BRITISH STANDARD

BS EN
933-6:2001

Tests for geometrical properties of aggregates —

Part 6: Assessment of surface characteristics — Flow coefficient of aggregates

The European Standard EN 933-6:2001 has the status of a British Standard

ICS 91.100.15

National foreword

This British Standard is the official English language version of EN 933-6:2001, which is included in a package of new European Standards being prepared by CEN/TC 154 relating to aggregates. Although the English language versions of these European Standards will be adopted as British Standards as they become available, the existing British Standards for aggregates will be retained, but only until such time that the completed package of European Standards becomes available. The original group of British Standards will then be withdrawn and this will be noted in *Update Standards*.

The UK participation in its preparation was entrusted by Technical Committee B/502, Aggregates, to Subcommittee B/502/6, Test methods, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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This British Standard, having been prepared under the direction of the Building and Civil Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 15 March 2002

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EUROPEAN STANDARD

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EN 933-6

October 2001

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English version

Tests for geometrical properties of aggregates - Part 6: Assessment of surface characteristics - Flow coefficient of aggregates

Essais pour déterminer les caractéristiques géométriques des granulats - Partie 6: Evaluation des caractéristiques de surface - Coefficient d'écoulement des granulats

Prüfverfahren für geometrische Eigenschaften von Gesteinskörnungen - Teil 6: Beurteilung der Oberflächeneigenschaften - Fließkoeffizienten von Gesteinskörnungen

This European Standard was approved by CEN on 30 September 2001.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 933-6:2001 E

Contents

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 April 2002, and conflicting national standards shall be withdrawn at the latest by December 2003.

This European 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 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 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 3: Determination of particle shape — Flakiness index

Part 4: Determination of particle shape — Shape index

Part 5: Determination of percentage of crushed and broken surfaces in coarse aggregate particles

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)

Annexes A, B and C are informative.

This standard includes a Bibliography.

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

1 Scope

This European Standard specifies methods for the determination of the flow coefficient of coarse and fine aggregates. It applies to coarse aggregate of sizes between 4 mm and 20 mm and to fine aggregate of size up to 4 mm.

NOTE 1 For coarse aggregates between 4 mm and 20 mm, the flow coefficient is linked with the percentage of crushed or broken surfaces of an aggregate and can therefore be used in association with the method specified in EN 933-5. Shape and surface texture characteristics also influence the result.

NOTE 2 Experience of this test has been generally limited to natural aggregates.

2 Normative references

This European Standard incorporates by dated or 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 (including amendments).

EN 932-2, *Tests 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 933-2, *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 1097-6, *Tests for mechanical and physical properties of aggregates — Part 6: Determination of particle density and water absorption.*

3 Terms and definitions

For the purposes of this European Standard the following terms and definitions apply.

3.1
aggregate size
designation of aggregate in terms of lower (d) and upper (D) sieve sizes expressed in terms 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 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 Principle

The flow coefficient of an aggregate is the time, expressed in seconds, for a specified volume of aggregate to flow through a given opening, under specified conditions using a standard apparatus.

5 Materials for the determination of the flow coefficient of coarse aggregate

A 6,3/10 mm reference aggregate with a particle density of 2,70 Mg/m^3 and a flow time (E_R) of (100 ± 2) s when the shutter has an opening of (42,0 ± 0,2) mm. In the formulae where E_R is used, it shall be taken as equal to 100 s and the particle density shall be taken as equal to 2,70 Mg/m^3.

NOTE 1 A recognized source of reference aggregate is the Laboratoire Régional des Ponts et Chaussées (LRPC), Rouen, BP 245, – - 76120 Le Grand-Quevilly, France. {Telephone: + (33) 2 35 68 81 0– - Fax: + (33) 2 35 69 39 55}

NOTE 2 A National Standards Body can recognize an alternative source of reference aggregate. The flow coefficient of the alternative source should be established in a controlled experiment carried out in at least ten laboratories, by cross testing against the LRPC reference aggregate. In case of dispute, the LRPC reference aggregate should be used.

