BS EN 13383-2:2013

BSI Standards Publication

Armourstone

Part 2: Test methods

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National foreword

This British Standard is the UK implementation of EN 13383-2:2013. It supersedes BS EN 13383-2:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/502, Aggregates.

A list of organizations represented on this committee can be obtained on request to its secretary.

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This European Standard was approved by CEN on 29 July 2011.

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Foreword

This document (EN 13383-2:2013) has been prepared by Technical Committee CEN/TC 154 “Aggregates”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2013, and conflicting national standards shall be withdrawn at the latest by November 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13383-2:2002.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

In comparison with the previous version, the following changes have been made.

- changes and clarifications to the sampling and sample reduction clauses, including a new informative annex on sampling from waterborne plant;
- introduction of requirements for sample preparation for the Micro-Deval test previously in EN 13383-1;
- deletion of an unused wet sieving method for the determination of particle size distribution of coarse gradings of armourstone.
- removal to an informative annex of a previously normative alternative to the reference method for determination of mass distribution of light and heavy gradings.

Otherwise the majority of the changes from the previous version are editorial.

EN 13383 *Armourstone* consists of the following parts:

Part 1: Specifications

Part 2: Test methods

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies sampling and test methods for natural, artificial and recycled aggregates for use as armourstone. This European Standard specifies the reference methods to be used for type testing and in case of dispute where an alternative method has been used. For other purposes, in particular factory production control, other methods may be used provided that an appropriate working relationship with the test method has been established.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 932-1:1996, *Tests for general properties of aggregates — Part 1: Methods for sampling*

EN 932-5, *Tests for general properties of aggregates — Part 5: Common equipment and calibration*

EN 933-1, *Tests for geometrical properties of aggregates — Part 1: Determination of particle size distribution — Sieving method*

EN 933-2, *Tests for geometrical properties of aggregates — Part 2: Determination of particle size distribution — Test sieves, nominal size of apertures*

EN 933-3, *Tests for geometrical properties of aggregates — Part 3: Determination of particle shape - Flakiness index*

EN 1097-1:2011, *Tests for mechanical and physical properties of aggregates — Part 1: Determination of the resistance to wear (micro-Deval)*

EN 1097-5, *Tests for mechanical and physical properties of aggregates — Part 5: Determination of the water content by drying in a ventilated oven*

ISO 3310-2, *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
armourstone grading
armourstone designation with a nominal lower and upper limit

Note 1 to entry: This designation accepts the presence of undersize and oversize pieces of armourstone.

3.2
nominal lower limit
mass or sieve size in a grading below which the armourstone pieces are considered to be undersized

3.3
nominal upper limit
mass or sieve size in a grading above which the armourstone pieces are considered to be oversized

3.4
coarse grading
designation with a nominal upper limit defined by a sieve size between and including 90 mm and 250 mm

3.5
light grading
designation with a nominal upper limit defined by a mass between and including 25 kg and 500 kg

3.6
heavy grading
designation with a nominal upper limit defined by a mass of more than 500 kg

3.7
fragment
aggregate pieces in the finest fraction of coarse gradings or the lightest fraction of light and heavy gradings for which the particle size distribution or mass distribution requirements apply

Note 1 to entry: For further information on grading, see EN 13383-1:2013, Annex A.

3.8
batch
production quantity, a delivery quantity, a partial delivery quantity (railway wagon-load, lorry-load, ship's cargo) or a stockpile produced at one time under conditions that are presumed uniform

Note 1 to entry: With a continuous process the quantity produced during an agreed period is treated as a batch.

3.9
sampling plan
procedure of allocation, withdrawal and preparation of a sample or samples from a material to yield the required information

3.10
sampling increment
quantity of material taken from a batch by one operation of the sampling apparatus

3.11
bulk sample
aggregation of the sampling increments

3.12
representative sample
sample created by taking sampling increments according to sampling plan, which makes it likely that the quality of this sample corresponds to that of the batch

3.13
subsample
sample obtained from sampling increments or a bulk sample by means of a sample reduction procedure

3.14
sampler
individual or a number of individuals working as a team, or an organisation, taking samples on a routine basis

3.15
length *L*
maximum dimension of a piece of armourstone as defined by the greatest distance apart of two parallel planes tangential to the stone's surface

3.16
thickness *T*
minimum dimension of a piece of armourstone as defined by the least distance apart of two parallel planes tangential to the stone's surface

3.17
constant mass
successive weighings after drying at least 24 h apart not differing by more than 0,1 %

Note 1 to entry: In many cases constant mass can be achieved after a test portion has been dried for a pre-determined period in a specified oven at (110 ± 5) °C. Test laboratories can determine the time required to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

4 Methods for sampling

4.1 General

This clause describes methods for obtaining samples of armourstone from preparation and processing plants including stocks and from silos, stockpiles and deliveries.

NOTE It is preferable that armourstone should be sampled at the quarry or during the loading for transport (or unloading).

The aim of sampling is to obtain samples that are representative of the average properties of the batch.

The methods described are also suitable for obtaining sampling increments which are to be tested separately.

Methods to be used for sample reduction are also given.

4.2 Principles of sampling

Proper and careful sampling and sample transport is a prerequisite for an analysis that will give reliable results. The correct use of the specified apparatus and methods helps to avoid biased sampling inclusive the possibility of human bias introduced by visual selection. Sampling variation caused by the heterogeneity of the batch shall be reduced to an acceptable level by taking an adequate number of sampling increments.

NOTE For guidance on numbers and sizes of samples and test portions for testing armourstone as specified in EN 13383-1:2013, see Annex G.

Sampling increments are selected at random from all parts of the batch that the samples are to represent. Armourstone from which no sampling increment can be taken (because it is not accessible, or for some other practical reason) shall not be considered to be part of the batch that is represented by the samples. For example, if sampling increments are taken from armourstone discharged from a silo, the samples represent the armourstone that has been discharged, not the armourstone remaining in the silo.

The sampler shall be informed of the aim of the sampling.

4.3 Sampling plan

A sampling plan shall be prepared, prior to sampling, taking into account the grading type, the nature and size of the batch, the local circumstances and the purposes of sampling. It shall include:

a) the type of the armourstone;

b) the aim of the sampling including a list of the properties to be tested;

c) the identification of the sampling points;

d) the mass or number of stones of sampling increments;

e) the number of sampling increments;

f) the sampling apparatus to be used;

g) the methods of sampling and sample reduction with reference to the clauses of this European Standard;

h) the relevant marking, packaging and dispatch of the samples.

4.4 Apparatus

4.4.1 Apparatus for sampling

4.4.1.1 Grab, fitted to either a crane or a hydraulic machine.

4.4.1.2 Bucket or fork, fitted to a wheeled loader or a hydraulic machine.

4.4.1.3 Truck, for receiving and/or transport of samples.

4.4.1.4 Lifting equipment and lifting aids, for stones that cannot be moved manually.

4.4.2 Apparatus for sample reduction and transport

4.4.2.1 A floor area, upon which samples can be deposited and tested. The floor shall be sufficiently clean and close-textured to be able to distinguish and recover the material of the sample from the floor material.

4.4.2.2 Shovels.

4.4.2.3 Rectangular sampling buckets, of sufficient size and of width not less than three times the nominal upper grading limit.

4.4.2.4 Suitable plates and wires, for sample reduction.

4.4.2.5 Containers for transport, such as bags, buckets or other suitable containers.

4.5 Sampling methods

4.5.1 General

Regulations for safety and ergonomics shall be followed.

WARNING Some sampling methods will inevitably involve the samplers working close to processing plant and moving vehicles. Those involved in the planning and execution of sampling should work closely with the operational management to ensure safe working practices.

Mechanically selected gradings should preferably be sampled from a stationary conveyor belt or from the stream of material. Sampling increments should be taken at regular intervals throughout the period the batch is in motion. Gradings of which the pieces of armourstone are individually handled may be sampled at the most convenient location.

Sampling from static batches should be avoided wherever possible since it is difficult to satisfy the principle of taking sampling increments at random from all parts of the batch, and hence segregation is likely to cause the sampling to produce biased results.

During sampling, grabs or other extraction equipment shall be filled to a minimum such that the degree of filling does not adversely affect the representative nature of the sample or sampling increment.

4.5.2 Sampling, for the determination of particle size distribution, mass distribution and shape characteristics

4.5.2.1 Sampling of material in bucket conveyors, bucket loaders, or grabs

Each sampling increment shall consist of the entire contents of a grab or bucket.

When this gives too large a sampling increment, it should be reduced by one of the methods described in 4.6.

4.5.2.2 Sampling at belt and chute discharge points

The period during which the sampling is to be done shall be divided into a number of equal intervals, and a sampling increment shall be taken in the middle of each interval.

A sample increment shall be taken by catching the discharge stream in a loader bucket, making sure that the complete cross-section of the stream of material is intercepted. At the beginning and the ending of the sampling the edge of the bucket shall pass the cross-section of the stream as fast as possible.

Where appropriate, sampling should only be started after a preliminary run to ensure that possible irregularities in the pass do not lead to unrepresentative samples.

Samples may also be taken at the discharge from a screen by the same method.

4.5.2.3 Sampling from stationary conveyor belts

Sampling should only be started after a preliminary run to ensure that possible irregularities in the pass do not lead to unrepresentative samples.

All sampling increments shall be taken at the same sampling point. In every sampling increment all material between two cross-sections shall be taken. The distance between the cross-sections shall be determined by the required quantity of the sampling increment.

4.5.2.4 Sampling from a silo

Sampling at a silo outlet shall be carried out in accordance with 4.5.2.2.

During filling of a silo the material segregates and as a result the finer material tends to be found in the centre of the silo with the coarser material along the wall sides. Alternating loading and discharging of a silo leads to a complex segregation pattern in the silo and this segregation causes variations in the

particle size distribution of the discharged material. The number of sampling increments should be related to this variation.

4.5.2.5 Sampling from stockpiles

When sampling from a segregated stockpile, from which material is being collected for transporting, a sampling increment shall be taken from the material which is being taken from the stockpile. For this purpose, the contents of one or more loader buckets, grabs, lorries or any other means of handling or transport shall be taken. The period during which the sampling is done shall be divided into a number of equal intervals and a sampling increment shall be taken in the middle of each interval.

If at the time of sampling no material of a segregated stockpile is undergoing routine removal, the removal of material shall be simulated so as not to distort the representativity of the sampling increment with the segregation effects associated with the initiation of stockpile extraction. The sampling increments shall be taken at random or at equal distances around the stockpile or part thereof to be sampled.

