

# **Tests for geometrical properties of aggregates**

## **Part 3. Determination of particle shape — Flakiness index**

The European Standard EN 933-3 : 1997 has the status of a  
British Standard

ICS 91.100.20

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 Association of Lightweight Aggregate Manufacturers  
 British Aggregate Construction Materials Industries  
 British Cement Association  
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The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Civil Engineering Test Equipment Manufacturers' Association  
 United Kingdom Accreditation Service

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 August 1997

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Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Foreword	2
Text of EN 933-3	3



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## National foreword

This British Standard has been prepared by Technical Committee B/502 and is the English language version of EN 933-3 : 1997 *Tests for geometrical properties of aggregates — Part 3: Determination of particle shape — Flakiness index*, published by the European Committee for Standardization (CEN).

It is one of a series of European Standards giving test methods for aggregates. These standards are being developed by Technical Committee CEN/TC 154 to provide a means of verifying requirements which will be specified in European product standards for aggregates for various uses.

It is intended that this standard will be included in a 'package' of European Standards to be declared by CEN/TC 154. When all the associated European test methods for aggregates are available, this Part of BS EN 933 will supersede BS 812 : Section 105.1.

### Cross-reference

Publication referred to	Corresponding British Standard
EN 933-2 : 1995	BS EN 933 <i>Tests for geometrical properties of aggregates</i> Part 2 : 1996 <i>Determination of particle size distribution —</i> <i>Test sieves, nominal size of apertures</i>

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### Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 6, an inside back cover and a back cover.

EUROPEAN STANDARD

EN 933-3

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English version

## Tests for geometrical properties of aggregates — Part 3: Determination of particle shape — Flakiness index

Essais pour déterminer les caractéristiques  
géométriques des granulats —

Partie 3: Détermination de la forme des granulats —  
Coefficient d'aplatissement

Prüfverfahren für geometrische Eigenschaften  
von Gesteinskörnungen —

Teil 3: Bestimmung der Kornform —  
Plattigkeitskennzahl

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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**CEN**

European Committee for Standardization  
Comité Européen de Normalisation  
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

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Ref. No. EN 933-3 : 1997 E

## Foreword

This European Standard 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 July 1997, and conflicting national standards shall be withdrawn at the latest by July 1997.

This standard forms part of a series of tests for geometrical properties of aggregates. Test methods for other properties of aggregates will be covered by Parts of the following draft European Standards:

- prEN 932 *Tests for general properties of aggregates*
- prEN 1097 *Tests for mechanical and physical properties of aggregates*
- prEN 1367 *Tests for thermal and weathering properties of aggregates*
- prEN 1744 *Tests for chemical properties of aggregates*

The other parts of prEN 933 will be:

- Part 1: *Determination of particle size distribution — Sieving method*
- Part 2: *Determination of particle size distribution — Test sieves, nominal size of apertures*
- Part 4: *Determination of particle shape — Shape index*
- Part 5: *Determination of crushed and broken surfaces in coarse aggregate particles*
- Part 6: *Determination of texture/shape — Flow coefficient of coarse aggregates*
- Part 7: *Determination of shell content — Percentage of shells for coarse aggregates*
- Part 8: *Assessment of fines — Sand equivalent test*
- Part 9: *Assessment of fines — Methylene blue test*
- Part 10: *Determination of fines — Grading of fillers (air jet sieving)*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## Contents

	Page
Foreword	2
1 Scope	3
2 Normative references	3
3 Definitions	3
4 Principle	3
5 Apparatus	3
6 Preparation of test portions	5
7 Procedure	5
8 Calculation and expression of results	5
9 Test report	5
<b>Annexes</b>	
A (informative) Example of test data sheet used for determining the flakiness index	6
B (informative) Precision	6

## 1 Scope

This Part of this European Standard specifies the procedure for the determination of the flakiness index of aggregate and applies to aggregates of natural or artificial origin, including lightweight aggregates.

The test procedure specified in this Part of this European Standard is not applicable to particle sizes of less than 4 mm or greater than 80 mm.

## 2 Normative references

This European Standard incorporates by dated or by undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

- prEN 932-2 *Tests for general properties of aggregates — Part 2: Methods for reducing laboratory samples*
- prEN 932-5 *Tests for general properties of aggregates — Part 5: Common equipment and calibration*
- prEN 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*

## 3 Definitions

For the purposes of this standard, the following definitions apply.

### 3.1 particle size fraction

Fraction of an aggregate passing the larger of two sieves and retained on the smaller.

NOTE. The lower limit may be zero.

### 3.2 test portion

The sample used as a whole in a single test.

