descriptive outline of each test method in BS EN 13383-2 and the other relevant European test method standards for aggregates is given in Clause 5 and Clause 6.

⁴) Further information about NEN, the Netherlands national standards body, can be found on www.nen.nl.

⁵) Further information about DIN, the German national standards body, can be found on www.din.de.

2.7 Evaluation of conformity

BS EN 13383-1:2002, Clause 8 requires that producers undertake and on request declare the results from:

- a) initial type tests used:
 - i) to characterize properties for new sources of armourstone; or
 - ii) where there is a major change in the raw materials or processing which can affect the properties of the armourstone; and
- b) factory production control to monitor conformity of the armourstone with the relevant BS EN 13383 requirements and the producer's declared values.

Minimum frequencies of tests are identified in BS EN 13383-1:2002, Annex D.

Guidance on the requirements for attestation of conformity and compliance with the provisions of the EU Construction Products Directive [2] is given in 4.9.

3 Differences between BS EN 13383 and existing UK guidance documents

3.1 General

BS 6349-1 is the only British Standard covering the subject of armourstone. The subject is dealt with in BS 6349-1:2000, Clause 57 under the title "Stone for armouring or protection works" and comprises about one page of text. BS EN 13383 supersedes the corresponding conflicting recommendations for stone for armouring in BS 6349-1 and introduces a more objective, comprehensive and appropriate system of quality control. BS 6349-1 guidance on armourstone can now be abandoned in favour of BS EN 13383 with confidence.

3.2 Geometrical requirements

3.2.1 Grading

The principal means by which any armourstone product is classified is by its grading. BS 6349-1 describes two types of armourstone grading, but no explanation is given as to when either should be used.

BS 6349-1:2000, 57.3.2 discusses *single-sized materials* for which it recommends that all stones should fall within stated upper and lower percentage tolerances of a nominal mass and that a stated percentage of the number of all the stones should exceed the nominal mass. It does not, however, give any guidance as to what these percentage tolerances should be, nor does it state what the percentage of stones required to exceed the nominal weight should be. It does, however, give a rather impractical and unnecessary recommendation that at least 75 % by mass of the stone in each single-sized material should consist of stones within the top half of the stated mass range.

BS 6349-1:2000, 57.3.3 discusses *graded materials*, including riprap. It describes how riprap is frequently specified in terms of its median mass m_{50} with typical maximum and minimum masses of $3.6m_{50}$ to $0.22m_{50}$, respectively.

BS EN 13383 abandons the BS 6349-1 distinction between *single-sized materials* and *graded materials* in favour of standard gradings. BS EN 13383 defines *coarse gradings*, *light gradings* and *heavy gradings*. The widths of these gradings are much wider for those gradings with smaller average mass than for those gradings with larger average mass.

BS EN 13383 defines *light gradings* as armourstone with a nominal upper limit of 25 kg to 500 kg. Most of these *light gradings*, roughly correspond to the graded materials referred to in BS 6349-1, such as riprap. BS EN 13383 defines *heavy gradings* as armourstone with a nominal upper limit of more than 500 kg. The *heavy gradings* correspond to the single-sized materials described in BS 6349-1 and certainly represent narrower grading widths than for the *light gradings*. The percentage deviation on the nominal weight for both the *light gradings* and *heavy gradings* is wider and thus more realistic than has previously been adopted in BS 6349-1. The width of both *heavy gradings* and *light gradings* is in fact based on accurate calibrations over many tests carried out on rock actually produced for major marine works in the Netherlands, reference to which is made in the CIRIA/CUR manual.

BS EN 13383 also defines *coarse gradings* as armourstone with a nominal upper sieve size limit of 125 mm to 250 mm. *Coarse grading* material is smaller than riprap but larger than the largest coarse aggregates specified in other European aggregate standards, i.e. larger than 40 mm. These *coarse gradings* will be useful as filters and, in the case of the 90/180 mm stone, for gabion filling.

The specification of armourstone sizes in BS EN 13383 is different to BS 6349-1 but has much in common with the system recommended in the CIRIA/CUR manual. *Coarse gradings* for armourstone are classified by sieve size fractions in a manner similar to the general aggregates specified in other European aggregate standards but require sturdier sieves because of the larger size of the material involved. When the grading particle size exceeds that for *coarse gradings*, they are classified by mass. *Light gradings* are generally deemed to be light enough to be bulk-handled. If individual handling of pieces is necessary, they are generally termed *heavy gradings*. Nominal lower and upper limits for sieve sizes (d/D mm) and for masses [$(a$ to b) kg] are used to designate the gradings and indicate the range in which most of the particle distribution occurs.