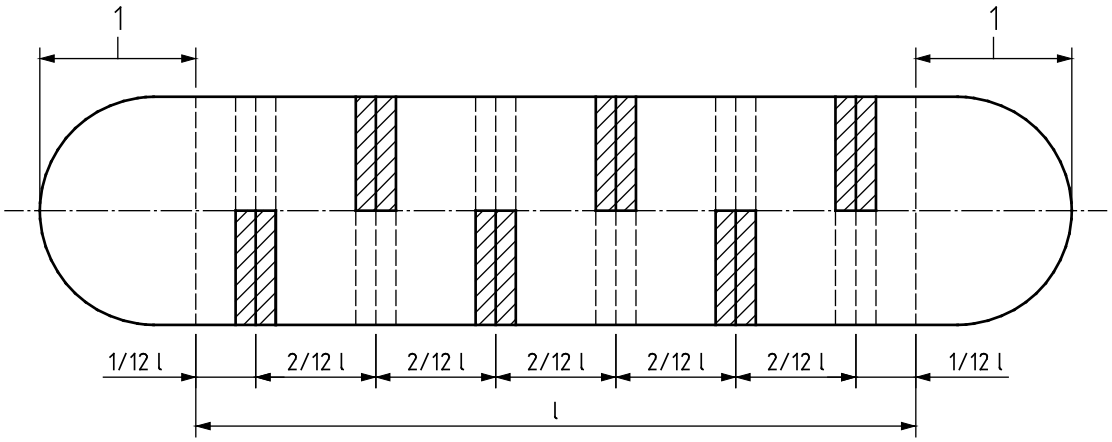
When sampling from a non-segregated stockpile, a sampling increment shall be taken as indicated for a segregated stockpile or by taking a quantity of material from a random location which is easily reached with the equipment available.

4.5.2.6 Sampling from floating equipment

When sampling cannot be performed during loading or unloading, sampling from floating equipment should be performed with reference to Scheme 1 or Scheme 2 of Annex H.

4.5.2.7 Sampling from wheeled transport

Discharge the contents of the vehicle partially or completely in a manner which produces an evenly distributed longitudinal pile of material. Sampling increments shall be taken from across the pile by removing, at random or at equally distributed locations, adequate quantities of material whilst avoiding the possibly segregated material at the start and finish of the pile (see Figure 1). Take the material in strips over the full width of the pile or in equal numbers of half strips from the left and right hand side of the centre line of the pile.



Dimensions are approximate

Key

1 potential segregation area

Figure 1 — Sampling locations in a spread-discharged load

When a batch to be sampled consists of more than one load, the sampling increments shall be taken from randomly selected loads using the method described above or taking each selected load as a whole as an increment.

When one load contains insufficient material for one sample to be tested several loads shall be taken.

4.5.3 Sampling for the determination of physical, chemical, durability and other properties

For the determination of physical, chemical, durability and other properties individual pieces of armourstone excluding fragments shall be taken randomly as sampling increments, forming together a bulk sample. For properties for which testing of aggregate is permitted, sampling shall be carried out in accordance with EN 932-1.

Sampling increments consisting of individual pieces of armourstone shall be taken from the batch to be tested and may be taken from the samples which have been taken for the determination of the particle size or mass distribution.

Sampling increments shall be selected by one of the following methods:

a) using random numbers (see EN 932-1:1996, Annex D);

b) taking pieces of armourstone in a sequence of predetermined positions relative to a randomly chosen starting point in a static batch;

c) taking pieces of armourstone from random sieve fractions or parts thereof during or after the determination of the particle size distribution using two samplers, one being a blindfolded selector and the other performing the actions;

d) taking pieces of armourstone at a time or number interval when the material to be sampled is passing in a random sequence of the stones, for instance during the determination of the mass distribution.

If individual pieces of armourstone are significantly larger than the minimum size or mass required for the test(s) to be executed, a portion of appropriate size or mass may be obtained by breaking a representative piece. (The objective is to obtain laboratory samples representative of the batch to be tested but to have carried sample reduction at source so as to minimize transport costs and reduce unnecessary sample reduction at the testing laboratory.).

4.6 Sample reduction

4.6.1 General

Wherever possible, samples shall be reduced to produce samples for testing of appropriate size at the sampling location.

If a sampling increment of a coarse grading is too large as test portion, one of the procedures as described in 4.6.2, 4.6.3 or 4.6.4 shall be used for the reduction of the sampling increment.

If a sampling increment of a light grading is too large for the preparation of the bulk sample, the procedure as specified in 4.6.3 or 4.6.4 shall be used for the reduction of the sampling increment.

If a sampling increment of a heavy grading is too large for the preparation of the bulk sample, the procedure as specified in 4.6.4 shall be used for the reduction of the sampling increment.

4.6.2 Reduction using buckets

Discharge the sample over one or more sample buckets.

When discharging a sample from a loader bucket, arrange the receiver bucket(s) to catch all the material from a cross-sectional segment or from one side of an imaginary cross-sectional plane in the centre of the loader bucket.

When discharging a sample from a grab, catch all the material from one symmetrical quarter or half of the grab content in one or more buckets.

If further reduction is required, tip the bucket(s) containing the reduced sample over two adjoining buckets and discard the contents of one bucket. Repeat this procedure until the required size of test portion is obtained.

4.6.3 Reduction using plates or wires

Discharge the sample over one or two vertically set plates. The distance between two parallel set plates shall be at least three times the sieve size of the nominal upper grading limit.

When discharging a sample from a loader bucket, take all the material from a cross-sectional segment or from one side of an imaginary cross-sectional plane in the centre of the loader bucket, discharged between two parallel and vertically set plates or at one side of a vertically set plate.

When discharging a sample from a grab, take all the material from one symmetrical quarter or half of the grab content, discharged between two vertically set plates at right angles to each other or at one side of a vertically set plate.

When reducing a sample already discharged onto a floor area (4.4.2.1) use wires representing imaginary separation planes.

For the reduction of a sample to approximately the half amount, stretch a wire as a separation line over the sample. Where segregation is present in one direction of the deposited sample, place the wire in the same direction (see Figure 2) and take the subsample by removing all armourstone located, or for the largest part located, at one side of the imagined vertical plane projected by the wire.

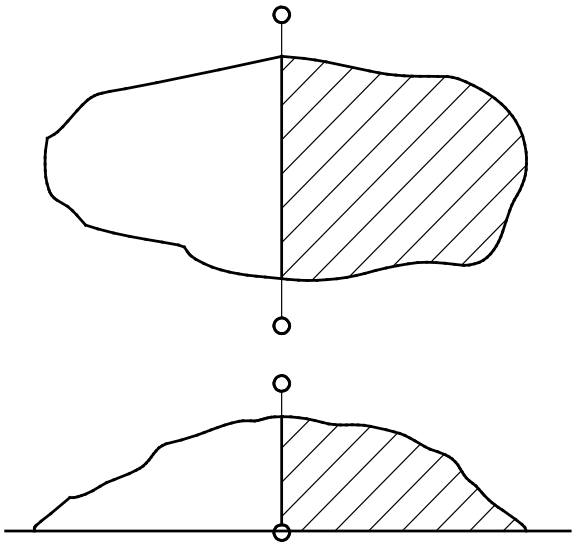


Figure 2 — Halving a sample by means of a separation plane

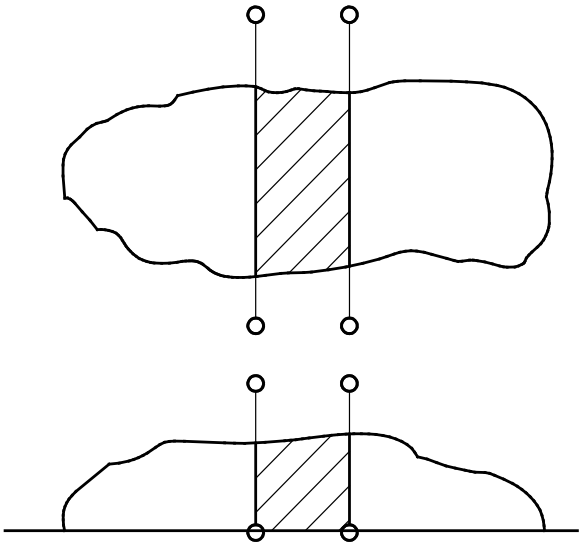


Figure 3 — Dividing a sample with two separation planes

For the reduction of a sample to less than the half amount, stretch two parallel wires as separation lines over the sample, so that the desired subsample lies between the two lines. Where segregation is present in one direction of the deposited sample, place the wires in the same direction (see Figure 3) and take the subsample by removing all stones located, or for the largest part located, between the imaginary vertical planes projected by the wires.

To facilitate the reduction procedure a sample to be reduced by using wires may be spread in a layer of thickness not greater than twice the nominal upper size of the material.

Where no segregation of the material has occurred, the subsample may be limited to half the separated strip.

4.6.4 Reduction using numbering

Each piece of armourstone in the sample shall be allocated an individual number in a consecutive sequence covering the entire sample. Each piece of armourstone shall be marked clearly and durably with the allocated number.

The subsample shall be taken by randomly selecting numbered pieces of armourstone until the required size of test portion is obtained.

4.7 Sample preparation for Micro-Deval test where aggregate sample not available

The test portion shall be prepared in accordance with EN 1097-1:2011, Clause 6, with the following variations:

4.7.1 The test portion shall be obtained by crushing at least six samples from separate pieces of armourstone for which the masses do not differ by more than 25 %. The crushing shall be carried out with a laboratory jaw crusher.

4.7.2 Flaky particles shall be removed by using bar sieves conforming to EN 933-3 as follows:

a) bar sieve of 6,3 mm for the fractions 10 mm to 11,2 mm (or 10 mm to 12,5 mm);

b) bar sieve of 8 mm for the fractions 11,2 mm to 14 mm (or 12,5 mm to 14 mm).

4.7.3 Cubical particles shall be removed by using bar sieves conforming to EN 933-3, as retained particles on the 12,5 mm bar sieve for the fractions 11,2 to 14 mm (or 12,5 mm to 14 mm).

4.8 Marking, packaging and dispatch of samples

The laboratory samples or containers in which they are transported shall be clearly and durably marked.

Marking shall include:

a) a unique code; or

b) identification of the laboratory samples, place of sampling, date of sampling and designation of the material.

Laboratory samples shall be transported in such a way that pieces of armourstone are not broken in transit.

4.9 Sampling report

The sampler shall prepare a sampling report for each laboratory sample or for each group of laboratory samples from a single source.

The sampling report shall refer to this part of this European Standard and state:

a) the sampling report identification (serial number);

b) the laboratory sample identification mark(s);

c) the date and place of sampling:

d) the grading type and the size of the batch;

e) the sampling point or identification of the batch sampled;

f) a reference to the sampling plan prepared in accordance with 4.3;

g) the name of the sampler;

h) any other relevant information.

NOTE An example of a sampling report is given in Annex A.

5 Determination of the particle size distribution of coarse gradings

5.1 Principle

The test consists of dividing up and separating a material, by means of a series of sieves, into several fractions of different sizes. The aperture sizes and the number of sieves shall be appropriate for the nature of the sample and the accuracy required.