### 3.3 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 predetermined period in a specified oven (see 5.4) at  $(110 \pm 5)^\circ\text{C}$ . 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 Principle

The test consists of two sieving operations. First, using test sieves, the sample is separated into various particle size fractions  $d_i/D_i$ , as given in table 1. Each of the particle size fractions  $d_i/D_i$  is then sieved using bar sieves which have parallel slots of width  $D_i/2$ .

The overall flakiness index is calculated as the total mass of particles passing the bar sieves expressed as a percentage of the total dry mass of particles tested.

If required, the flakiness index of each particle size fraction  $d_i/D_i$  is calculated as the mass of particles passing the corresponding bar sieve, expressed as a percentage by mass of that particle size fraction.

## 5 Apparatus

All apparatus shall conform to the general requirements of prEN 932-5.

**5.1 Test sieves**, with square apertures, conforming to EN 933-2, with the following aperture sizes:

80 mm; 63 mm; 50 mm; 40 mm; 31,5 mm; 25 mm;  
20 mm; 16 mm; 12,5 mm; 10 mm; 8 mm; 6,3 mm;  
5 mm and 4 mm.

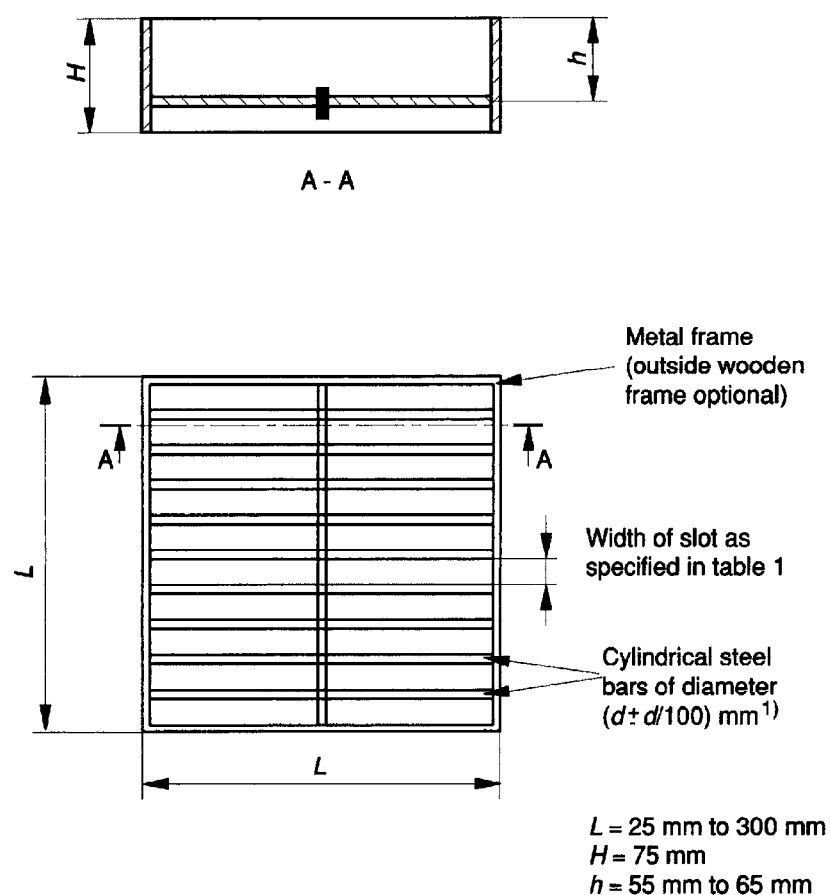
**5.2 Corresponding bar sieves**, comprising parallel cylindrical bars conforming to figure 1 and the tolerances given in table 1. The tolerances on the width of slot shall apply to the entire length of each slot.

**Table 1. Bar sieves**

Particle size fraction $d_i/D_i$ mm	Width of slot in bar sieve mm
63/80	$40 \pm 0,3$
50/63	$31,5 \pm 0,3$
40/50	$25 \pm 0,2$
31,5/40	$20 \pm 0,2$
25/31,5	$16 \pm 0,2$
20/25	$12,5 \pm 0,2$
16/20	$10 \pm 0,1$
12,5/16	$8 \pm 0,1$
10/12,5	$6,3 \pm 0,1$
8/10	$5 \pm 0,1$
6,3/8	$4 \pm 0,1$
5/6,3	$3,15 \pm 0,1$
4/5	$2,5 \pm 0,1$

**5.3 Balance or scale**, accurate to  $\pm 0,1\%$  of the mass of the test portion.

**5.4 Ventilated oven**, thermostatically controlled to maintain a temperature of  $(110 \pm 5)^\circ\text{C}$ , or other suitable equipment for drying the aggregates, without causing any particle size breakdown.