3.2.2 Shape

BS 6349-1 recommends that stone for armouring or protection works should be prismoidal in shape with the maximum dimension of stones never exceeding three times the minimum dimension and generally not exceeding twice the minimum dimension. In preference to these BS 6349-1 recommendations, the majority of UK armourstone producers have adopted the CIRIA/CUR manual's geometrical recommendations. BS EN 13383 specifies geometrical requirements that are based on the recommendations given in the CIRIA/CUR manual. Guidance on BS EN 13383 geometrical requirements is given in 4.2.

3.3 Physical, chemical and durability requirements

The use of BS 6349-1 and the CIRIA/CUR manual has been widespread in the UK for the specification of the physical (mechanical) and durability properties of armourstone.

BS 6349-1 recommends the use of BS 812 aggregate tests for the determination of the physical and durability properties of armourstone. These tests are performed on samples that are representative of the armourstone. They include test methods for the determination of apparent relative density, water absorption, the aggregate impact value (AIV), the 10 % percent fines value (TFV) and the aggregate abrasion value (AAV). Of these tests, only the density and water absorption tests have been included in BS EN 13383, but in a different form to BS 812. The other BS 812 tests are not included in BS EN 13383 because they are too focussed on aggregate (small-scale stones). Instead, BS EN 13383 has included tests that reflect armourstone (large-scale stones) performance.

Most of the BS EN 13383 tests are the same as those in the CIRIA/CUR manual. The BS EN 13383 tests that are not included in the CIRIA/CUR manual, and are therefore new to the UK, include the uniaxial compressive strength test for determining resistance to breakage, a test for determining percentage of crushed and broken surfaces and the micro-Deval test for resistance to wear.

The magnesium sulphate soundness test specified in BS EN 1367-2 was recommended in BS 6349-1 for the testing of the durability of armourstone. BS EN 13383 also specifies the use of BS EN 1367-2, however BS EN 13383 only requires testing in accordance with the BS EN 1367-2 magnesium sulphate soundness test when the water absorption of the armourstone is greater than 0.5 %. Further guidance on determining the durability of armourstone is given in 4.5.

BS 6349-1 includes a recommendation for the testing of block integrity in accordance with the drop test outlined in the CIRIA/CUR manual, using full-scale armourstone pieces. BS EN 13383 does not include a requirement to test for block integrity because there is insufficient experience of testing for this property in Europe to be able to set requirement levels. However, BS EN 13383-1:2002, Annex B does give guidance on block integrity, including information about the CIRIA/CUR drop test. Further guidance on block integrity is also given in 4.3.2.2.

4 Requirements of BS EN 13383-1

4.1 General

Each clause in BS EN 13383 that specifies armourstone properties, i.e. Clause 4, Clause 5, Clause 6 and Clause 7, starts with a general subclause which draws attention to the necessity only to specify those properties relevant to the particular armourstone and end use of the armourstone. Where this is the case the wording “when required” is used.

In BS EN 13383, tables of specified requirements allow the user to choose an appropriate “category” for each property. The style of category designation is intended to be self-explanatory and related to the specified limiting value. For example, category $M_{DE}20$ means that armourstone with a maximum micro-Deval index value of 20 is required. However, there are instances where the category designation represents more than one requirement, for example, the resistance to breakage category CS_{60} specified in BS EN 13383-1:2002, Table 9 represents two different requirements and does not just mean that a compressive strength of greater than 60 MPa is required. Further guidance on resistance to breakage is given in 4.3.2.

An option to use a “no requirement” category is also provided. For example, a category for the proportion of crushed or broken surfaces of RO_{NR} is included in BS EN 13383:2002, Table 7 and it means that there is no specified requirement for the proportion of crushed or broken surfaces. A category of RO_5 , on the other hand, would require a limiting value of 5 % for pieces of armourstone with less than 50 % of crushed or broken surfaces.

When the value obtained for a particular property is outside the indicated limit or categories, the producer can provide a declared value. For example, if the percentage of pieces of armourstone with a length-to-thickness ratio of greater than 3 for a coarse grading exceeds 20 %, the producer can state a maximum value of $LT_{Declared}$ in accordance with BS EN 13383-1:2002, Table 6. Therefore, if the value is 25, the producer would state LT_{25} and the armourstone user should determine whether this is adequate for his purposes.

4.2 Geometrical requirements

4.2.1 Grading (BS EN 13383-1:2002, 4.2)

4.2.1.1 General

BS EN 13383-1:2002, 4.2 specifies requirements for three different types of armourstone gradings:

- a) coarse gradings, defined as having a nominal upper sieve size limit of 125 mm to 250 mm;
- b) light gradings, defined as having a nominal upper limit of 25 kg to 500 kg;
- c) heavy gradings, defined as having a nominal upper limit of more than 500 kg.