The cumulative mass of the pieces of armourstone passing each sieve shall be expressed as a percentage of the total mass of the material.

5.2 Apparatus

5.2.1 All apparatus, unless otherwise stated, shall conform to the general requirements of EN 932-5.

5.2.2 Steel rod sieves, with square openings of 250 mm, 180 mm, 125 mm, 90 mm and 63 mm, fitting on receivers, and a single opening sieve, 360 mm. Alternatively, for 125 mm, 90 mm and 63 mm square openings, perforated steel plate sieves.

Steel bar sieves shall comprise steel bars welded together at right angles, forming square openings, with dimensions equating to the nominal sieve sizes with tolerances of ± 2,0 mm for the 360 mm, 250 mm, 180 mm and 125 mm sieves and ± 1,0 mm for the 90 mm and 63 mm sieves. In all cases the 63 mm sieve shall be used.

Perforated steel plate sieves shall be in accordance with EN 933-2.

5.2.3 Test sieves, apertures conforming to ISO 3310-2 with apertures smaller than 63 mm.

5.2.4 Receivers, with a volume of at least 0,1 m^3, on which the sieves will fit.

5.2.5 Weighing equipment, with a weighing capacity of at least 150 kg, accurate to 0,5 kg.

5.2.6 Shovels, and brushes.

5.2.7 A floor area, upon which the test portion can be deposited and tested. The floor shall be sufficiently clean and close-textured to be able to distinguish and recover the material of the test portion from the floor material.

5.3 Preparation of test portion

The sample shall be obtained from a bulk sample of six sampling increments taken out of a static batch or three sampling increments obtained from a stream of material and reduced if necessary in accordance with the requirements of Clause 4 to produce the required test portion.

The mass of the test portion in kilograms shall be at least twice the nominal upper limit of the grading in millimetres.

5.4 Procedure

Place the sieves on the receivers.

Pass the sample in successive parts over the sieves in order of increasing sieve size, starting with the 63 mm sieve up to and including the 250 mm sieve. Place the 360 mm sieve over the stones retained on the 250 mm sieve.

Brush off, where present, any adhesive materials from the pieces of armourstone and catch the fine material in the receiver under the 63 mm sieve.

Ensure that all pieces of armourstone which may pass the sieve in any orientation have so passed before the retained material is placed on the subsequent sieve.

Remove the fraction which passes the 63 mm sieve and weigh its mass (m_1).

If this mass is greater than 80 kg, split the fraction, taking and weighing a representative part of at least 40 kg (m_2). Execute the split by discharging the homogenised material over two adjoining receivers taking care to avoid any loss of material.

Sieve the fraction which passes the 63 mm sieve, or the representative part thereof, in accordance with EN 933-1.

Weigh the material retained on each sieve separately (M_i) and weigh the fraction which passes the sieve with the smallest aperture size (m_3) to $\pm$ 0,5 kg.

5.5 Calculation and expression of results

Record the various masses on a test data sheet (see Annex B).

If the fraction which passed the 63 mm sieve has been split before being sieved further, determine the values of M_i and m_3 for the ISO 3310-2 test sieves by multiplying the individual fractional masses by m_1/m_2.

Calculate as a percentage the mass (r_i) retained on each sieve to the nearest 0,1 % from the following formula:

$$r_i = \frac{M_i}{\Sigma M_i + m_3} \times 100$$

where

M_i is the mass of material retained on a sieve, in kilograms;

ΣM_i is the cumulative mass of material retained on all sieves, in kilograms;

m_3 is the mass of material passing the sieve with the smallest aperture size, in kilograms.

Calculate the cumulative percentage mass (R_i) retained on each sieve to the nearest 0,1 %.

Calculate the cumulative percentage mass passing each sieve (P_i) from the following formula:

$$P_i = 100 - R_i$$

Record to the nearest whole number.

5.6 Test report

5.6.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identity of laboratory;

c) identification of the sample;

d) mass of test portion;

e) cumulative percentages of the masses passing each of the sieves, to the nearest whole number;

f) date of test.

5.6.2 Optional data

The test report can include the following information:

a) name and location of the sample source;

b) description of the material and of the sampling procedure;

c) graphical presentation of results.

6 Determination of the mass distribution of light and heavy gradings

6.1 Principle

The test consists of dividing a material into several fractions by means of weighing individual pieces of armourstone. The average mass of the pieces of armourstone is derived by dividing the total mass excluding fragments by the number of pieces of armourstone.

A reference method is specified. The use of other methods not described in this standard for determining mass distribution are permitted, in particular for factory production control, provided that an appropriate working relationship with the reference method has been established.

A method employing bulk weighing is given in Annex D as an example. For initial type testing and in cases of dispute the reference method should be used.

6.2 Apparatus

6.2.1 All apparatus, unless otherwise stated, shall conform to the general requirements of EN 932-5.

6.2.2 Weighing equipment, accurate to 5 % of the nominal lower limit of the grading to be tested.

6.2.3 Lifting equipment and lifting aids, for armourstone that cannot be moved manually.

6.2.4 A floor area, upon which the test portion can be deposited and tested. The floor shall be sufficiently clean and close-textured to be able to distinguish and recover the material of the test portion from the floor material.

6.3 Preparation of test portion

A bulk sample shall be taken in accordance with the requirements of Clause 4 consisting of at least three sampling increments from a stream of material or at least six sampling increments from a static batch.

For heavy gradings, the sampling increment may well be a single piece of armourstone and in this case considerably more than 6 sampling increments will be needed to meet the requirements of Table 1 below.

The sample shall be reduced if necessary in accordance with the requirements of Clause 4 to produce the required test portion.

The number of pieces of armourstone heavier than fragments in the test portion of heavy and light gradings shall be as specified in Table 1.

Table 1 — Number of pieces of armourstone in test portions for determination of mass distribution

Grading kg	Minimum number of pieces of armourstone heavier than fragments
Heavy grading: 10 000 to 15 000	25
Heavy grading: 6 000 to 10 000	30
Heavy grading: 3 000 to 6 000	60
Heavy grading: 1 000 to 3 000	90
Heavy grading: 300 to 1 000	140
Light gradings	200

6.4 Procedure

Weigh each piece of armourstone heavier than a fragment separately (M_i) to ± 5 % of the nominal lower limit of the grading.

Weigh all fragments together (M_f) to ± 5 % of the nominal lower limit of the grading.

Count and record the total number of pieces of armourstone heavier than a fragment (*n*).

6.5 Calculation and expression of results

Record the various masses on a test data sheet (see example given in Annex C).

Calculate the cumulative mass of pieces of armourstone including fragments (M_n) with a mass smaller than each specified mass in the mass distribution.

Calculate, to the nearest whole number, the cumulative percentage of pieces of armourstone (P_n) with a mass smaller than each specified mass in the mass distribution in accordance with the following formula:

$$P_n = \frac{M_n}{\Sigma M_i + M_f} \times 100$$

where

M_n is the cumulative mass of the pieces of armourstone including fragments with a mass smaller than each specified mass in the mass distribution, in kilograms;

ΣM_i is the cumulative mass of all the pieces of armourstone larger than a fragment, in kilograms;

M_f is the mass of the fragments, in kilograms.

Calculate the average mass of the pieces of armourstone heavier than a fragment (M_{em}) in kilograms to the nearest 1 kg in accordance with the following formula:

$$M_{em} = \frac{\Sigma M_i}{n}$$

where

ΣM_i is the cumulative mass of all the pieces of armourstone larger than a fragment, in kilograms;

n is the number of the pieces of armourstone heavier than a fragment.

6.6 Test report

6.6.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identity of laboratory;

c) identification of the sample;

d) number of pieces of armourstone heavier than fragments in the test portion;

e) cumulative percentages of pieces of armourstone with a mass smaller than each specified mass in the mass distribution;

f) average mass of the pieces of armourstone heavier than a fragment;

g) date of test.

6.6.2 Optional data

The test report can include the following information:

a) name and location of the sample source;

b) description of the material and of the sampling procedure;

c) graphical presentation of the mass distribution for method specified in Clause 6.

For this purpose, the cumulative masses smaller than and equal to every measured mass of a piece of armourstone expressed in percentage should be plotted.

7 Determination of the percentage of pieces of armourstone with a length-to-thickness ratio greater than 3

7.1 Principle

The individual pieces of armourstone shall be classified on the basis of their maximum length *L* and minimum thickness *T*, as determined by visual inspection, by using straight laths and a carpenter's rule or a tape-measure, or by using a calliper.

7.2 Apparatus

7.2.1 All apparatus, unless otherwise stated, shall conform to the general requirements of EN 932-5.

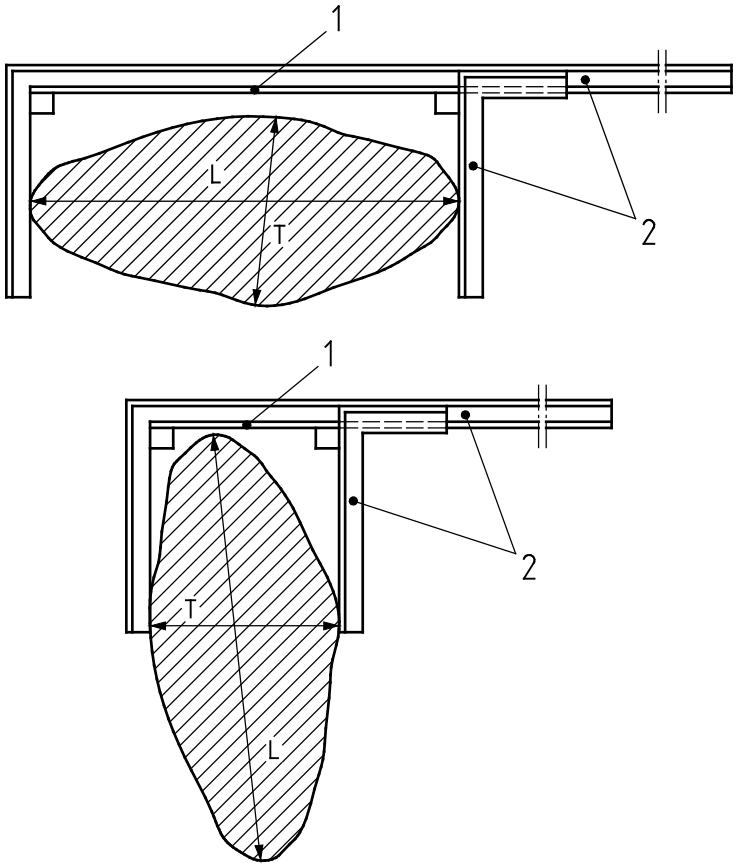
7.2.2 Two straight laths, of length greater than the largest thickness (*T*) of the piece of armourstone to be tested.

7.2.3 Carpenter's rule or tape-measure, readable to ± 3 % of the largest length (*L*) of the piece of armourstone to be tested.

