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Testing aggregates —

Part 103: Methods for determination of particle size distribution —

Section 103.1 Sieve tests

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Committees responsible for this British Standard

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Aggregate Concrete Block Association
Association of Consulting Engineers
Association of Consulting Scientists
Association of Lightweight Aggregate Manufacturers
Brick Development Association
British Aggregate Construction Materials Industries
British Ceramic Research Association
British Civil Engineering Test Equipment Manufacturers' Association
British Precast Concrete Federation Ltd.
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Foreword

This section of BS 812, prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee, is a revision of **7.1** of BS 812-1:1975, which is withdrawn by amendment. The remaining sections of BS 812-1 and BS 812-2, 3 and 4 are also being revised and as each of the tests, or collection of related tests, is revised, it is intended to issue it as a separate Part or Section of this standard.

It is intended that other British Standards should call up BS 812 test methods as the basis of compliance. Nevertheless, it is *not* intended that all aggregates should be subjected regularly to all the listed tests. Requirements in other British Standard specifications will refer only to the relevant test methods.

Some of the tests in other Parts of BS 812 are of limited application, and advice on the use of simpler tests is given, for example, when they can be used for a preliminary sorting of aggregates to see whether more expensive testing is justified.

Removal of fine material by decantation, described as the modified method in the BS 812-1, has been made the preferred method in this revision to ensure reliable testing of aggregate containing fine material that may cause agglomeration of particles.

In this revision the masses retained at the completion of sieving have been rationalized.

Reference should be made to BS 812-101 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 Section of BS 812 describes two methods for the determination of the particle size distribution of samples of aggregates and fillers by sieving.

NOTE 1 For sampling and testing lightweight aggregates for concrete see BS 3681.
NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

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

3 Principle

3.1 Washing and sieving

This is the preferred method (see **7.2**) for aggregates which may contain clay or other materials likely to cause agglomeration of particles. It involves preliminary separation by washing through a fine sieve before determining particle size distribution by dry sieving.

3.2 Dry sieving

This is an alternative method (see **7.3**) which may be used for coarse and fine aggregates free from particles which cause agglomeration.

NOTE 1 Dry sieving gives inaccurate results for aggregates containing clay but is quicker and less laborious to carry out than washing and sieving.
NOTE 2 It is not possible to specify accurately the amount of clay or other materials which will make the method given in **7.3** inappropriate and unless it can be demonstrated (e.g. by previous experience) that that method gives accurate results, it is recommended that the method described in **7.2** should always be used. Because of this some materials specifications may call for washing and sieving to be followed at all times.

4 Sampling

The sample used for the test (the laboratory sample) shall be taken in accordance with the procedures described in clause 5 of BS 812-102:1984.

5 Apparatus

5.1 *A sample divider,* of size appropriate to the maximum particle size to be handled or alternatively a flat shovel and a clean, flat, hard horizontal surface, e.g. a metal tray for use in quartering.

NOTE A suitable divider is the riffle box illustrated in BS 812-102.

5.2 *A ventilated oven,* thermostatically controlled to maintain a temperature of 105 ± 5 °C.

5.3 *A balance, or balances,* of suitable capacity accurate to 0.1 % of the mass of the test portion.

NOTE In general, two balances, one of approximately 5 kg capacity accurate to 1 g and the other of approximately 500 g capacity accurate to 0.1 g, will suffice. If aggregate of larger than 28 mm nominal size is to be tested a balance of 50 kg capacity accurate to 10 g will also be required.

5.4 *Test sieves and nesting guard sieve,* of the sizes and apertures appropriate to the specification of the material being tested, complying with BS 410 and with the appropriate sizes of lid(s) and receivers.

NOTE 1 A set of sieves of the sizes and apertures given in Table 1 will cover most applications of the method.
NOTE 2 Some advice on cleaning and checking sieves is given in appendices A and B.

Table 1— Particulars of sieves for sieve analysis

Nominal aperture sizes	
Square hole perforated plate, 450 mm or 300 mm diameter	**Wire cloth, 300 mm or 200 mm diameter**
mm	mm
75.0	3.35
63.0	2.36
50.0	1.70
37.5	1.18
28.0	
20.0	µm
14.0	850
10.0	600
6.30	425
5.00	300
	212
	150
	75[a]

[a] For some applications, 63 µm is appropriate.