BS EN 13383-1:2002, Table 1 to Table 5 define coarse, light and heavy gradings in terms of nominal lower and upper limits for sieve sizes (d/D mm) or for masses [a to b] kg and indicate the required range in which most of the particle distribution occurs.

The selection of a BS EN 13383-1 grading for armourstone depends on the intended end use of the armourstone. Detailed guidance on the selection of an armourstone grading is given in BS 6349-1 and the CIRIA/CUR manual. This guidance is summarized as follows.

- 1) For *cover layers*, hydraulic design formulae, such as those given in BS 6349-1 and the CIRIA/CUR manual, are used to determine the armourstone grading needed for a particular end-use. These hydraulic design formulae can produce a value of M_{50} , the mass for which 50 % by mass of the armourstone is lighter. The CIRIA/CUR manual gives guidance that helps to show the correlation between M_{50} and the average mass of an armourstone for some of the light and heavy gradings given in BS EN 13383-1:2002, Table 2 and Table 4. Further guidance on this correlation is given in 4.2.1.2 and 4.2.1.3 for light gradings and heavy gradings, respectively. The general trend is that the M_{50} mass for an armourstone grading is nearly always greater than the average mass.

NOTE 1 The CIRIA/CUR manual actually shows the relationship between W_{50} (the weight for which 50 % by mass of the armourstone is lighter) and W_{em} (the effective mean weight). However, the ratio between W_{50} and W_{em} is the same as that between M_{50} (equivalent to $W_{50}/\text{gravitational force}$) and the average mass (equivalent to W_{em}).

NOTE 2 Armourstone producers should determine values for M_{50} in accordance with the calculations for the distribution of light and heavy gradings given in BS EN 13383-2:2002, Clause 6.

- 2) For *underlayers* or *filter layers*, the choice of grading depends on different practical and design criteria to that used for cover layers, e.g. geotechnical filter criteria.

BS EN 13383-1 gives the option to declare coarse, light and heavy gradings that are different from those given in BS EN 13383-1:2002, Table 1 to Table 5. There can be a particular need to declare additional heavy gradings in parts of the UK where the natural discontinuities in a local rock source limit the maximum size of rock available to an armourstone user.

The width of any declared gradings should follow the same general grading widths and ratios between grading limits as exhibited by the gradings specified in BS EN 13383-1:2002, Table 1 to Table 5. In the same way as for the gradings specified in BS EN 13383-1:2002, Table 1 to Table 5, this should include the declaration of four limits. These four limits are defined in BS EN 13383-1:2002, Annex A as the extreme lower limit (ELL), nominal lower limit (NLL), nominal upper limit (NUL) and extreme upper limit (EUL).

4.2.1.2 Coarse gradings (BS EN 13383-1:2002, 4.2.1)

Coarse gradings are generally used for filter layers, underlayers, bedding stone and gabions. Coarse gradings are described in BS EN 13383-1 in millimetres with the designation d/D , where d is the lower limiting sieve size and D is the upper limiting sieve size. The majority of the particle size distribution of an armourstone lies between these two values and requirements for this are specified in BS EN 13383-1:2002, 4.2.1.

The coarse gradings in BS EN 13383-1 are expressed in reverse order to the current British Standard system for aggregates, i.e. BS EN 13383-1 gives the lower sieve size before the upper sieve size.

BS EN 13383-1 specifies the use of sieve sizes that are larger than those sieves used in other European Standards for aggregates, extending the range beyond that specified in the ISO 3310-2 series of sieves used in other European Standards for aggregates. However, the sizes of these larger sieves continues along the same geometrical progression of sieve sizes described in ISO 3310-2.

NOTE 1 BS EN 13383-2:2002, Clause 5 describes the method of determining the particle size distribution of coarse gradings, including a detailed account of the required sieve sizes.

The armourstone pieces in the finest fraction of the coarse gradings are termed “fragments”. BS EN 13383-1:2002, Table 1 specifies that, for coarse gradings, the fragment fraction shall account for up to 5 % of the armourstone.

BS EN 13383-1:2002, 4.2.1 specifies the following five coarse gradings:

- a) three gradings of systematically increasing mean size:
 - 1) 45/125 mm;
 - 2) 63/180 mm;
 - 3) 90/250 mm;
- b) one wider grading of 45/180 mm;
- c) one narrower grading of 90/180 mm suitable for special applications, e.g. gabions.