7.2.4 Calliper, as shown in Figure 4 or any equivalent equipment.

In cases of dispute the equipment shown in Figure 4 shall be used.

7.2.5 Weighing equipment, accurate to 5 % of the masses to be weighed.



Key

1 tape measure

2 L-steel

Figure 4 — Calliper

7.3 Preparation of test portion

The sample shall be taken and reduced if necessary in accordance with the requirements of Clause 4 to produce the required test portion. Fragments shall be discarded.

The number of pieces of armourstone in a test portion shall be as specified in Table 2.

Table 2 — Number of pieces of armourstones in test portions for determination of shape characteristics

Grading kg	Minimum number of pieces of armourstone
Heavy grading: 10 000 to 15 000	25
Heavy grading: 6 000 to 10 000	30
Heavy grading: 3 000 to 6 000	60
Heavy grading: 1 000 to 3 000	90
Heavy grading: 300 to 1 000	140
Light gradings and coarse gradings	200
Test portions obtained for the determination of the mass distribution (Clause 6) of a light or heavy mass grading may be used for this test. For coarse gradings the test may be performed on representative parts of sieve fractions obtained from the determination of the particle size distribution (Clause 5) containing a sufficient number of armourstones.	

7.4 Procedure

7.4.1 Measurement of stones

Should unambiguous assessment of $L/T > 3$ of any piece of armourstone not be possible by visual inspection, position the armourstone with its two extremities between the two straight laths positioned parallel to each other and at right angles to the longest dimension (length L). Measure the length L at right angles to the laths using the carpenter's rule or the tape-measure. Measure the thickness T by positioning the two straight laths parallel to each other and tangential to the smallest dimension (thickness: T). Measure the thickness T at right angles to the laths using the carpenter's rule or the tape measure.

Measure the dimensions L and T to $\pm$ 3 %. If this accuracy cannot be met using the above procedure the calliper (7.2.4) shall be used.

7.4.2 Heavy gradings

For heavy gradings count the number of pieces of armourstone (N_1) with a L/T ratio greater than 3 and the total number of pieces of armourstone tested (N_2).

7.4.3 Light gradings

For light gradings weigh the total mass of the pieces of armourstone (M_1) with a L/T ratio greater than 3 and the total mass of the pieces of armourstone tested (M_2).

7.4.4 Coarse gradings

For coarse gradings weigh the total mass of the pieces of armourstone (M_{si}) with a *L/T* ratio greater than 3 in each size fraction and the total mass of the pieces of armourstone tested (M_{ti}) in each size fraction.

7.5 Calculation and expression of results

7.5.1 Heavy gradings

Calculate the percentage, *X*, of pieces of armourstone with a length-to-thickness ratio greater than 3 in accordance with the following formula:

$$X = N_1 / N_2 \times 100$$

where

N_1 is the number of pieces of armourstones with a *L/T* ratio greater than 3;

N_2 is the total number of pieces of armourstones tested.

Record the percentage to the nearest whole number.

7.5.2 Light gradings

Calculate the percentage, *X*, of pieces of armourstone with a length-to-thickness ratio greater than 3 in accordance with the following formula:

$$X = M_1 / M_2 \times 100$$

where

M_1 is the total mass of the pieces of armourstone with a *L/T* ratio greater than 3, in kilograms;

M_2 is the total mass of the pieces of armourstone tested, in kilograms.

Record the percentage to the nearest whole number.

7.5.3 Coarse gradings

Calculate the percentage, *X*, of pieces of armourstone with a length-to-thickness ratio greater than 3 in accordance with the following formula:

$$X = \sum_{i=1}^{n} \frac{M_{si}}{M_{ti}} V_i = \frac{M_{s1}}{M_{t1}} V_1 + \frac{M_{s2}}{M_{t2}} V_2 + \ldots\ldots\ldots \frac{M_{sn}}{M_{tn}} V_n$$

where

M_{si} is the mass of the pieces of armourstone with a *L/T* ratio greater than 3 in each size fraction;

M_{ti} is the total mass of the pieces of armourstone tested in each size fraction;

V_i is the percentage by mass of size fraction *i* in the test portion (derived from the determination of the particle size distribution specified in Clause 5).

Record the percentage to the nearest whole number.

7.6 Test report

7.6.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identity of laboratory;

c) identification of the sample(s);

d) number of pieces of armourstone tested;

e) percentage by number of heavy gradings and the percentage by mass of coarse;

f) light gradings of the pieces of armourstone with a *L/T* ratio greater than 3;

g) date of test.

7.6.2 Optional data

The test report can include the following information:

a) name and location of the sample(s) source;

b) for coarse gradings, the test result per individual fraction investigated;

c) description of the material and of the sampling procedure.

8 Determination of particle density and water absorption

8.1 Principle

Particle density is calculated from the ratio of mass to volume of a piece of armourstone or part thereof. The water absorption is determined by weighing the test portion in the saturated and surface dried condition and again in the oven-dried condition. The volume, for various moisture conditions, is determined from the mass of the water displaced, by weight reduction in a wire-basket.

8.2 Apparatus

8.2.1 All apparatus, unless otherwise specified, shall conform to the general requirements of EN 932-5.

8.2.2 Ventilated oven, thermostatically controlled to maintain a temperature of (110 ± 5) °C.

8.2.3 Balance, capable of weighing to ± 0,05 % of test portion mass. The capacity of the balance shall be suitable to allow the wire basket containing the sample to be suspended and weighed in water.

8.2.4 Thermometer, accurate to 1 °C.

8.2.5 Wire basket, or perforated container of suitable size to allow suspension from the balance.

8.2.6 Watertight tank, containing water at (22 ± 3) °C in which the basket may be freely suspended with a minimum clearance of 50 mm between the basket and the sides of the tank.

8.2.7 Container, of similar capacity to the wire basket for storage of the sample in water.

8.2.8 Sawing or coring machine.

8.2.9 Washing equipment and brush.

8.2.10 Chamois or equivalent synthetic leather.

8.3 Materials

8.3.1 Water, boiled and cooled before use.

The water should be free from any impurity that would significantly affect its density.

8.4 Preparation of test portion

The sample shall be reduced if necessary in accordance with the requirements of Clause 4 to produce the required test portion.

The test portion shall consist of a single piece of armourstone or part thereof with a mass of at least 150 g. If water absorption is to be determined, the mass of the test piece shall not exceed 450 g.

Remove any loose fragments and wash the test portion under running water to remove adhering fine particles.

8.5 Test procedure

Place the prepared test portion in the container and completely immerse it in water until its mass is constant. Place the test portion in the wire-basket suspended from the balance and immerse them in the tank containing water with a cover of at least 50 mm of water above the top of the basket. Determine the apparent mass of the test portion in water (M_2) and measure the temperature of the water in the tank to the nearest 1 °C.

Remove the test portion from the water and immediately remove the water from its surface using a moist chamois or equivalent synthetic leather, until the surface is dull and no longer wet and shiny, and weigh the test portion (M_1).

Dry the test portion in the oven at a temperature of (110 ± 5) °C until it has reached constant mass (M_3).

Record all weighing to an accuracy of 0,05 % of the mass of the test portion or better.

8.6 Calculation and expression of results

Calculate the particle density ρ (Mg/m^3) in accordance with the following formula:

$$\rho = \frac{M_3 \times \rho_w}{M_1 - M_2}$$

where

M_1 is the mass of the saturated and surface dried test portion, in grams;

M_2 is the apparent mass in water of the saturated test portion, in grams;

M_3 is the mass of the oven-dried test portion, in grams;

ρ_w is the density of water at the temperature recorded when M_2 was determined, see Annex E, in megagrams per cubic metre.

Calculate the water absorption W_{as} (as a percentage of the dry mass) from the following formula:

$$W_{as} = \frac{M_1 - M_3}{M_3} \times 100$$

where

M_1 is the mass of the saturated and surface dried test portion, in grams;

M_3 is the mass of the oven-dried test portion, in grams.

Express the values of particle density to the nearest 0,01 Mg/m^3 and the water absorption to the nearest 0,1 %.

NOTE An indication of precision is given in Annex F.

8.7 Test report

8.7.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identity of the laboratory;

c) identification of the sample;

d) the nominal grading of the armourstone from which the sample was taken;

e) mass of dry sample tested;

f) the test results;

g) date of test.

8.7.2 Optional data

The test report can include the following information:

a) name and location of the sample source;

b) description of the material and of the sampling procedure.

9 Determination of resistance to freezing and thawing

9.1 Principle

The procedure is based on the testing of a test portion consisting of one piece of armourstone. However, several such test portions can be tested at the same time and share both an oven and low temperature cabinet.

A test portion of armourstone, having been soaked in water at atmospheric pressure and packed in plastic foil to avoid drying out during freezing, is subjected to 25 freeze-thaw cycles. This involves cooling down to -17,5 °C in air and then thawing out in a water-bath. After completion of the 25 freeze-thaw cycles, the test portion is examined for any changes such as crack formation, and/or loss of mass.

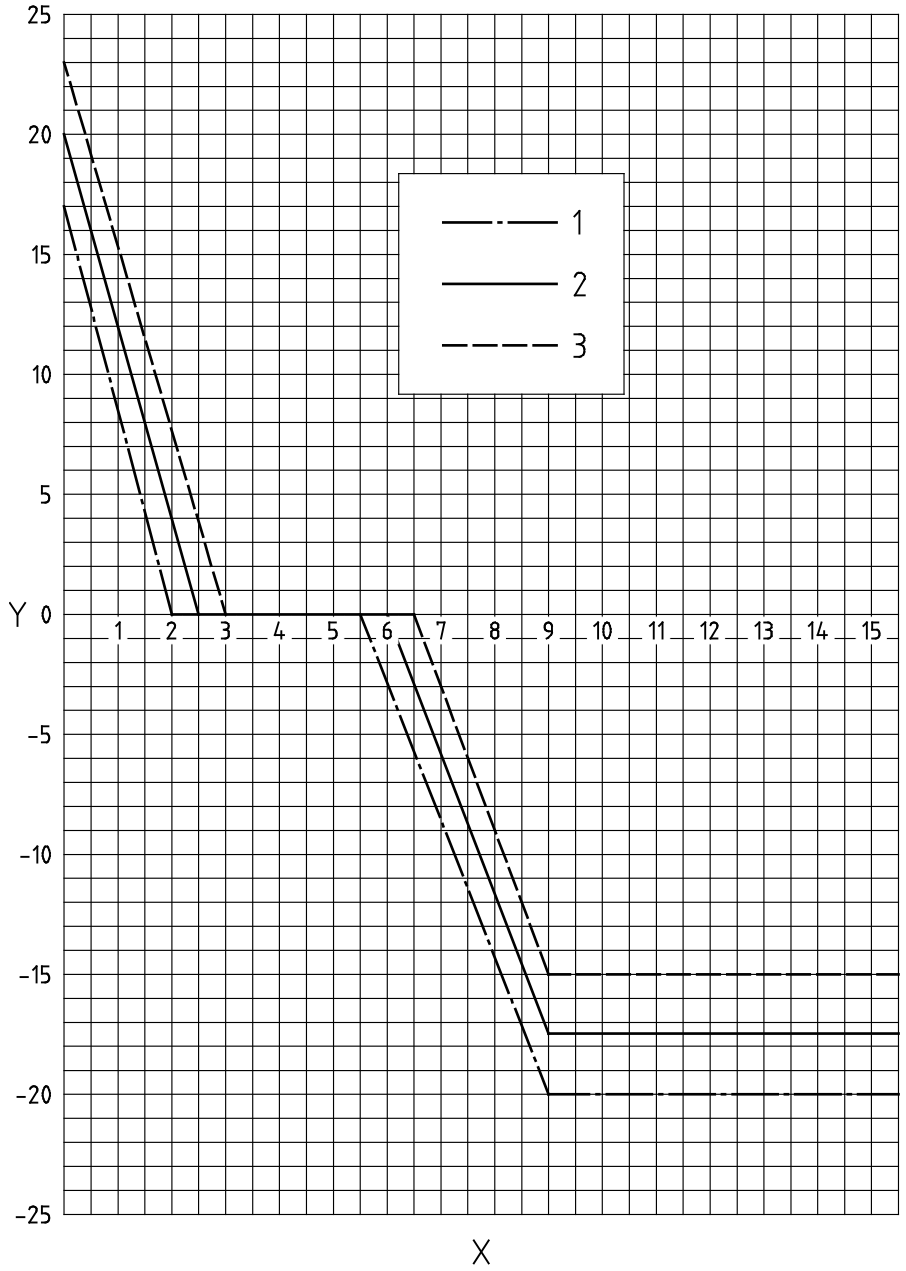
The test method consists of soaking at atmospheric pressure and storage in water for thorough water absorption (see 9.5.1) and exposure to frost action under water (see 9.5.2).

