BRITISH STANDARD

BS 812-111: 1990

Testing aggregates —

Part 111: Methods for determination of ten per cent fines value (TFV)

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee (CAB/-) to Technical Committee CAB/2, upon which the following bodies were represented:

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Contents

Foreword

This Part of BS 812 has been prepared under the direction of the Cement, Gypsum, Aggregate and Quarry Products Standards Policy Committee, and is a revision of clause **8** of BS 812-3:1975, which is withdrawn. It forms part of a general revision of the 1975 edition of BS 812. As each of the tests, or collection of tests is revised, it will be issued as a separate Part or Section of this standard.

The methods described in this revision have not been changed technically from that given in BS 812-3:1975, but the opportunity has been taken to include a procedure for determining the ten per cent fines value of aggregates in a soaked condition. This has been done because some aggregates have a significantly reduced resistance to crushing when tested in this condition. With such aggregates, tests on soaked samples give a more reliable indication of their performance in practice.

It is intended that other British Standards should call up BS 812 test methods as the basis for compliance. Nevertheless it is *not* intended that all aggregates should be subjected to all the listed tests. Specifications in other standards should call up only relevant tests.

Reference should be made to BS 812-101:1984 for general guidance on testing aggregates, precision of test methods and variance arising from sampling errors.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 812 describes methods for the determination of the ten per cent fines value (TFV) of aggregates which give a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load.

Two procedures are described, one in which the aggregate is tested in a dry condition and the other in a soaked condition.

The methods are applicable to both weak and strong aggregates passing a 14.0 mm test sieve and retained on a 10.0 mm test sieve. For other size fractions, a recommended method is described in appendix A.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 812 the definitions given in BS 812-100, BS 812-101 and BS 812-102 apply.

3 Principle

A test specimen is compacted in a standardized manner into a steel cylinder fitted with a freely moving plunger. The specimen is then subjected to a load applied through the plunger. This action crushes the aggregate to a degree which is dependent on the crushing resistance of the material. The degree of crushing is assessed by a sieving test on the crushed specimen. The procedure is repeated with various loads to determine the maximum force which generates a given sieve analysis. This force is taken as the ten per cent fines value (TFV).

4 Sampling

The sample used for the test (the laboratory sample) shall be taken in accordance with clause **5** of BS 812-102:1989.

5 Apparatus

NOTE All apparatus should comply with the general requirements of BS 812-100.

5.1 *General*

5.1.1 *A steel cylinder*,, open-ended of nominal 150 mm internal diameter with plunger and baseplate, of the general form and dimensions shown in Figure 1 and given in Table 1. The surfaces in contact with the aggregate shall be machined and case hardened, or otherwise treated, so as to have a hardness value of not less than 650 HV, in accordance with BS 427, and shall be maintained in a smooth condition.

5.1.2 *A tamping rod,* made out of straight iron or steel bar of circular cross section, 16 ± 1 mm diameter and 600 ± 5 mm long, with both ends hemispherical.

5.1.3 *A balance,* of at least 3 kg capacity readable to 1 g.

5.1.4 *Test sieves,* with square-hole perforated plate of sizes 14.0 mm and 10.0 mm and a woven wire 2.36 mm test sieve. The test sieves shall comply with BS 410.

5.1.5 *A compression testing machine,* capable of applying any force up to 500 kN and which can be operated to give a uniform rate of loading so that this force is reached in 10 min (see **7.1.2**). The machine shall comply with the requirements of BS 1610 for a grade 1 or grade 2 machine. The machine may be used with or without a spherical seating.

5.1.6 *A cylindrical metal measure,* for measuring the sample, of sufficient rigidity to retain its form under rough usage and having an internal diameter of 115 ± 1 mm and an internal depth of 180 ± 1 mm.

5.1.7 *A well-ventilated oven,* thermostatically controlled at a temperature of 105 ± 5 °C.

5.1.8 *A rubber mallet.*

5.1.9 *A metal tray,* of known mass large enough to contain 3 kg of aggregate.

5.1.10 *A brush,* with stiff bristles.