<sup>1)</sup> Usual diameter range from 5 mm to 15 mm depending on width of slot

**Figure 1. Bar sieves**



## 6 Preparation of test portions

Samples shall be taken and reduced in accordance with prEN 932-2.

NOTE. The mass of the test portion depends on the dimensions and the percentage of its largest components.

The mass of the test portion shall be as specified in table 1 of prEN 933-1.

Dry the test portion at  $(110 \pm 5)^\circ\text{C}$  to constant mass. Allow to cool, weigh and record the mass as  $M_0$ .

## 7 Procedure

### 7.1 Sieving on test sieves

Using the sieves specified in 5.1, sieve the test portion as specified in prEN 933-1.

Weigh and discard all particles passing the 4 mm sieve and retained on the 80 mm sieve.

Weigh and retain separately all the particles in each particle size fraction  $d_i/D_i$  between 4 mm and 80 mm.

### 7.2 Sieving on bar sieves

Sieve each particle size fraction  $d_i/D_i$  obtained from 7.1 on the corresponding bar sieve given in table 1. This sieving operation shall be carried out manually and shall be considered complete when the retained material does not change by more than 1 % during 1 min of this sieving operation.

Weigh the material from each particle size fraction passing through the corresponding bar sieve.

## 8 Calculation and expression of results

The results shall be recorded on test data sheets (see example in annex A). Calculate the sum of the masses of the particle size fractions  $d_i/D_i$  and record this as  $M_1$ .

Calculate the sum of the masses of the particles in each of the particle size fractions  $d_i/D_i$  which pass through a corresponding bar sieve of slot width  $D_i/2$ , and record this as  $M_2$ .

The overall flakiness index  $FI$  is calculated from the following equation:

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

where

$M_1$  is the sum of the masses of the particles in each of the particle size fractions  $d_i/D_i$ , in grams;

$M_2$  is the sum of the masses of the particles in each particle size fraction passing the corresponding bar sieves of slot width  $D_i/2$ , in grams.

The overall flakiness index ( $FI$ ) shall be recorded to the nearest whole number.

The flakiness index for each particle size fraction  $FI_i$  shall be calculated, if required, from the following equation:

$$FI_i = (m_i/R_i) \times 100 \quad (2)$$

where

$R_i$  is the mass of each particle size fraction  $d_i/D_i$ , in grams;

$m_i$  is the mass of the material in each particle size fraction  $d_i/D_i$  which passes through the corresponding bar sieve of slot width  $D_i/2$ , in grams.

If the sum of the masses  $R_i$  together with the masses of any discarded particle size fractions (see 7.1) differs by more than 1 % from the mass  $M_0$  (see clause 6), the test shall be repeated, using another test portion.

## 9 Test report

### 9.1 Mandatory data

The test report shall include the following information:

- a) the number of this European Standard;
- b) identification of the sample;
- c) identification of the laboratory;
- d) the mass of the test portion;
- e) the overall flakiness index  $FI$  to the nearest whole number;
- f) the reception date of the sample.

### 9.2 Optional data

The test report can include the following information:

- a) the name and location of the sample source;
- b) a description of the material and of the sampling procedure;
- c) the flakiness index  $FI_i$  of each particle size fraction, to the nearest whole number;
- d) the mass of the test portion;
- e) the sampling certificate, if available;
- f) the date of test.

## Annex A (informative)

### Example of test data sheet used for determining the flakiness index

Flakiness index:		Laboratory:		
EN 933-3		Operator:		
Identification of the sample:		Date:		
Test portion mass $M_0 =$ g		Mass retained on 80 mm sieve = g Mass passing 4 mm sieve = g Sum of discarded masses = g		
Sieving on test sieves		Sieving on bar sieves		
Particle size fraction $d/D_1$ mm	Mass ( $R_i$ ) of particle size fraction $d_i/D_1$ g	Nominal width of slot in bar sieve mm	Mass passing bar sieve ( $m_i$ ) g	$FI_i = (m_i/R_i) \times 100$
63/80 50/63 40/50 31,5/40 25/31,5 20/25 16/20 12,5/16 10/12,5 8/10 6,3/8 5/6,3 4/5		40 31,5 25 20 16 12,5 10 8 6,3 5 4 3,15 2,5		
$M_1 = \sum R_i =$		$M_2 = \sum m_i =$		
$FI = (M_2/M_1) \times 100 =$				
$100 \times \frac{M_0 - \{ \sum R_i + \sum (\text{discarded masses}) \}}{M_0} =$				< 1 %

## Annex B (informative)

### Precision

Estimates of the repeatability ( $r$ ) and reproducibility ( $R$ ) for values of the overall flakiness index ( $FI$ ) between 8 and 20 are  $r = 2,8$  and  $R = 5$ .

## List of references

See national foreword.



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