6 Apparatus

6.1 General

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

6.2 Apparatus for general purposes

6.2.1 Test sieves, conforming to EN 933-2, of the following aperture sizes:

0,063 mm, 2 mm, 4 mm, 6,3 mm, 8 mm, 10 mm, 14 mm and 20 mm.

6.2.2 Ventilated oven, thermostatically controlled to maintain a temperature of (110 ± 5) °C or equipment for drying the aggregate which does not cause any particle size breakdown.

6.2.3 Balance, accurate to 0,1 % of the mass to be weighed.

6.2.4 Stopwatch or stopclock, to read 0,1 s.

6.3 Additional apparatus required for the determination of the flow coefficient of coarse aggregate

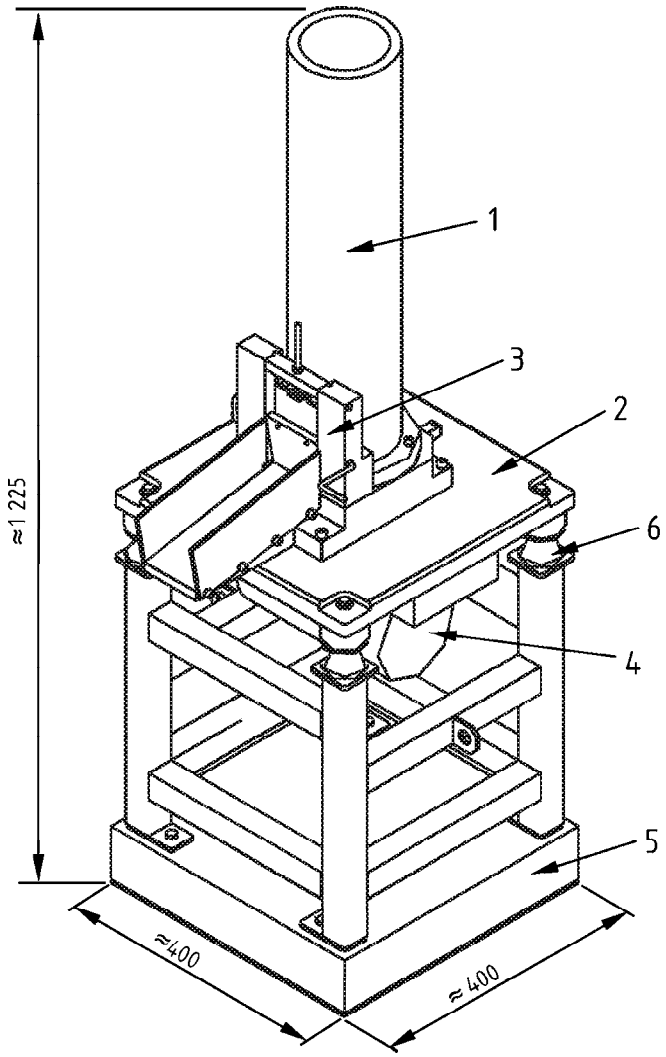
6.3.1 Bar sieves, conforming to EN 933-3, with apertures of 4 mm and 5 mm.