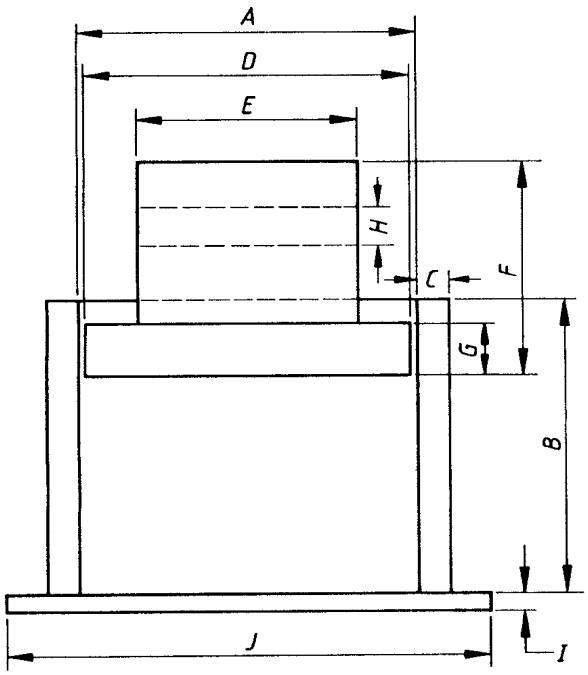
5.2 *Additional apparatus for testing aggregate in a soaked condition*

5.2.1 *Drying cloths or absorbent paper,* for the surface drying of the aggregate after it has been soaked in water, e.g. two hand-towels of a size not less than 750 mm × 450 mm or rolls of absorbent paper of suitable size and absorbency.

5.2.2 *One or more wire-mesh baskets,* having apertures not larger than 6.5 mm or a perforated container of convenient size with hangers for lifting purposes.

5.2.3 *A stout watertight container,* in which the basket(s) may be immersed

5.2.4 *A supply of clean water,* of drinking quality.



NOTE. See table 1.

Figure 1 — Outline form of cylinder and plunger apparatus for ten per cent fines test

Table 1 — Principal dimensions of cylinder and plunger apparatus

Component	**Dimensions** (see Figure 1)	**Nominal 150 mm internal diameter of cylinder**	**Nominal 75 mm internal diameter of cylinder** (see appendix A)
Cylinder		mm	mm
	Internal diameter, *A*	154 ± 0.5	78.0 ± 0.5
	Internal depth, *B*	125 to 140	70.0 to 85.0
	Minimum wall thickness, *C*	16.0	8.0
Plunger			
	Diameter of piston, *D*	152 ± 0.5	76.0 ± 0.5
	Diameter of stem, *E*	> 95 to ≤ *D*	> 45.0 to ≤ *D*
	Overall length of piston plus stem, *F*	100 to 115	60.0 to 80.0
	Minimum depth of piston, *G*	not less than 25.0	not less than 19.0
	Diameter of hole, *H*	20.0 ± 0.1	10.0 ± 0.1
Baseplate			
	Minimum thickness, *I*	10	10
	Length of each side of square, *J*	200 to 230	110 to 115

6 Preparation of test portions and specimens

6.1 Test portions

Reduce the laboratory sample using the procedures described in clause **6** of BS 812-102:1989 to produce a test portion of sufficient mass to produce three test specimens of 14 mm to 10 mm size fraction.

NOTE A single test specimen is that quantity of material required to fill the cylinder (see **7.1.1** and Table 2).

Table 2 — Guide to minimum mass of test portions required to obtain a suitable mass of material to determine the ten per cent fine value

Grading of the aggregate	Minimum mass of the test portion[a]
mm	kg
All-in aggregate 40 max. size	60
All-in aggregate 20 max. size	45
Graded aggregate 40 to 5	40
Graded aggregate 20 to 5	25
Graded aggregate 14 to 5	15

[a] For normal density aggregates

6.2 Test specimens in a dry condition

6.2.1 Thoroughly sieve the entire surface dry test portion on the 14 mm and 10 mm test sieves to remove the oversize and undersize fractions. Divide the resulting 14 mm to 10 mm fraction to produce three test specimens each of mass such that the depth of the material in the cylinder is approximately 100 mm after tamping as described in **7.1** (see note 1).

NOTE 1 The appropriate quantity of aggregate may be found conveniently by filling the cylindrical measure in three layers of approximately equal depth. Tamp each layer 25 times, from a height of approximately 50 mm above the surface of the aggregate, with the rounded end of the tamping rod. Level off using the tamping rod as a straightedge.