9.2 Apparatus

9.2.1 All apparatus, unless otherwise stated, shall conform to the general requirements of EN 932-5.

9.2.2 Ventilated drying oven, with forced circulation of adequate capacity. The oven shall be capable of being controlled at (110 ± 5) °C.

9.2.3 Balance, with an accuracy of ± 0,1 % of the mass being measured.



Key

1 lower limit

2 control

3 upper limit

X time in h

Y temperature in °C

Figure 5 — Temperature curve in the centre of the filled can (reference measuring point) located in the middle of the cabinet

9.2.4 Low temperature cabinet, (upright or chest) with air circulation. A manual method of control may be used, provided the correct cooling curve, as shown in Figure 5, is adhered to. In the case of a dispute, the automatic control shall be used.

9.2.5 Container, made from corrosion resistant sheet metal or plastics of suitable wall thickness, having a nominal capacity of six times the volume of the test portion.

9.2.6 A can, made from seamless drawn or welded corrosion resistant sheet metal, with a wall thickness of about 0,6 mm, a nominal capacity of 2 000 ml, an internal diameter of 120 mm to 140 mm, and an internal height of 170 mm to 220 mm, covered with an appropriate lid.

9.2.7 Sawing or coring machine.

9.2.8 Plastics sheeting with a thickness of 0,05 mm.

9.2.9 Suitable brush.

9.3 Materials

Water, boiled and cooled before use.

9.4 Test portions

9.4.1 General

9.4.1.1 Introduction

The sample shall be taken in accordance with Clause 4 and reduced if necessary in accordance with the requirements of Table 3 to produce the required test portion. The test portion shall consist of one piece of armourstone or part thereof without open visible cracks.

NOTE For armourstone both sampling and preparation are to some extent dependent on the mass of the piece of armourstone selected for the test. Three groups are recognised, see Table 3.

Table 3 — Masses of laboratory samples and test portions

Piece of armourstone	Laboratory sample	Test portion freeze-thaw	Test portion water absorption	Reference clause
> 20 kg	> 10 kg	10 kg to 20 kg	150 g to 450 g	9.4.1.2
450 g to 20 kg	450 g to 20 kg	450 g to 10 kg	150 g to 450 g	9.4.1.3
150 g to 450 g	150 g to 450 g	150 g to 450 g	150 g to 450 g	9.4.1.4

9.4.1.2 The test portion of 10 kg to 20 kg for the freeze-thaw test shall be obtained by splitting or sawing a laboratory sample of at least 10 kg from a block of more than 20 kg. The specimen of 150 g to 450 g for testing water absorption shall be removed from the laboratory sample by sawing or drilling.

9.4.1.3 The test portion of 450 g to 10 kg for the freeze-thaw test shall be obtained by splitting or sawing from a laboratory sample of 450 g to 20 kg. The specimen of 150g to 450g for testing water absorption shall be removed from the laboratory sample by sawing or drilling.

Where the test portion for water absorption is larger than the remaining part of the laboratory sample it shall be used as the freeze-thaw portion.

9.4.1.4 The test portion of 150 g to 450 g for the freeze-thaw test corresponds with the piece of armourstone to be tested and is also used for testing the water absorption.

NOTE The testing of water absorption is the first stage in the determination of the resistance to freezing and thawing of armourstone.

9.4.2 Preparation of test portions

Wash, and remove adherent particles from the test portion by brushing. Dry at (110 ± 5) °C, as specified in EN 1097-5, until constant mass is achieved, allow to cool to ambient temperature and weigh immediately (M_1).

Weighing shall be performed to an accuracy of 0,1 %.

9.5 Procedure

9.5.1 Soaking at atmospheric pressure

The test portion, prepared in accordance with 9.4.1, shall be stored at atmospheric pressure for (24 ± 1) h in the container (see 9.2.5) at 20 °C to 25 °C, in distilled or demineralised water, the water covering the test portion by at least 10 mm for the full 24 h period of the soaking.

9.5.2 Exposure to freezing and thawing

After soaking, take the test portion out of the container, wrap it in plastic sheeting minimising entrapped air, and place in the low temperature cabinet. Ensure that the heat is extracted from the test portion as uniformly as possible form all sides. To achieve this it may be necessary to reposition the test portion after each freeze-thaw cycle, within the cabinet. The distance between test portion and the sidewalls of the cabinet, shall not be less than 50 mm. In the case of testing several test portions at the same time, these shall not be touching.

Using the temperature at the centre of a covered can filled with 8/16 mm aggregate and water, situated in the centre of the cooled area, as the reference measuring point of temperature, regulate the cabinet so that the temperature follows a cooling curve inside the limits as shown in Figure 5.

Subject the samples in the cabinet to a series of 25 freeze-thaw cycles as follows.

a) Reduce the temperature from (20 ± 3) °C to (0 to -1) °C in (150 ± 30) min and hold at (0 to -1) °C for (210 ± 30) min.

b) Reduce the temperature from (0 to -1) °C to (- 17,5 ± 2,5) °C in (180 ± 30) min and hold at (- 17,5 ± 2,5) °C for a minimum of 240 min.

If it is necessary to interrupt the test during the freezing cycle or when under manual control, for example at weekends, the can should be kept at (- 17,5 ± 2,5) °C. Any interruption should not exceed 72 h.

c) At no stage allow the air temperature to fall below - 22 °C.

d) After the completion of each freezing cycle remove the plastics sheeting and thaw the test portion in the container by immersion in water at approximately 20 °C. Thawing shall be considered to be completed when the temperature has reached (20 ± 3) °C.

e) After the completion of each thawing phase hold the test portion in water at (20 ± 3) °C for a maximum of 10 h. Each freeze-thaw cycle shall be completed within 24 h with the exception of an interruption as mentioned in b).

9.5.3 Inspection and weighing

On completion of the 25th cycle take the test portion out of the container and dry at (110 ± 5) °C, and allow to cool to ambient temperature and weigh as specified in 9.4.2 (M_2).

Examine the test portion visually and note any open cracks or other signs of disintegration.

NOTE Formation of open cracks or opening of existing discontinuities can more objectively be determined by measuring the velocity of acoustic waves through the test portion before and after freezing and thawing (also see EN 13383-1:2013, Annex C).

9.6 Calculation and expression of results

Calculate the result of the freeze-thaw test in accordance with the following formula, to the nearest 0,1 %:

$$F = \frac{M_1 - M_2}{M_1} \times 100$$

where

M_1 is the initial dry mass of the test portion, in grams;

M_2 is the final dry mass of the test portion, in grams;

F is the percentage loss in mass of the test portion after freeze-thaw cycling.

9.7 Test report

9.7.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identity of the laboratory;

c) identification of the sample;

d) the nominal grading of armourstone from which the sample was taken;

e) the description of the visual appearance of the test portion after the freeze-thaw test, including the formation of open cracks and any unusual disintegration;

f) the result of the freeze-thaw test F, expressed to the nearest 0,1 % by mass;

g) date of test.

9.7.2 Optional data

The test report can include the following information:

a) name and location of the sample source;

b) description of the material and of the sampling procedure.

10 Determination of signs of “Sonnenbrand" and disintegration of steel slags

10.1 Principle

Individual pieces of armourstone (excluding fragments) are visually examined for signs of "Sonnenbrand” and samples of steel slags (excluding fragments) are tested for percentage loss in mass. The procedure is based on the testing of a test portion consisting of one piece of armourstone or part thereof, but it is permitted that several such test portions may be tested at the same time and share the boiling.

NOTE 1 Sonnenbrand is a type of rock decay that can be present in some basalts and which manifests itself under the influence of atmospheric conditions. Sonnenbrand starts with the appearance of grey/white star-shaped spots. Usually hairline cracks are generated radiating out from the spots and interconnecting them. This reduces the strength of the mineral fabric, and as a result the rock decays to small particles. Depending on the source, this process might take place within months of extraction or extend over several decades. In exceptional cases, a rapid decay results in the formation of large cracks and the breaking of aggregate particles or armourstone.

NOTE 2 Steel slags might contain oxides of calcium and magnesium, which when in contact with water these mineral phases will react to form hydroxides with a resultant increase in volume. As a result of these reactions, steel slag aggregates can develop cracks and/or break down into smaller pieces over a period of time, with a resultant drop in strength and/or durability.

10.2 Apparatus

10.2.1 All apparatus, unless otherwise stated, shall conform to the general requirements of EN 932-5.

10.2.2 Sawing machine.

10.2.3 Steel can, with water-cooled lid or with a lid with a small vent hole.

10.2.4 Heat source, capable of boiling the can and contents.

10.2.5 Moist cloth.

10.2.6 Test sieves, conforming to EN 933-2.

10.2.7 Balance, with an accuracy of ± 0,1 % of the mass of the test portion.

10.2.8 Ventilated drying oven, with forced circulation of adequate capacity. The oven shall be capable of being controlled at (110 ± 5) °C.