6.3.2 Container, of volume approximately 10 l.

6.3.3 Vibratory plate, (see Figure 1) comprising the following parts:

6.3.3.1 Bubble level, incorporated in the upper platform of the table and capable of setting in a horizontal position.

Dimensions in millimetres

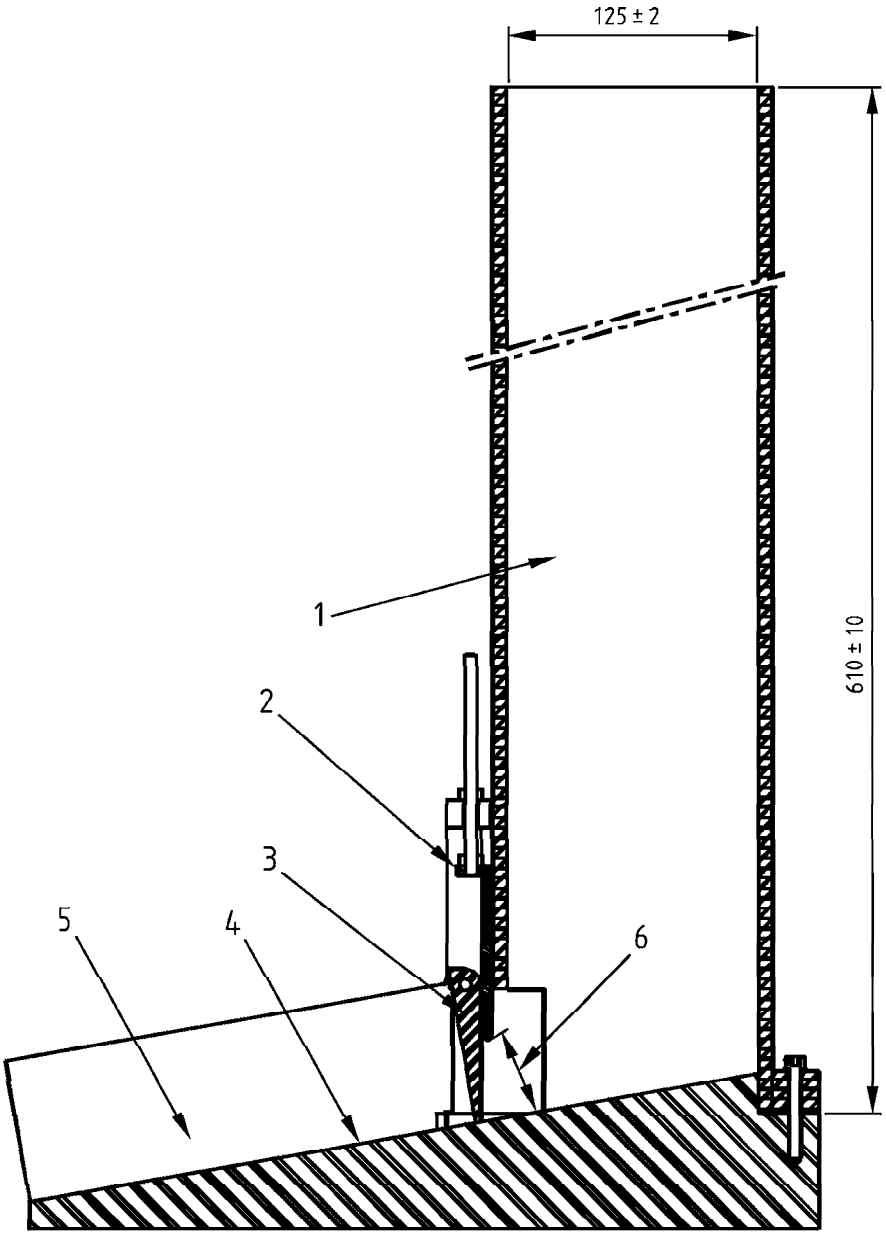


Key

1 Tube for test portion (see 6.3.4.4 and Figure 2)
2 Vibratory plate (see 6.3.3 and Figure 2)
3 Flow channel (see Figure 2)
4 Vibrator (see 6.3.3.4)
5 Baseplate (see 6.3.3.3)
6 Rubber suspension (see 6.3.3.2)

Figure 1 — Vibratory table and flow unit for coarse aggregate

Dimensions in millimetres



Key

1 Tube for test portion (see 6.3.4.4)
2 Shutter (see 6.3.4.2)
3 Movable flap (see 6.3.4.3)
4 Flow channel (see 6.3.4.1)
5 Slope 10° ± 0,1°
6 Adjustable from (40 ± 1) to (60 ± 1)