NOTE 2 Mechanical sieving should only be used for aggregates which do not degrade under its action.

6.2.2 Dry the test specimens by heating at a temperature of 105 ± 5 °C for a period of not more than 4 h. Cool to room temperature before testing. Record the mass of material comprising the test specimens.

6.3 Test specimens in a soaked condition

6.3.1 Prepare the test specimens using the procedure described in **6.2** except that the test portion is tested in the as-received condition and not as oven-dried material. Place each test specimen (see note) in the wire basket and immerse it in the water in the container with a cover of at least 50 mm of water above the top of the basket. Immediately after immersion remove the entrapped air from the specimen by lifting the basket 25 mm above the base of the container and allowing it to drop 25 times at a rate of about once a second. Keep the basket and aggregate completely immersed during the operation and for a subsequent period of between 24 ± 2h and maintain the water temperature at 20 ± 5 °C.

NOTE The appropriate quantity of aggregate to use may be found as described in **6.2**.

6.3.2 After soaking, remove the specimen of aggregate from the basket and blot the free water from the surface with the absorbent cloths. Carry out the test procedure immediately after this operation.

7 Procedure

7.1 Aggregates in dry condition

7.1.1 Place the cylinder of the test apparatus in position on the baseplate and add the test specimen in thirds, each third being subjected to 25 strokes from the tamping rod distributed evenly over the surface of the layer and dropping from a height approximately 50 mm above the surface of the aggregate.

NOTE The particles of some aggregates may break down when tamped in this way. If this occurs it should be reported.

Carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on this surface. Take care to ensure that the plunger does not jam in the cylinder.

7.1.2 Place the apparatus, with the test specimen and plunger in position, between the platens of the testing machine. Apply force at as uniform a rate as possible (see note 1) so as to cause a total penetration of the plunger in 10 min ± 30 s of approximately:

a) 15 mm for rounded or partially rounded aggregates, e.g. uncrushed gravels;

b) 20 mm for normal crushed aggregates;

c) 24 mm for vesicular (honeycombed) aggregates e.g. some slags.

NOTE 1 When, during the early stages of the test, there is a significant deformation, it may not be possible to maintain the required loading rate and variations in the loading rate may occur especially at the beginning of the test. These variations should be kept to a minimum with the principal object of completing the test in the overall time of 10 mins ± 30 s.

NOTE 2 These figures may be varied according to the extent of the rounding or honeycombing.

NOTE 3 When an aggregate impact value (AIV) as determined by the procedure given in BS 812-112 is available, the force required (in kW) for the first ten per cent fines test can be estimated by means of the following equation more conveniently than by the use of the dial gauge.

$$\text{Required force} = \frac{4\,000}{AIV}$$

This value of force will nearly always give a percentage of fines within the required range of 7.5 % to 12.5%.

7.1.3 Record the maximum force (f) applied to produce the required penetration. Release the force and remove the crushed material by holding the cylinder over a clean tray of known mass and hammering on the outside of the cylinder with the rubber mallet until the particles are sufficiently disturbed to enable the mass of the specimen to fall freely on to the tray.

NOTE If this fails to remove the compacted aggregate other methods should be used but take care not to cause further crushing of the particles.

Transfer any particles adhering to the inside of the cylinder, the baseplate and the underside of the plunger to the tray by means of a stiff bristle brush. Weigh the tray and the aggregate and record the mass of aggregate used (M_1) to the nearest gram.

7.1.4 Sieve the whole of the specimen in the tray on the 2.36 mm test sieve until no further significant amount passes during a further period of 1 min. Weigh and record the masses of the fractions passing and retained on the sieve to the nearest gram (M_2 plus M_3 respectively). If the total mass (M_2 plus M_3) differs from the initial mass (M_1) by more than 10 g, discard the result and test a further specimen.

If the percentage of material (m) passing the sieve, calculated from

$$M = \frac{M_2}{M_1} \times 100$$

does not fall within the range 7.5 % to 12.5 %, test a further specimen, using an adjusted maximum test loading to bring the percentage of fines within the range and record the value of m obtained.

NOTE 1 The formula given in **8.1** may be used for calculating the force required.
NOTE 2 In the operations described in **7.1.3** and **7.1.4** take care to avoid loss of fines.
NOTE 3 Mechanical sieving should only be used for aggregates which do not degrade under its action.