10.2.9 A suitable brush.

10.3 Materials

10.3.1 Water, boiled and cooled before use.

10.4 Preparation of test portions

10.4.1 Test portion for the visual examination of armourstone for signs of “Sonnenbrand”

For the determination of the presence of signs of "Sonnenbrand", the laboratory sample shall be taken in accordance with Clause 4 from a quarry rock pile and shall consist of one piece of armourstone, which shall be large enough to give a sawn surface equal to or greater than 0,005 m^2.

Cut the piece of armourstone to give two sawn test portions, and mark each for identification.

Wash each test portion and remove adherent particles by brushing.

10.4.2 Test portion for the determination of loss in mass of a piece of steel slag after boiling

The sample shall be taken in accordance with Clause 4 and reduce the laboratory samples if necessary in accordance with 4.6 and discard pieces of slag with visible cracks.

Wash the test portion, remove adherent particles by brushing, and dry to constant mass. Allow the test portion to cool to ambient temperature and weigh (m_0).

Weighing shall be performed to an accuracy of 0,1 %. Mark the test portion for identification.

10.5 Procedure

10.5.1 Visual examination of signs of “Sonnenbrand" in a piece of armourstone

Place one of the two test portions in the steel can and fill with distilled or demineralised water so that the test portion will remain covered during boiling, and cover with a lid. Bring the can and contents to boiling and maintain boiling for (36 ± 1) h.

Remove the warm test portion from the can and allow to surface dry.

Lightly moisten the sawn surface with a moist cloth and as the sawn surface dries again, examine for any of the following and record observations:

a) formation of grey/white star shaped spots or radiating hairline cracks;

b) formation of larger cracks;

c) breakage of the test portion.

A comparison may be made between the test portion under test and the unboiled test portion.

10.5.2 Determination of loss in mass of a piece of steel slag after boiling

Place the test portion in the steel can and fill with distilled or demineralised water so that the test portion will remain covered during boiling, and cover with lid.

Bring the can and contents to boiling within 0,5 h and maintain boiling for (8 ± 1) h.

Leave the test portion immersed in water for a minimum of 8 h during cooling. Remove the test portion from the can and dry to constant mass at (110 ± 5) °C. Weigh and record the test portion mass, in grams, as m_1.

Examine and record crack formation.

If the test portion has fragmented during boiling, record the mass of the largest remaining fragment.

10.6 Calculation and expression of results

10.6.1 Determination of the percentage loss in mass of a piece of steel slag after boiling

Calculate the percentage loss in mass in accordance with the following formula:

$$M_1 = \frac{m_0 - m_1}{m_0} \times 100 \text{ (accurate to 0,1 \%)}$$

where

M_1 is the percentage loss in mass;

m_0 is the mass of the test portion before boiling, in grams;

m_1 is the mass of the test portion or the largest remaining fragment after boiling and drying, in grams.

10.7 Test report

10.7.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identity of the laboratory;

c) identification of the sample;

d) the nominal grading of armourstone from which the sample was taken;

e) visual observations of the sawn test portion, including any unusual disintegration and in particular, whether any signs of Sonnenbrand were found after boiling;

f) result of the boiling test on the piece of steel slag, including observed crack formation and mass loss, expressed to the nearest 0,1 % by mass;

g) date of test.

10.7.2 Optional data

The test report can include the following information:

a) name and location of sample source;

b) description of the material and of the sampling procedure.

Annex A
(informative)

Example of a sampling report

Sampling Report Identification (serial number).:

Laboratory Sample Identification mark:	Number of packages:

Description of armourstone sampled

Name of pit / quarry or production plant:
Name of producer:
Type: *quarried rock / slag / gravel / ……..inland / marine……*
Grading type:
Nature of batch: *stockpile / silo / shipload / lorry load / ……...*
Purpose for which armourstone is to be used:
Location of sampling point(s):
Identification of batch:
Size of batch:
Other comments (e.g. warnings if appropriate):

Description of sampling method

Reference to standard used:
Date and time of sampling:
Reference to sampling plan used:
Weather conditions at time of sampling:
Sampling method used (see Clause 4):

Apparatus used:	*wheeled loader / grab / ……*
Mass of sample:	
Number of pieces of armourstone:	
Other comments:	
Method of sample reduction:	
Dispatch of the samples:	
Sampler: (print name)	

Contract details

Contract identification:
Name and address of party requesting the sample:
Name(s) of persons present at time of sampling:
Signature(s) of sampler(s):

NOTE Copying of this form is permitted.

Annex B
(informative)

Example of a particle size distribution of a coarse grading

PARTICLE SIZE DISTRIBUTION

Laboratory	:
Date	:
Operator	:
Identification of the sample	: 45/125 mm
Method used	:dry sieving or wet sieving

Mass of fraction passing sieve 63 mm: m_1 = 90,0 kg

Mass of sieved part of m_1: m_2 = 42,6 kg

m_1/m_2 = 2,11

Mass of fraction passing sieve with smallest aperture size:

$m_3 = 2{,}8 \times 2{,}11 = 5{,}9$ kg

Total mass: $\Sigma M_i + m_3 = 267{,}3$ kg

Sieve size **mm**	**Mass retained on ISO 3310-2 test sieves** **kg**	**Mass retained on all sieves** M_i **kg**	**Percentage retained** r_i	**Cumulative percentage retained** R_i	**Cumulative percentage passing** P_i
180 mm		0,0	0,0	0,0	100
125 mm		9,1	3,4	3,4	97
90 mm		45,0	16,8	20,2	80
63 mm		123,1	46,1	66,3	34
45 mm	32,4	68,4	25,6	91,9	8
31,5 mm	7,5	15,8	5,9	97,8	2
		ΣM_i = 261,4 kg			

Remarks:

NOTE Copying of this form is permitted.

Annex C
(informative)

Example of a mass distribution: reference method

MASS DISTRIBUTION

Laboratory:	Date :
Operator :	Sample: 10 to 60 kg
Method used: EN 13383-2:2013, 6.5	

Stone no.	Mass M_i kg	Mass ≥ 2 < 10 kg	Mass ≥ 60 < 120 kg	Mass ≥ 120 kg
1	22,9			
2	36,6			
3	8,1	8,1		
4	67,2		67,2	
5	4,2	4,2		
6	126,1			126,1
7	13,8			
8	44,6			
9	14,9			
10	32,5			
11	7,2	7,2		
12	23,6			
13	60,0		60,0	
	.	.	.	.
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.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
197	6,5	6,5		
198	18,9			
199	24,5			
200	22,3			
201	33,3			
n= 202	17,8			
TOTALS	ΣM_i = 5 292,4	a = 204,0	b = 981,6	c = 126,1

$\Sigma M_i + M_f$	= 5 350,6 kg	
< 2 kg (M_f)	= 58,2 kg	= 1 %
< 10 kg (M_f+a)	= 262,2 kg	= 5 %
< 60 kg (ΣM_i+M_f-b-c)	= 4 242,9 kg	= 79 %
< 120 kg (ΣM_i+M_f-c)	= 5 224,5 kg	= 98 %

ΣM_i = 5 292,4 kg

n = 202

M_{em} = ΣM_i / n = 26 kg

Annex D
(informative)

Example method for determination of mass distribution (employing bulk weighing)

D.1 Principle

The test consists of dividing a material into several fractions by means of visually comparing individual pieces of armourstone to reference stones of pre-determined mass and then counting the stones in each fraction

D.2 Apparatus

D.2.1 Apparatus as required for reference method by 6.2.1 to 6.2.4 inclusive.

D.2.2 5 reference pieces of armourstone with masses determined by weighing of respectively ELL, NLL, NUL, EUL and (NLL+NUL)/2 to $\pm$ 5 % of NLL displayed as a visual reference for further counting of the test portion.

D.3 Preparation of test portion

As for reference method (see 6.3).

D.4 Procedure

Weigh the total test portion (M_T) to $\pm$ 1 %.

Estimate the mass of the heaviest piece of armourstone in the sample, m_{max}.

Spread the sample over the working area. Every stone shall be fully visible and able to be compared with the reference pieces of armourstone.

Based on a visual assessment of the mass of each individual piece of armourstone of the sample, count and record the number of pieces of armourstone with mass between that of successive reference stones.

NOTE It might be easier to allocate each piece of armourstone of the test sample to one of the 4 categories defined by successive reference stones and, then, count the number of pieces of armourstone in between successive reference stones.

D.5 Calculation and expression of results

Record on a test data sheet (see example below) the numbers of blocks, N_1 N_2 N_3 and N_4 lying in mass between the masses of the successive reference stones, where:

N_1 is the number of blocks with mass between ELL and NLL

N_2 is the number of blocks with mass between NLL and (NLL+NUL)/2

N_3 is the number of blocks with mass between (NLL+NUL)/2 and NUL

N_4 is the number of blocks with mass between NUL and EUL

Determine the characteristic masses for the pieces of armourstone lying in mass between the successive reference stones as follows:

m1 = mean [ELL ; NLL] = (ELL+NLL)/2

m_2 = mean [NLL ; (NLL+NUL)/2] = (3 NLL+NUL)/4

m_3 = mean [(NLL+NUL)/2 ; NUL] = (NLL+3 NUL)/4

m_4 = mean [NUL ; EUL] = (NUL+EUL)/2

For greater accuracy, the average mass of the pieces of armourstone each category may be determined by bulk weighing of all stones in each category and dividing by the total number of stones in that category.

Determine the percentage by weight associated with each characteristic mass as follows:

- associated with m_4 : $p_4 = m_4 \times N_4 / M_T$

- associated with m_3 : $p_3 = m_3 \times N_3 / M_T$

- associated with m_2 : $p_2 = m_2 \times N_2 / M_T$

- associated with m_1 : $p_1 = m_1 \times N_1 / M_T$

Determine the mass of fragments, $m_f = M_T - [m_1 \times N_1 + m_2 \times N_2 + m_3 \times N_3 + m_4 \times N_4]$

Determine the percentage of fragments, $p_f = m_f / M_T$

Determine the cumulative percentages by weight, P_i, less than the masses of each of the reference stones as follows:

- percentage less than or equal to ELL : $P_0 = p_f$

- percentage less than or equal to NLL : $P_1 = p_1 + p_f$

- percentage less than (or equal to NLL + NUL)/2 : $P_2 = P_1 + p_2$

- percentage less than or equal to NUL : $P_3 = P_2 + p_3$

- percentage less than or equal to EUL : $P_4 = P_3 + p_4$

- percentage less than or equal to m_{max} : $P_{max}=1$

When required, determine the average mass (without fragments) as follows:

$$M_{em} = \frac{N_1 \times m_1 + N_2 \times m_2 + N_3 \times m_3 + N_4 \times m_4}{N_1 + N_2 + N_3 + N_4}$$

D.6 Test report

As for reference method (see 6.6).