Figure 2 — Flow unit for coarse aggregate

Dimensions in millimetres

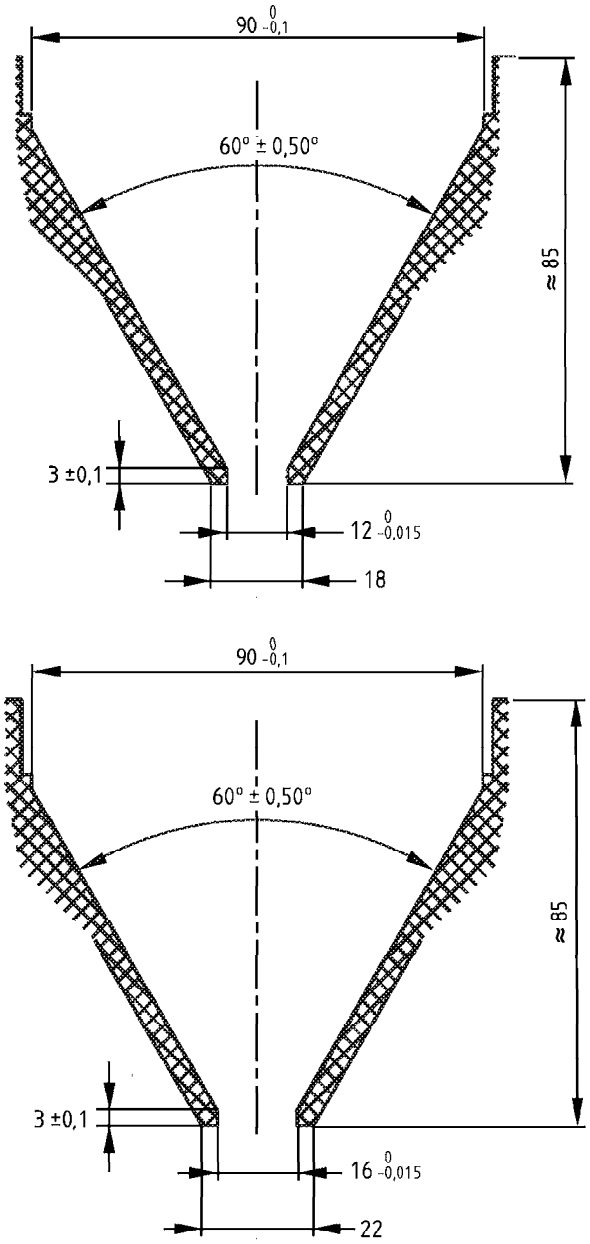


Figure 3 — Additional funnels for flow unit for fine aggregate

6.3.3.2 **Four rubber suspensions**, of Shore hardness (160 ± 30) N/mm joining the upper platform of the table to the support frame.

6.3.3.3 **Baseplate**, of mass (100 ± 10) kg, fixed under the frame.

6.3.3.4 **Vibrator**, using unbalanced weights, fixed under the platform; with its axis of rotation horizontal and perpendicular to the axis of the flow channel. The speed of rotation shall be (2970 ± 20) revolutions/min and it shall have a frequency of vibration of 50 Hz and an amplitude of (0,18 ± 0,02) mm when the flow unit is empty.

6.3.4 **Flow unit**, of total mass (42,3 ± 0,1) kg (see Figure 2) comprising the following:

6.3.4.1 **Metal flow channel**, with a slope of (10,0 ± 0,1)°, a width of (90 ± 1) mm and fitted with plastic sides.

6.3.4.2 **Metal shutter,** to adjust the height of the opening between (40 ± 1) mm and (60 ± 1) mm.

NOTE The height of the opening can be checked by using metal gauge block of a given height ± 0,1 mm.