7.1.5 Repeat the complete test procedure with the same mass of aggregate at the same force that gave a percentage fines value within the range 7.5 % to 12.5 %.

7.2 Aggregates in a soaked condition

Follow the procedure described in **7.1** except that after the crushed specimen has been removed from the cylinder (see **7.1.3**) dry it in the oven at a temperature of 105 ± 5 °C either to constant mass or for a minimum period of 12 h. Allow the dried material to cool and weigh to the nearest gram (M_1). Complete the procedure as described in **7.1.4** and **7.1.5**.

NOTE The use of the aggregate impact value to estimate the required force as described in the note 3 to **7.1.2** is not applicable to the determination of the ten per cent fines value for soaked aggregates.

8 Calculations and expression of results

8.1 Calculate the force F (in kN), to the nearest whole number, required to produce 10 % of fines for each test specimen, with the percentage of material passing in the range 7.5 % to 12.5 %, from the following expression:

$$F = \frac{14f}{m + 4}$$

where

f is the maximum force (in kN)
m is the percentage of material passing the 2.36 mm test sieve at the maximum force.

8.2 Calculate the mean of the two results to the nearest 10 kN for forces of 100 kN or more, or to the nearest 5 kN for forces of less than 100 kN. Report the mean as the ten per cent fines value, unless the individual results differ by more than 10 kN and by more than 0.1 times the mean value. In this case repeat the test on two further specimens, calculate the median of the four results to the nearest 10 kN for forces of 100 kN or more, or to the nearest 5 kN for forces of less than 100 kN, and report the median as the ten per cent fines value.

NOTE The median of four results is calculated by excluding the highest and the lowest result and calculating the mean of the two middle results.

9 Precision

9.1 A precision experiment was carried out involving 15 laboratories. Details of the experiment and the precision data are given in appendix B.

9.2 Uses of precision data are described in clause **5** of BS 812-101:1984.

10 Test report

The report shall affirm that the ten per cent fines value of the dry aggregate and/or soaked aggregate was determined in accordance with this Part of BS 812 and whether or not a certificate of sampling is available. If available, a copy of the certificate shall be provided. The test report shall contain the following additional information:

a) sample identification and sample description;

b) the condition in which the aggregate was tested, i.e. dry or soaked;

c) the ten per cent fines value of the dry aggregate; and/or

d) the ten per cent fines value of the soaked aggregate.

Appendix A Recommended method for determining the ten per cent fines value for other size fractions of aggregate

A.1 General

When required, or if the definitive size fraction passing the 14 mm test sieve and retained on a 10 mm test sieve is not available, tests may be made on aggregates of other sizes which pass a 28.0 mm test sieve and are retained on a 2.36 mm test sieve. Because of the lack of experience of testing sizes other than the definitive size fraction, it has not been possible to give any positive indication as to how the results obtained on non-standard sizes would compare with those obtained by the standard test procedures.

A.2 Apparatus

A.2.1 *General* The apparatus is as described in clause **5**, or for testing aggregate smaller than 10 mm in particle size, as described in **A.2.2** to **A.2.7**.

A.2.2 *A steel cylinder,* open-ended with plunger and baseplate, generally as described in **5.1**, with a nominal internal diameter of 75 mm. The general form of dimensions of the cylinder and of the plunger are shown in Figure 1 and given in Table 1.

A.2.3 *A tamping rod,* Made out of straight steel of circular cross section, 8 mm diameter and 300 mm long. One end shall be rounded.

A.2.4 *A balance,* of at least 500 g capacity readable to 0.2 g.

A.2.5 *Test sieves,* of appropriate sizes as given in Table 3. The test sieves shall comply with BS 410.

Table 3 — Particulars of test sieves for testing other size fractions of aggregates

Size fraction	Nominal aperture size of test sieve complying with BS 410			
	For preparation of test specimens		For separating fines	
	Passing	Retained		
	mm	mm	mm	μm
Larger than standard	28.0	20.0	5.00	—
	20.0	14.0	3.35	—
Standard	14.0	10.0	2.36	—
Smaller than standard	10.0	6.30	1.70	—
	6.30	5.00	1.18	—
	5.00	3.35	—	850
	3.35	2.36	—	600

A.2.6 *A compression testing machine,* generally as described in **5.1.5** except that it shall be capable of applying any force of up to 100 kN, and of being operated to give a uniform rate of loading so that this force is reached in 10 min (see note 1 to **7.1.2**).