NOTE 2 Guidance on the sieves used to determine the particle size distribution of coarse gradings is given in BS EN 13383-2:2002, 5.2.2.

4.2.1.3 Light gradings (BS EN 13383-1:2002, 4.2.2)

Light gradings are generally used for filter layers, underlayers, bedding stone and cover layers in river-banks. Light gradings are described in BS EN 13383-1 in kilograms with the designation a to b , where a is the nominal lower limit (NLL) of stone mass and b is the nominal upper limit (NUL) of stone mass. The majority of the particle size distribution of an armourstone lies between these two values and percentage passing requirements for this are specified in BS EN 13383-1:2002, 4.2.2. Extreme upper limit (EUL) mass values and extreme lower limit (ELL) mass values are also specified in BS EN 13383-1 and are also required to meet percentage passing requirements. BS EN 13383-1:2002, Annex A gives a diagrammatic representation of the relationship between values for ELL, NLL, NUL and EUL.

The armourstone pieces in the finest fraction of the light gradings are termed “fragments”.

BS EN 13383-1:2002, Table 2 and Table 3 specify that, for light gradings, the fragment fraction shall account for up to 2 % of the armourstone.

BS EN 13383-1:2002, 4.2.2 specifies the following five light gradings:

a) four gradings suitable for use in all hydraulic structures, except cover layers that are used in the aggressive conditions defined in the CIRIA/CUR manual:

- 1) (5 to 40) kg;
- 2) (40 to 200) kg;
- 3) (10 to 60) kg;
- 4) (60 to 300) kg;

NOTE 1 Quarry yields are likely to restrict production to either (5 to 40) kg and (40 to 200) kg or to (10 to 60) kg and (60 to 300) kg.

b) one wider grading of (15 to 300) kg suitable for underlayers, filters and core material and generally more economical to produce, particularly in the smaller UK quarries.

NOTE 2 The (15 to 300) kg grading should not be used in a cover layer because the grading is too wide and is likely to segregate under wave action, resulting in the loss of armourstone material.

BS EN 13383-1:2002, 4.2.2 specifies two categories for each of the five light grading designations.

BS EN 13383-1:2002, Table 2 specifies category A light gradings and BS EN 13383-1:2002, Table 3 specifies category B light gradings. BS EN 13383-1:2002, 4.2.2 requires that light graded armourstone conforms to either category A gradings, category B gradings or the gradings declared by the producer.

Category A light gradings confer a tighter control than category B gradings on the mass distribution by limiting the acceptable range of average mass. This will also limit the acceptable range of values for M_{50} , the mass for which 50 % by mass of the armourstone is lighter.

NOTE 3 The CIRIA/CUR manual indicates that the value of M_{50} for the light gradings is greater than their corresponding average mass by a factor of:

- a) 1.3 for (5 to 40) kg;
- b) 1.15 for (40 to 200) kg;
- c) 1.3 for (10 to 60) kg;
- d) 1.15 for (60 to 300) kg.

The CIRIA/CUR manual does not give a factor for the (15 to 300) kg grading because M_{50} values are only used in the design of cover layers and the (15 to 300) kg grading is too wide to be used in a cover layer. Guidance on the use of values for M_{50} is given in 4.2.1.1.

In most cases, armourstone produced to conform to a category B light grading (e.g. $LMB_{60/300}$) will also conform to the equivalent category A light grading (e.g. $LMA_{60/300}$). Therefore, for light grades, category B gradings will be acceptable in the UK. However, where the armourstone is to be used in a cover layer, category A should be used.

BS EN 13383-1 specifies the determination of the mass distribution of light gradings in accordance with either of two methods in BS EN 13383-2:2002, Clause 6. The reference method specified in BS EN 13383-2:2002, 6.4.1 requires that each individual piece of armourstone is weighed separately whilst the alternative method specified in BS EN 13383-2:2002, 6.4.2 only requires that the total mass and mass of selected pieces of armourstone is determined. Difficulties can occur in the handling and weighing of the larger pieces of stone of the light gradings. Particular attention should be given to ensuring that the weighing equipment, including hand-held gauges if applicable, is adequate to meet the accuracy requirements given in BS EN 13383-2:2002, 6.2.2 and that the equipment can take the weight of the largest stones in a particular light grading.

Generally, the alternative method specified in BS EN 13383-2:2002, 6.4.2 can be used. However, the reference method specified in BS EN 13383-2:2002, 6.4.1 should be used:

- 1) for the testing of armourstone for cover layers;
- 2) in cases of dispute;
- 3) where there is no ongoing production control system;
- 4) for initial type testing (i.e. for new sources of armourstone and where there is a major change in the raw materials or processing).