6.3.4.3 **Metal movable flap**, to release the flow of material.

6.3.4.4 **Plastic tube for test portion**, inside diameter (125 ± 2) mm and height (610 ± 10) mm.

6.4 Additional apparatus required for the determination of the flow coefficient of fine aggregate

6.4.1 **Flow unit,** comprising the following:

6.4.1.1 **Two funnels**, 85 mm high, made from polycarbonate, one with a 12 mm opening, the other with a 16 mm opening (see Figure 3).

6.4.1.2 **Cylindrical body,** which can be fitted into the wider end of the funnels, inside diameter 90 mm, and minimum 125 mm high.

6.4.1.3 **Stand**, to hold the cylinder and funnel with a cover plate which can be moved to open and close the opening at the lower end of the funnel.

6.4.2 **Container**, of sufficient capacity to receive the material flowing from the funnel.

7 Determination of the flow coefficient of coarse aggregates

7.1 General

The test is carried out on one of the following particle size fractions:

4/6,3 mm, 6,3/10 mm, 10/14 mm, 4/10 mm or 4/20 mm.

7.2 Preparation of test portions

7.2.1 Reference aggregate

Wash and dry sieve a sufficient quantity of the 6,3/10 mm reference aggregate (see clause 5) on 6,3 mm, 8 mm and 10 mm test sieves and retain separately the 6,3/8 mm and the 8/10 mm size fractions.

Sieve the 6,3/8 mm size fraction on a 4 mm bar sieve and the 8/10 mm fraction on a 5 mm bar sieve, discarding any particles passing the bar sieves.

Reduce each size fraction in accordance with EN 932-2 to obtain (5,0 ± 0,1) kg of each and then combine them to produce a reference test portion.

NOTE Any sieved particles of reference aggregate remaining after the size reduction stage can be retained for use in subsequent reference test portions.

After each use, the reference test portion shall be washed on a 4 mm test sieve and dried at (110 ± 5) °C to constant mass before further use. After having been used for 30 reference tests, the reference test portion shall be compared to a previously unused reference test portion by testing each in accordance with 7.3.1 and 7.3.2. If the results on the two reference test portions differ by more than 4 s the original reference test portion shall be discarded. Reference test portions that are not discarded after 30 uses shall be checked again at intervals of 30 uses.

7.2.2 Test portions

Wash and dry sieve the laboratory sample to obtain a particle size fraction of either 4/6,3 mm, 6,3/10 mm, 10/14 mm, 4/10 mm or 4/20 mm as appropriate for the aggregate size of the laboratory sample.

NOTE In selecting which of the five size fractions above should be tested, the particle size fraction which represents the greatest part of the aggregate size of the laboratory sample should be taken. The selected fraction should be within the nominal size of the tested aggregate.

Reduce the particle size fraction in accordance with EN 932-2 to produce a test portion mass (in kilograms), to within 0,2 kg, of the mass given by the following equation:

$$\text{Mass of test portion} = 10\,\frac{\rho_{rd}}{2{,}70}$$

where:

ρ_{rd} is the particle density of the aggregate to be tested on an oven dried basis, determined in accordance with EN 1097-6, in megagrams per cubic metre;

2,70 is a fixed value for the particle density of the reference material on an oven dried basis, in megagrams per cubic metre.

7.3 Procedure

7.3.1 General

A reference test (7.3.2) shall be carried out immediately prior to the first daily determination of E_c (7.3.3).

Before each test procedure the vibratory plate shall be horizontal and during all tests the room temperature shall be between 15 °C and 30 °C.

The plate shall be continuously vibrating during all tests, commencing at least 5 min before each series of tests.

Place the container on the balance, located so as to receive particles from the lower end of the flow channel and display the accumulating mass of received particles.

With the shutter set at the opening size specified in 7.3.2 and 7.3.3 and the flap closed, place the test portion in the tube holder.