Example of a mass distribution determined by bulk weighing method

Laboratory :	Date :
Operator :	Sample: 3000 to 6000 kg
Method used:	EN 13383 : Part 2 (counting method)

	ELL ≤ block mass < NLL	ELL ≤ block mass < (NLL+NUL)/2	(NLL+NUL)/2 ≤ block mass < NUL	NUL≤ Block mass < EUL	Mass of the heaviest stone (estimate)
	i.e. 2 t to 3 t	i.e. 3 t to 4,5 t	i.e. 4,5 t to 6 t	i.e. 6 t to 9 t	
Block no.					
1	x	-	-	-	
2	x	-	-	-	
3	-	-	-	x	
4	-	x	-	-	
5	-	-	x	-	8 500
…	…	…	…	…	
…	…	…	…	…	
55	-	x	-	-	
56	-	x	-	-	
57	x	-	-	-	
58	-	x	-	-	
59	x	-	-	-	
60	-	x	-	-	

					nbr of stones
10	29	12	9	**= 60**	
2 500	3 750	5 250	7 500		
				M_T, total mass	
10 × 2500 = 25 000	29 × 3750 = 108 750	12 × 5250 = 63 000	9 × 7500 = 67 500	**= 264 250**	
25 000/ 264 250 = 9,46 %	108 750/ 264 250 = 41,15 %	63 000/ 264 250 = 23,84 %	67 500/ 264 250 = 25,54 %		

Mass (kg)	**2 500**	**3 750**	**5 250**	**7 500**	**8 500**
Cum. passing	**9,46 %**	9,46 + 41,15 = **50,61 %**	50,41 + 23,84 = **74,25 %**	74,25+ 25,54 = **99,79 %**	**100 %**

264 250 / 60 = **4 404**

Mass of the reference stones (for information):

At ELL = 1 950 kg ; at NLL = 3 200 kg ; average = 4 400 kg

At NUL = 6 140 kg ; at EUL = 9 160 kg.

Remarks: This sample did not include any fragments

Annex E
(informative)

Density of water

Table E.1 — Density of water

Temperature °C	Density Mg/m^3
5	1,000 0
6	0,999 9
7	0,999 9
8	0,999 8
9	0,999 8
10	0,999 7
11	0,999 6
12	0,999 5
13	0,999 4
14	0,999 2
15	0,999 1
16	0,998 9
17	0,998 8
18	0,998 6
19	0,998 4
20	0,998 2
21	0,998 0
22	0,997 8
23	0,997 5
24	0,997 3
25	0,997 0
26	0,996 8
27	0,996 5
28	0,996 2
29	0,995 9
30	0,995 6

Annex F
(informative)

Precision for determination of particle density and water absorption (see Clause 8)

Repeatability *r* and reproducibility *R*

The precision data given below has been extracted from national standards. The method used may deviate slightly from this European Standard.

Table F.1 — Repeatability *r* and reproducibility *R*

Particle density		**Water absorption**	
Repeatability *r* Mg/m^3	Reproducibility *R* Mg/m^3	Repeatability *r* % by mass	Reproducibility *R* % by mass
0,004 to 0,019	0,005 to 0,020	0,15	0,20
NOTE Repeatability and reproducibility for values of particle density and water absorption depend on surface conditions such as roughness of the stone material.			

Annex G
(informative)

Guidance on sampling for testing

This annex, whilst not normative, provides a general review of the normative requirements for testing armourstone as given by EN 13383-1.

Table G.1 presents the general review. When using this table, the following possibilities for using samples for testing several properties can be taken into account:

- Samples re tests for property numbers 1 and 2 can be used for testing remaining properties after testing particle size or mass distribution respectively.

- Test portions for tests for property number 14b (water absorption) can be used as test portions re test number 14a.

- In case of coring or sawing cubes for testing for property number 14a (water absorption), these test portions can also be used as test portions for property number 10 (resistance to breakage).

- Samples for tests for properties 13 (resistance to wear) and 21 (resistance to salt crystallisation) can be taken from samples for tests for property 22 (resistance to freezing and thawing) being larger than 20 kg.

- Test portions for tests for properties 13 (resistance to wear) and 21 (resistance to salt crystallisation) can also be prepared from aggregate where suitable aggregate representative of the armourstone is available.

Table G.1 — Samples and test portions for testing armourstone

Property number [a]	Property	EN 13383-1:2013, subclause	Sampling clause	Sample(s) number	Test portion(s)			Test	Test result(s)
					Preparation	Nature	Number		
Geometrical requirements									
1	Particle size description	4.2.1	4.5.2	3 or 6	Reduction [b] (see 4.6)			*M* kg stones	3 or 6
2	Mass distribution	4.2.2 4.2.3	4.5.2	3 or 6	Aggregation	*n* stones (see 6.3)	1	Clause 6	1
7a	Shape coarse gradings	4.3.2	4.5.2	3 or 6	Reduction (see 4.6)	≥ 200 stones	1	Clause 7	1
7b	Shape light and heavy gradings	4.3.3/4.3.4	4.5.2	3 or 6	Aggregation	*n* stones (see Clause 7, Table 2)	1	Clause 7	1
8	Crushed or broken surfaces	4.4	4.5.2	See property 7a and 7b	See property 7a and 7b	See property 7a and 7b	1	visual	1
Physical requirements									
10	Resistance to	5.3	4.5.3	10 [c]	Coring and/ or sawing,	Core or cube 50	10	EN 1926:2006,	Per portion, average (n = 9),

Property number [a]	Property	EN 13383-1:2013, subclause	Sampling clause	Sample(s) number	Test portion(s)			Test	Test result(s)
	breakage				saturation	or 70 mm		Annex A	exceedance level (n = 2)
13	Resistance to wear	5.4	4.5.3, 4.7	≥ 6 [c] total ≥ 6 kg	Crushing, sieving, composition	500 g 10 mm to 14 mm	2	EN 1097-1	Average
14a	Particle density	5.2	4.5.3	At least 10 [c]	Cleaning	≥ 150 g	At least 10 [e]	Clause 8	Per portion, average and least
14b	Water absorption	7.3	4.5.3	At least 10 [c] (re subsequent test for property 22) 10 (re subsequent test for property 21)	Coring or sawing from laboratory samples (re subsequent tests for property 22 [f] and 21), cleaning	150 g to 450 g	At least 10 [e] (re subsequent test for property 22) 10 [e] (re subsequent test for property 21)	Clause 8	Absorption per portion
Chemical requirements									
15	Petrographic	9.1, (Annex C)	4.5 or	See EN 932-3	see EN 932-3	EN 932-3	Description		

Property number [a]	Property	EN 13383-1:2013, subclause	Sampling clause	Sample(s) number	Test portion(s)			Test	Test result(s)
	description		raw material						
16	Dicalcium silicate disintegration	7.2.1	4.5.3	1	Cleaning, breaking	30 stones	1	EN 1744-1	1
17	Iron disintegration	7.2.2	4.5.3	1	-	30 stones	1	EN 1744-1	1
18	Volume stability (Disintegration of steel slag)	7.2.3	4.5.3	20 + 20 [c d]	Cleaning, drying	1 stone	20 + 20 [c d]	Clause 10	Per portion
19a	Impurities (general)	6.2						Visual	Description
19b	Impurities (soil)	5.5						Visual	Description
Durability									
21	Resistance to salt crystallization	7.5	4.5.3	≥ 6 [c] total > 6 kg	Crushing, sieving	500 g 10 mm to 14 mm	2	EN 1367-2	Average
22	Resistance to freezing and	7.4	4.5.3	10 + 10 [c d e]	Splitting or sawing	150-20 kg [g]	$n_1 + n_2$ [h]	Clause 9	Loss of mass

Property number [a]	Property	EN 13383-1:2013, subclause	Sampling clause	Sample(s) number	Test portion(s)			Test	Test result(s)
	thawing				cleaning (also see property [WATER ABSORPTION])				per portion
23	'Sonnenbrand' of basalt	7.6	4.5.3	10 + 20 [c d]	Sawing	Sawn faces $\geq 0{,}005\ m^2$	20 + 20 [c d]	Clause 10	Per portion

[a] Property numbering corresponds to that in EN 13236.

[b] If necessary.

[c] Pieces of armourstone or parts thereof.

[d] Second number depending on the results of first number of stones. Second number of samples can directly be taken and sent to the laboratory together with the first number, or can be taken or sent to the laboratory if necessary depending on the test result of the first number.

[e] Stones 150 g to 20 kg or part of 10 kg to 20 kg from heavier stones.

[f] Excluding stones 150 g to 450 g.

[g] Remaining part of stone from which a part was removed for the determination of the water absorption or test portion for determination of water absorption if this is larger.

[h] From samples with water absorption > 0,5 % by mass.

Annex H
(informative)

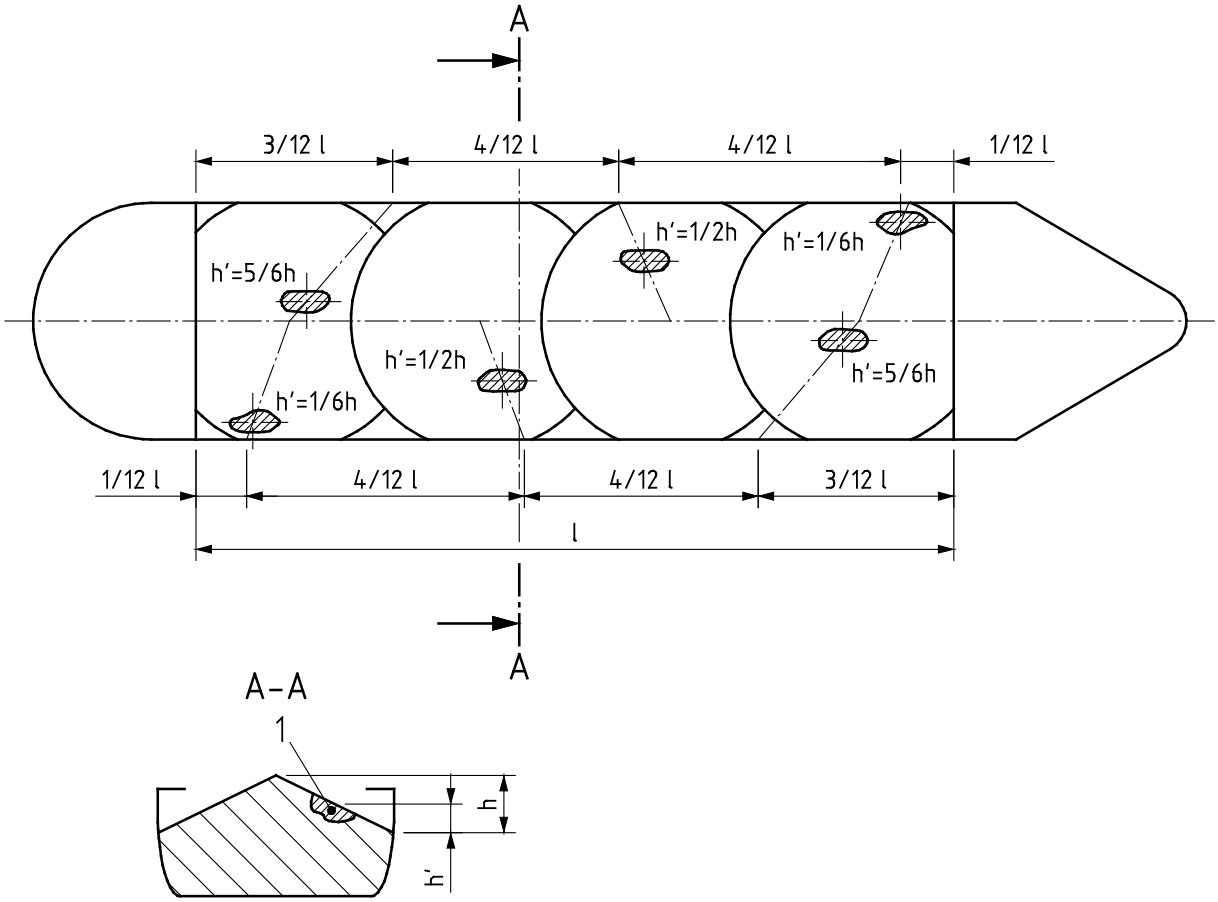
Guidance on sampling for testing

H.1 General

When sampling from floating equipment, sampling increments may be taken according to either Scheme 1 or Scheme 2. The selection of the sampling scheme will depend on the relative size of the unloading equipment and the floating equipment. Scheme 1 will be more suitable when the unloading grab is small in comparison to the width of the barge, whereas Scheme 2 will be more suitable when the unloading grab is larger.

