

Tests for geometrical properties of aggregates

Part 4: Determination of particle shape — Shape index

ICS 91.100.15

National foreword

This British Standard is the UK implementation of EN 933-4:2008. It supersedes BS EN 933-4:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/502/6, Test methods.

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

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**Tests for geometrical properties of aggregates - Part 4:
Determination of particle shape - Shape index**

Essais pour déterminer les caractéristiques géométriques
des granulats - Partie 4: Détermination de la forme des
granulats - Coefficient de forme

Prüfverfahren für geometrische Eigenschaften von
Gesteinskörnungen - Teil 4: Bestimmung der Kornform -
Kornformkennzahl

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Management Centre: rue de Stassart, 36 B-1050 Brussels

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Foreword

This document (EN 933-4:2008) 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of an identical text or by endorsement, at the latest by September 2008, and conflicting national standards shall be withdrawn at the latest by September 2008.

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 933-4:1999.

This European Standard is one of a series of standards for tests for geometrical properties of aggregates. Test methods for other properties of aggregates are covered by Parts of the following European Standards:

EN 932, Tests for general properties of aggregates
EN 1097, Tests for mechanical and physical properties of aggregates
EN 1367, Tests for thermal and weathering properties of aggregates
EN 1744, Tests for chemical properties of aggregates
EN 13179, Tests for filler aggregate used in bituminous mixtures

The other parts of EN 933 are:

Part 1 - Determination of particle size distribution - Sieving method
Part 2 - Determination of particle size distribution - Test sieves, nominal size of apertures
Part 3 - Determination of particle shape - Flakiness index
Part 5 - Determination of percentage of crushed and broken surfaces in coarse aggregate particles
Part 6 - Assessment of surface characteristics - Flow coefficient of aggregates
Part 7 - Determination of shell content - Percentage of shells in coarse aggregates
Part 8 - Assessment of fines - Sand equivalent test
Part 9 - Assessment of fines - Methylene blue test
Part 10 - Assessment of fines - Grading of fillers (air jet sieving)

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1 Scope

This standard describes the reference method used for type testing and in cases of dispute, for the determination of the shape index of coarse aggregates. For other purposes, in particular factory production control, other methods may be used provided an appropriate working relationship with the reference method has been established.

The test method specified in this European Standard is applicable to particle size fractions d_i/D_i where $D_i \leq 63$ mm and $d_i \geq 4$ mm.

2 Normative references

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

EN 932-2, *Test for general properties of aggregates - Part 2: Methods for reducing laboratory samples*

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 1097-6, *Tests for mechanical and physical properties of aggregates - Part 6: Determination of the particle density and water absorption*

3 Terms and definitions

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

3.1

aggregate size

designation of aggregate in terms of lower (d) and upper (D) sieve sizes, expressed as d/D

NOTE This designation accepts the presence of some particles which will be retained on the upper sieve (oversize) and some which will pass the lower sieve (undersize).

3.2

particle size fraction d_i/D_i

fraction of an aggregate passing the larger (D_i) of two sieves and retained on the smaller (d_i)

3.3

test portion

sample used as a whole in a single test

3.4

constant mass

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

NOTE In many cases constant mass can be achieved after a test portion has been dried for a pre-determined period in a specified oven (see 5.5) 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.

3.5

particle length L

maximum dimension of a particle as defined by the greatest distance between two parallel planes tangential to the particle surface

3.6

particle thickness E

minimum dimension of a particle as defined by the least distance between two parallel planes tangential to the particle surface

4 Principle

Individual particles in a sample of coarse aggregate are classified on the basis of the ratio of their length L to thickness E using a particle slide gauge where necessary.

The shape index is calculated as the mass of particles with a ratio of dimensions L/E more than 3 expressed as a percentage of the total dry mass of particles tested.

5 Apparatus

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

5.2 Particle slide gauge, an example of which is shown in Figure 1.

5.3 Test sieves, with nominal size of apertures as specified in EN 933-2.

5.4 Tightly fitting pan and lid, for the sieves.

5.5 Ventilated oven, thermostatically controlled to maintain $(110 \pm 5) ^\circ\text{C}$, or other suitable equipment for drying the aggregates, if it does not cause any particle size breakdown.