After (20 ± 5) s open the flap and allow the test portion to flow along the channel and into the container on the balance.

When 1 kg has flowed into the container, as indicated by the balance, start the stopwatch and stop it when the balance indicates that a mass of aggregate (m), in kilograms, calculated in accordance with the following equation, has flowed:

$$m = [1 + (7\rho_{rd}/2{,}70)]$$

where:

ρ_{rd} is the particle density of the aggregate to be tested on an oven dried basis, determined in accordance with EN 1097-6, in megagrams per cubic metre;

2,70 is a fixed value for the particle density of the reference material on an oven dried basis, in megagrams per cubic metre.

Record this flow time to 0,1 s.

Allow the entire test portion to flow through the apparatus and then thoroughly clean the tube holder and flow channel.

Recover and re-use the entire test portion for any necessary repeat determination of this flow time.

7.3.2 Reference test

Set the shutter at an opening of (42,0 ± 0,2) mm and carry out the procedure in 7.3.1 5 times using a reference test portion.

Record the average flow time of 5 runs as E_{ce}.

If $E_R - 5\text{ s} \leq E_{ce} \leq E_R + 5\text{ s}$, the reference test is complete.

If however, $E_{ce} > E_R + 5$ s, or $E_{ce} < E_R - 5$ s, repeat the procedure in 7.3.1 using the same reference test portion with the shutter opening increased or decreased as appropriate within the range (41,0 ± 0,2) mm to (43,0 ± 0,2) mm, until a value of E_{ce} is obtained such that $E_R - 5\text{ s} \leq E_{ce} \leq E_R + 5\text{ s}$.

The apparatus shall be withdrawn from use if a reference test flow time value of $E_R - 5\text{ s} \leq E_{ce} \leq E_R + 5\text{ s}$ cannot be obtained with the shutter set at an opening of between (41,0 ± 0,2) mm and (43,0 ± 0,2) mm.

NOTE E_R is taken as equal to 100 s.

7.3.3 Test procedure

Set the shutter at an opening of (42,0 ± 0,2) mm for test portions of 4/6,3 mm, 6,3/10 mm, 10/14 mm and 4/10 mm size fractions. However, if the procedure specified in 7.3.2 for the reference test portion required an adjusted shutter opening in order to obtain a flow time E_{ce} such that the value of

$$E_R - 5\text{ s} \leq E_{ce} \leq E_R + 5\text{ s}$$

then the shutter shall be set to the same adjusted opening for this test procedure on any of the above four size fractions.

For 4/20 mm size fractions set the shutter opening to (60,0 ± 0,2) mm.

Carry out the procedure described in 7.3.1 five times on each test portion, recording the flow times as E_{cmi} and the average of the five single determinations as E_{cm}.

NOTE E_R is taken as equal to 100 s.

7.3.4 Calculation and expression of results

Calculate the flow coefficient E_c in accordance with the following equation:

$$E_c = E_{cm} + (E_R - E_{ce})$$

where:

E_{cm} is the average flow time for the test portion, in seconds;

E_R is the flow time for the reference material taken as equal to 100 s;

E_{ce} is the flow time for the reference test portion, in seconds.

Express the value rounded to the nearest second.

NOTE 1 An example of a test data sheet is given in annex A.

NOTE 2 A statement on the precision of this test is given in annex B.

7.3.5 Test report

7.3.5.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identification of the test laboratory;

c) identification of the sample;

d) particle size fraction tested;

e) flow coefficient (E_c) to the nearest second;

f) date of receipt of sample.

7.3.5.2 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 sample reduction procedure;

c) mass of test portion;

d) particle density of material tested, ρ_{rd} in megagrams per cubic metre on an oven dried basis;

e) date of test.

8 Determination of the flow coefficient of fine aggregates

8.1 General

The test is carried out on one of the following particle size fractions:

0,063/2 mm or 0,063/4 mm.

8.2 Preparation of test portions

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

Wash and dry sieve the sample.