A.2.7 *A cylindrical metal measure,* generally as described in **5.1.6** except that it shall have an internal diameter of 57 ± 1 mm and an internal depth of 90 ± 1 mm.

A.3 Preparation of test portions and specimens

Follow the procedure described in clause **6**, using the appropriate sieves as described in Table 3, according to size of the fraction under test. For a grading of test portion of less than 10 mm maximum size, a minimum mass of 1 kg is required.

A.4 Procedure

Follow the procedure described in clause **7** using the appropriate separating sieves given in Table 3.

NOTE The penetration of the plunger may not accord with the values given in clause **7**.

A.5 Calculations and expression of results

Follow the general procedure described in clause **8**.

A.6 Test report

The test report shall contain the information specified in clause **10** with additionally, the size of aggregate tested.

Appendix B Details of the evaluation of precision data

B.1 The precision data given in Table 4 and Table 5 were determined from an experiment conducted in 1989/90 involving 15 laboratories. The experiment was designed and the data analysed following the principles set out in BS 5497-1. The materials used were taken from 4 t stockpiles. Laboratory samples of approximately 125 kg were taken in accordance with BS 812-102, and one laboratory sample of each material was sent to each laboratory. Two test portions were prepared from each laboratory sample for the determination of the ten per cent fines value. (The same materials were also used for the precision experiments recorded in BS 812-110 and BS 812-112.)

B.2 The tests for outliers given in BS 5497-1 were applied to the data. Data from one laboratory were found to contain outliers.

B.3 Variation due to the preparation of the samples (V_s) in the precision trial may be assumed to be small so that R_1 will be similar to R_2. The definitions of repeatability r_1 and reproducibility R_1 and R_2 and of the variances V_{r1}, V_s and V_L are given in BS 812-101. The values given in Table 4 and Table 5 apply when a test result is obtained as the average of two determinations of the ten per cent fines value on sub-samples of the same test portion, when both determinations comply with the checks on the masses and the percent fines given in **7.1.4**.

Table 4 — Precision values for the determination of ten per cent fines value using materials in the dry condition

Material	Mean value of the data	Repeatability r_1	Reproducibility R_2	$\sqrt{V_{r1}}$	$\sqrt{(V_L + V_s)}$
	kN	kN	kN	kN	kN
Argillaceous limestone (A)	118	18	40	6	13
Blast-furnace slag (B)	104	15	38	5	12
Carboniferous limestone (C)	219	13	42	5	14
Igneous rock (I)	263	20	59	7	20
Mixed gravel (M)	192	16	42	6	14

Table 5 — Precision values for the determination of ten percent fines value using materials in the soaked condition

Material	Mean value of the data	Repeatability r_1	Reproducibility R_2	$\sqrt{V_r}$	$\sqrt{(V_L + V_s)}$
	kN	kN	kN	kN	kN
Argillaceous limestone (A)	39	3	21	1	7
Blast-furnace slag (B)	89	10	12	3	3
Carboniferous limestone (C)	214	13	52	5	18
Igneous rock (I)	195	18	57	6	19
Mixed gravel (M)	172	10	32	4	11

Publications referred to

BS 410, *Specification for test sieves.*

BS 427, *Method for Vlckers hardness test.*

BS 427-1, *Testing of metals.*

BS 427-2, *Verification of the testing machine.*

BS 812, *Testing aggregates.*

BS 812-100, *General requirements and calibration.*

BS 812-101, *Guide to sampling and testing aggregates.*

BS 812-102, *Methods of sampling.*

BS 812-110, *Methods for determination of aggregate crushing value (ACV).*

BS 812-112, *Methods for determination of aggregate impact value (AIV).*

BS 1610, *Materials testing machines and force verification equipment.*

BS 1610-1, *Specification for the grading of the forces applied by materials testing machines.*

BS 1610-2, *Specification for the grading of equipment used for the verification of the forces applied by materials testing machines.*

BS 5497, *Precision. of test methods.*

BS 5497-1, *Guide for the determination of repeatability and reproducibility for a standard test method by inter-laboratory tests.*

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