5.6 Balances or scales, of suitable capacity, readable to 0,1 % of the mass to be weighed.

5.7 Trays

5.8 Sieving machine, (optional).

Dimensions in millimetres

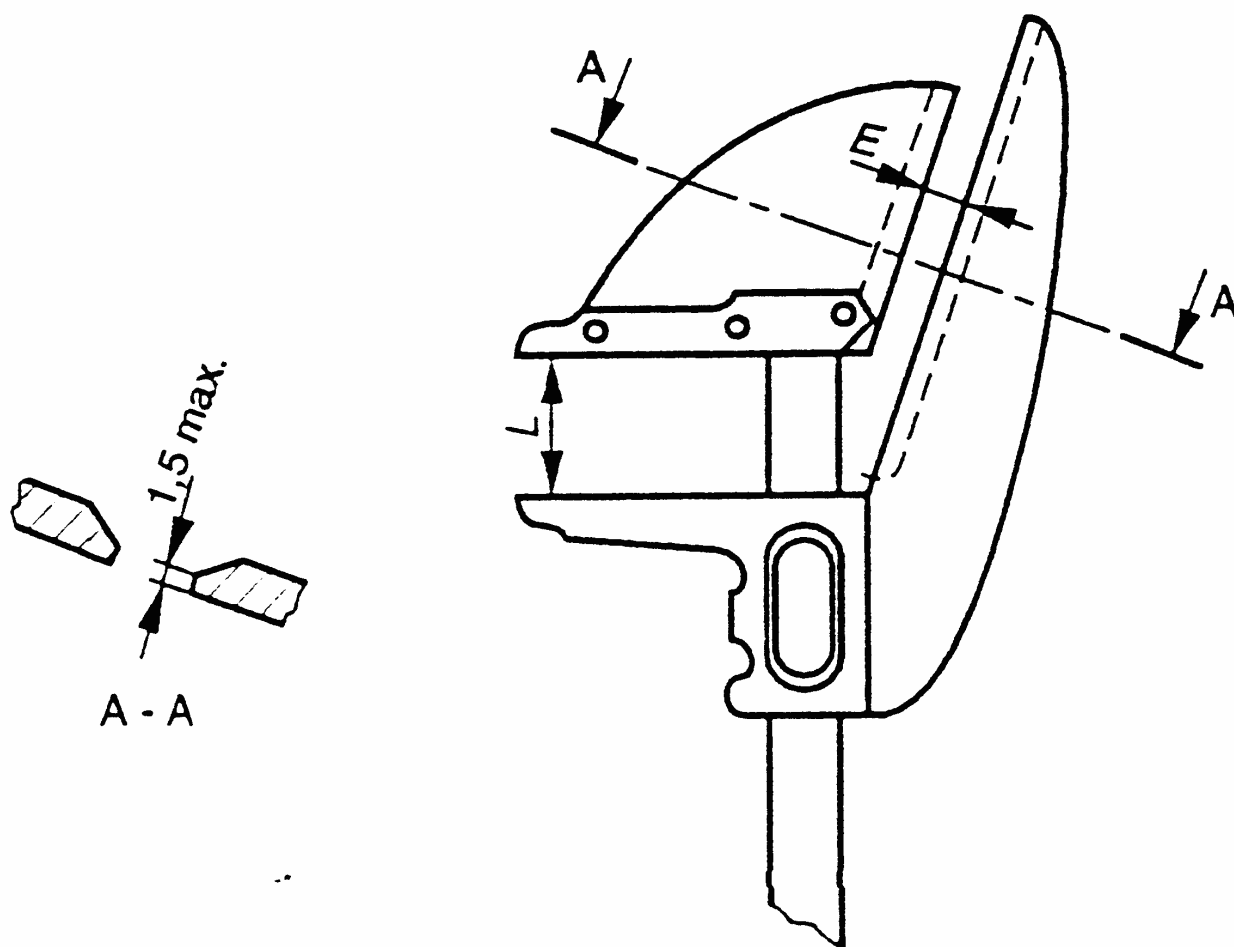


Figure 1 - Example of a particle slide gauge

6 Preparation of test portion

The sample shall be reduced in accordance with the requirements of EN 932-2.

Dry the sample at $(110 \pm 5) ^\circ\text{C}$ to constant mass.

Sieve on appropriate test sieves with sufficient vigour to ensure complete separation of particles greater than 4 mm. Discard the particles retained on the 63 mm test sieve and those passing the 4 mm test sieve.

If necessary further reduce the sample in accordance with EN 932-2 to produce a test portion.

Record the mass of the test portion as M_o .

The mass of the test portion shall be as specified in Table 1.

Table 1 - Mass of test portions

Upper aggregate size D	Test portion mass (minimum)
mm	kg
63	45
32	6
16	1
8	0,1

NOTE 1 For the other upper aggregate sizes D , appropriate test portion masses may be interpolated from those given in Table 1.

NOTE 2 For aggregates of particle density less than 2,00 Mg/m³ or more than 3,00 Mg/m³ in accordance with EN 1097-6 an appropriate correction should be applied to the test portion masses given in Table 1 based on the density ratio, in order to produce a test portion of approximately the same volume as those for aggregates of normal density.

Sample reduction shall yield a test portion with a mass larger than the minimum but not of an exact predetermined value.

7 Procedure

7.1 General

The test shall be carried out on each particle size fraction d_i/D_i where $D_i \leq 2d_i$.

Test portions from samples for which $D > 2d$ shall be separated into particle size fractions d_i/D_i where $D_i \leq 2d_i$ during the subsequent test procedure.