H.2 Sampling scheme 1

For the sampling prior to the unloading of a segregated load, sampling increments shall be taken from the locations shown in Figure H.1 at the surface of the load, with the aid of the unloading equipment.



Dimensions are approximate

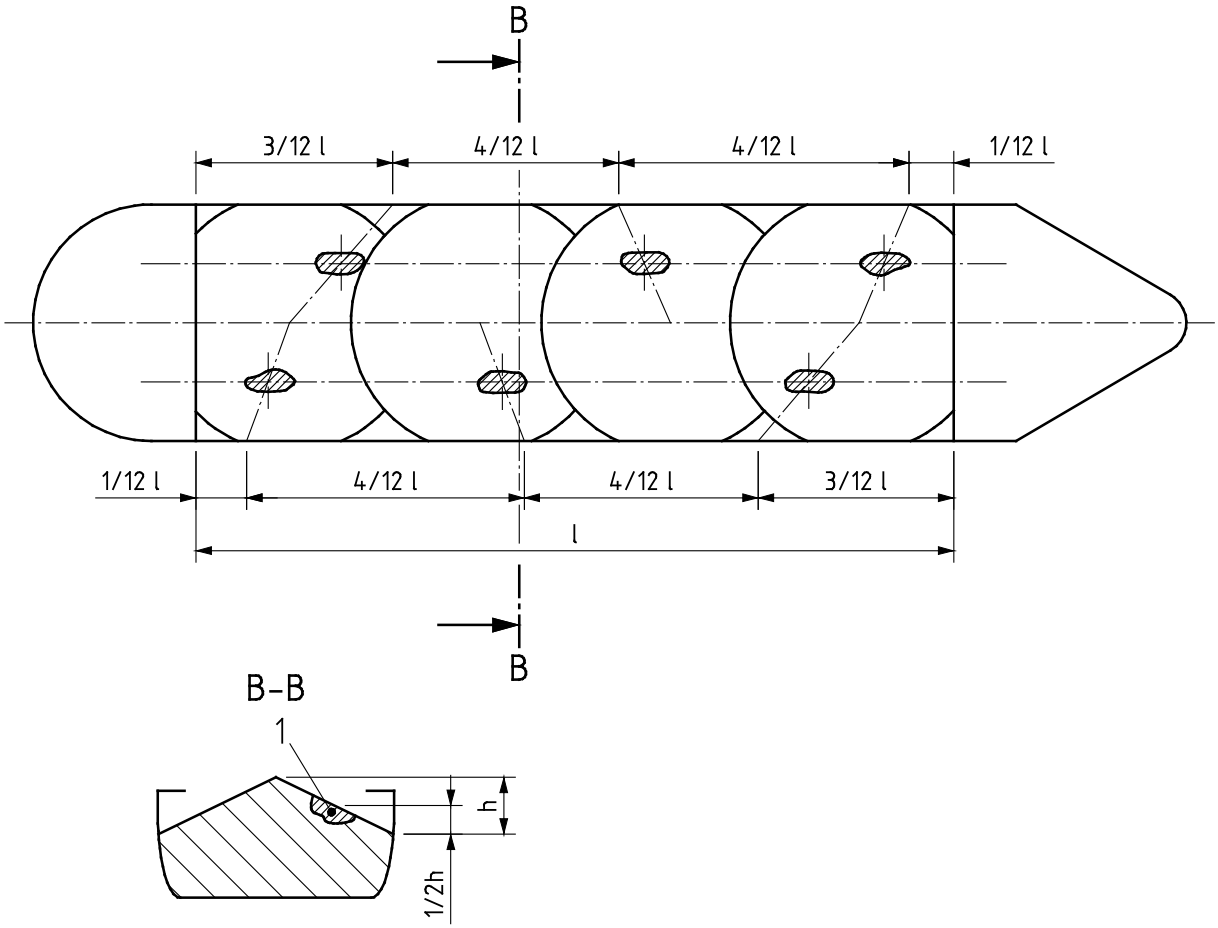
Key

1 sample

Figure H.1 — Sampling locations in a load under Scheme 1

For the sampling of a non-segregated load, sampling increments shall be taken as is indicated for a segregated load or by taking a quantity of material at random or evenly distributed locations at the surface of the load as shown in Figure H.2, with the aid of the unloading equipment.

When sampling during unloading, sampling increments shall be taken with the aid of the unloading equipment. The required number of sampling increments shall be taken at approximately equal intervals from the whole of the load to be sampled.



Dimensions are approximate

Key

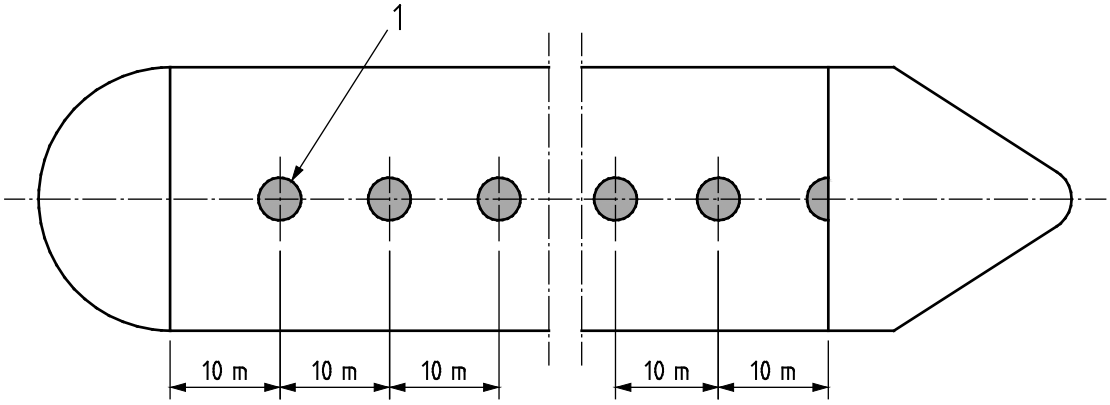
1 sample

Figure H.2 — Sampling locations in a non-segregated load under Scheme 1

H.3 Sampling scheme 2

Sampling increments shall be taken from the locations shown in Figure H.3 at the surface of the load with the aid of the unloading equipment prior to the unloading of the load. The sampling shall be carried out at intervals of 10 m along the length of the hold of the floating equipment.

NOTE The required number of sampling locations will depend on the length of the hold of the floating equipment.

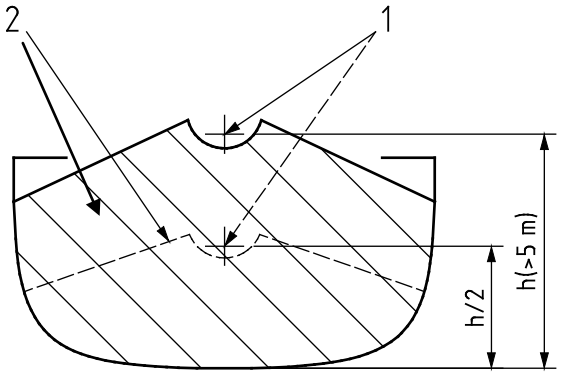


Key

1 sampling location

Figure H.3 — Sampling locations for a small load under Scheme 2

Where floating equipment has a hold capable of holding armourstone to a depth greater than 5 m, further sampling shall carried out from the location shown in Figure H.4 after the completion of partial unloading.



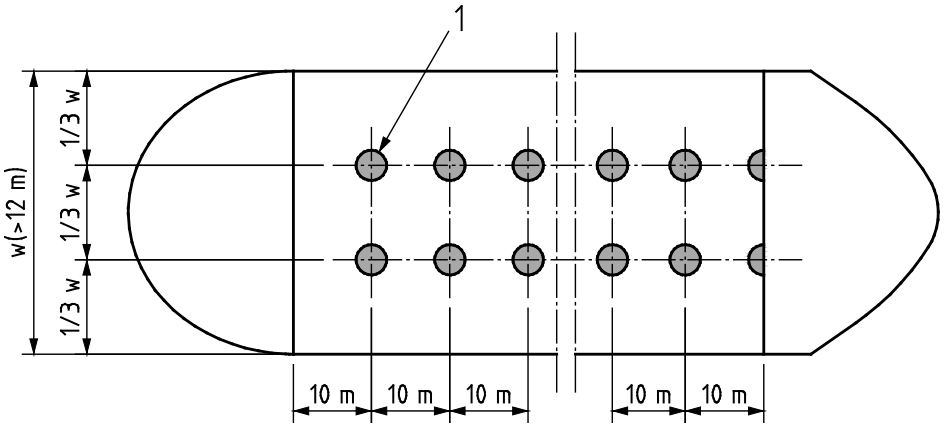
Key

1 sample location

2 after partial unloading

Figure H.4 — Sampling locations for a deep load under Scheme 2

Where floating equipment has a hold of width greater than 12 m, sampling shall be carried out from the locations shown in Figure H.5. The sampling increments shall be spaced at approximately equal intervals, adjusted to take account of the required number of samples for the load to be sampled.



Key

1 sample location

Figure H.5 — Sampling locations for a wide load under Scheme 2

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[1] EN 1744-1, *Tests for chemical properties of aggregates — Part 1: Chemical analysis*

[2] EN 1926:2006, *Natural stone test methods - Determination of uniaxial compressive strength*

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