Discard the particles retained on the 4 mm (or 2 mm) test sieve and those passing the 0,063 mm test sieves.

Further reduce the sample to produce a test portion of mass M_1 (kilograms) calculated in accordance with the following equation:

$$M_1 = \left(\frac{\rho_{rd}}{2{,}70} \pm 0{,}002 \right)$$

where:

ρ_{rd} is the particle density of the aggregate to be tested, on an oven dried basis determined in accordance with EN 1097-6, in megagrams per cubic metre;

2,70 is a fixed value for the particle density of the reference material on an oven dried basis, in megagrams per cubic metre.

8.3 Procedure

Select a funnel, using the 12 mm opening for 0/2 mm fine aggregates or 16 mm opening for 0/4 mm fine aggregates. Fit the cylindrical body to the selected funnel and place it on its stand, its opening closed off. Place the test portion in the flow unit, restricting the height of fall to avoid compacting the material.

NOTE A satisfactory way to place the fine aggregate inside the cylinder is to pour it from a small scoop around the side of the cylinder in a circular movement.

Open the orifice and at the same time start the stopwatch; record the time E_{csi}, to 0,1 s for all the material to flow through the funnel. Repeat five times, using the same test portion, recording the time for each single determination.

8.4 Calculation and expression of results

The flow coefficient E_{cs}, expressed in seconds, of the fine aggregate being tested, is the average of the five single determinations of E_{csi}, rounded off to the nearest second.

NOTE 1 An example of a test data sheet is given in annex C.

NOTE 2 A statement on the precision of this test is given in annex B.

8.5 Test report

8.5.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identification of the test laboratory;

c) identification of the sample;

d) particle size fraction tested;

e) flow coefficient (E_{cs}) to the nearest second;

f) date of receipt of sample.

8.5.2 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 sample reduction procedure;

c) mass of test portion;

d) particle density of material tested on an oven dried basis;

e) date of test.

Annex A
(informative)

Example of test data sheet for the determination of the flow coefficient of coarse aggregates

EN 933-6	Laboratory :
Identification of the sample :	Date :
	Operator :

Test portion mass :	kg

Particle size fraction *d*/*D* (mm)	
Particle density (Mg/m^3)	
Opening of the shutter (mm)	
Mass = $1 + \left(\frac{7\rho_{rd}}{2,70} \right)$ kg	
Flow time (second ± 0,1)	E_{cmi}
1st determination	
2nd determination	
3rd determination	
4th determination	
5th determination	
Average value	E_{cm}

E_R =

E_{ce} =

$E_c = E_{cm}+(E_R-E_{ce})$ =

to nearest 1 s

Annex B
(informative)

Precision

B.1 Coarse aggregates

The following values of repeatability, r_1, and reproducibility, R_1, have been obtained on a 6,3/10 mm fraction, by a series of two tests in 10 French laboratories:

$r_1 = 4$

$R_1 = 5$

B.2 Fine aggregates

18 French laboratories:

fine aggregates	0,08 mm to 2 mm	$r = 1,2$
		$R = 2,9$
	0,08 mm to 4 mm	$r = 0,8$
		$R = 1,2$

Annex C
(informative)

Example of test data sheet for the determination of flow coefficient of fine aggregates

EN 933-6	Laboratory :
Identification of the sample :	Date :
	Operator :

Test portion mass :	kg

Particle size fraction *d*/*D* (mm) :	
Particle density, ρ_{rd} (Mg/m^3)	
Diameter of funnel (mm)	
Flow time (s ± 0,1)	E_{csi}
1st determination	
2nd determination	
3rd determination	
4th determination	
5th determination	

E_{CS} average of 5 single determinations to nearest 1 s	

Bibliography

EN 933-5, *Tests for geometrical properties of aggregates — Part 5: Determination of percentage of crushed and broken surfaces in coarse aggregate particles*

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