7.2 Test portions where $D \leq 2d$

Separate the particle size fraction d_i/D_i where $D_i \leq 2d_i$ from the test portion by sieving in accordance with EN 933-1.

Discard any particles smaller than d_i and any larger than D_i .

Record the particle size fraction d_i/D_i that is to be tested and record the mass of the particle size fraction d_i/D_i as M_1 .

Assess the length L and thickness E of each particle using a particle slide gauge where necessary and set aside those particles which have a dimensional ratio $L/E > 3$. These particles are classified as non-cubical.

NOTE The number of particles requiring individual classification using the gauge can be reduced by a preliminary separation of particles with a L/E ratio significantly different from 3.

Weigh the non-cubical particles and record their mass as M_2 .

7.3 Test portion where $D > 2d$

Separate the test portion into particle size fractions d_i/D_i where $D_i \leq 2d_i$ by sieving in accordance with EN 933-1.

NOTE 1 Test sieves of appropriate aperture sizes from the following series should be used, viz. 4 mm; 5,6 mm; 8 mm; 10 mm; 11,2 mm; 12,5 mm; 16 mm; 22,4 mm; 31,5 mm; 45 mm; 63 mm; and the values of d_i and D_i of each size fraction tested should be recorded in the test report.

Record the mass of each particle size fraction (M_i) and calculate and record the percentage by mass of each particle size fraction d_i/D_i to the test portion mass M_0 as V_i .

Discard any size fraction d_i/D_i which comprises less than 10 % of M_0 .

NOTE 2 If any remaining size fraction d_i/D_i contains less than 100 particles, it should if required, be recorded in the test report.

Any size fraction d_i/D_i which contains an excessive number of particles can be further reduced in accordance with EN 932-2, but after such reduction at least 100 particles of that size fraction shall remain.

Record the mass of particles to be tested in each remaining particle size fraction d_i/D_i as M_{1i} .

Assess the length L and thickness E of each particle using a particle slide gauge where necessary and set aside those particles in each size fraction which have a dimensional ratio $L/E > 3$. These particles are classified as non-cubical.

Record the mass of non-cubical particles in each of these size fractions d_i/D_i as M_{2i} .

8 Calculation and expression of results

8.1 Test portions where $D \leq 2d$

Calculate the shape index (SI) in accordance with the following equation:

$$SI = (M_2/M_1) \times 100 \quad (1)$$

where

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

M_2 is the mass of the non-cubical particles, in grams.

Record the shape index to the nearest whole number.

8.2 Test portions where $D > 2d$

8.2.1 Size fractions not reduced

Calculate the shape index (SI) in accordance with the following equation:

$$SI = \frac{\sum M_{2i}}{\sum M_{1i}} \times 100 \quad (2)$$

where

$\sum M_{1i}$ is the sum of the masses of the size fractions tested, in grams;

$\sum M_{2i}$ is the sum of the masses of the non-cubical particles in each of the size fractions tested, in grams.

Record the shape index to the nearest whole number.

8.2.2 Reduced size fractions

Calculate the percentage of non-cubical particles in each size fraction tested and record as SI_i . Calculate the weighted mean percentage of non-cubical particles (SI) in accordance with the following equation:

$$SI = \frac{\sum (V_i \times SI_i)}{\sum V_i} \quad (3)$$

where

V_i is the percentage by mass of particle size fraction i in the sample tested;

SI_i is the percentage by mass of non-cubical particles in particle size fraction i .

Record the weighted mean percentage of non-cubical particles to the nearest whole number.

9 Test report

9.1 Required data

The test report shall include the following information.

- reference to this European Standard (EN 933-4:2008);
- identification of the laboratory;
- identification of the sample;
- shape index (SI) to the nearest whole number;
- values of d_i and D_i of particle size fractions tested;

- f) sample reception date.

9.2 Optional data

The test report can include the following information.

- a) name and location of the sample source;
- b) description of material and of sample reduction procedure;
- c) mass of test portion (M_0);
- d) mass of size fraction(s) tested (M_1 or M_{1i});
- e) mass of non-cubical particles in size fraction(s) tested (M_2 or M_{2i});
- f) any size fraction d_i/D_i with less than 100 particles;
- g) sampling certificate, if available;
- h) date of test.

Annex A
(informative)

Example of a test data sheet used for determining the shape index of coarse aggregate

EN 933-4	Laboratory :
Identification of the sample:	Date :
	Operator :

$M_o =$ g

Particle size fraction d_i/D_i where $D_i \leq 2d_i$ mm	Mass M_1 g	Mass M_2 g	Shape index SI % $= (M_2/M_1) \times 100$ to the nearest whole number

NOTE When a particle size fraction d_i/D_i has been reduced an appropriate test data sheet can be used and the weighted mean values calculated as specified in 8.2.

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