5.5 *A mechanical sieve shaker* (optional).

5.6 *Trays,* that can be heated in the ventilated oven (**5.2**) without damage or change in mass.

5.7 *Containers,* of a size sufficient to contain the test portion plus five times its volume of water (for washing and sieving method only).

6 Preparation of test portion

Reduce the sample in accordance with the procedures described in clause **6** of BS 812-102:1984 to produce the required number of test portions each of which complies with the minimum mass given in Table 2. Dry the test portions by heating at a temperature of 105 ± 5 °C to achieve a dry mass which is constant to within 0.1 %. Allow to cool, weigh and record as M_1.

Table 2 — Minimum mass of test portion for sieve analysis

Nominal size of material	Minimum mass of test portion
mm	kg
63	50
50	35
40	15
28	5
20	2
14	1
10	0.5
6	0.2
5	0.2
3	0.2
< 3	0.1

7 Procedure

7.1 General

7.1.1 For some materials, e.g. all in aggregates or hoggin, the particle size distribution may result in excess mass on one or more sieves particularly on the finer sizes.

Therefore, if it is not possible to include extra sieves of appropriate intermediate size to reduce the loading, adopt one of the following procedures.

a) Subdivide the test portion into two or more sub-portions. Determine the particle size distribution for each portion and combine the results for the purpose of reporting.

b) Separate the test portion on an appropriate sieve, e.g. 20 mm or 5 mm. Weigh the retained and passing fractions to determine the proportion of each present. Determine the particle size distribution of each fraction separately, reducing where necessary by quartering or by means of a sample divider (**5.1**) as described in clause **6** of BS 812-102:1984. Calculate the particle size distribution of the original sample by combining the results for each fraction in the proportions present.

7.1.2 When special procedures for fillers are required to measure the amount finer than 75 µm, carry these out either in accordance with **7.2** of BS 812-1:1975 or BS 812-104[1)].

7.2 Washing and sieving method

7.2.1 *Preliminary separation*

7.2.1.1 Wet both sides of a 75 µm test sieve (**5.4**), reserved for use in this test only, and fit a nesting guard sieve (e.g. 1.18 mm) on top. Mount the sieves in such a way that the suspension passing the test sieve can be run to waste or, when required, collected in a suitable vessel.

7.2.1.2 Place the weighed oven dried test portion in a container (**5.7**) and add sufficient water to half fill the container. Agitate the contents so that particles smaller than 75 µm are completely separated from coarser particles.

NOTE Soaking or continued agitation or, in the case of large particles, brushing may be required to achieve complete separation.

7.2.1.3 Pour the suspension of fine solids on to the guarded 75 µm test sieve.

NOTE The suspension passing the test sieve may be run to waste unless it is required for other purposes.

7.2.1.4 Continue washing the coarse residue until the water passing the test sieve is clear (see note 2) and then wash all the residues from the container and sieve(s) into the tray (**5.6**). Remove excess free water by careful decantation through the test sieve, avoiding transfer of solids (see note 2) and dry the residue in the oven (**5.2**) at 105 ± 5 °C until constant mass is achieved. Cool, weigh and record as M_2.

NOTE 1 Avoid excess water flows which may damage or flood the sieves.
NOTE 2 If some transfer of solids does occur wash them back into the tray and repeat the operation.
NOTE 3 Fine sieves are fragile and the integrity of the mesh should be checked frequently (see appendix B).

7.2.1.5 Determine the mass of material passing the test sieve as $M_1 - M_2$.

7.2.2 *Sieving the dried residue*

7.2.2.1 Nest the clean and dry sieves on a fitting receiver in order of increasing aperture size from bottom to top. Place the dried residue on the top coarsest sieve and cover with a fitting lid. Either by hand or using the mechanical sieve shaker (**5.5**), shake the sieves for a sufficient time to separate the test sample into the size fractions determined by the sieve apertures used.

NOTE Experience has shown that the preliminary separation (**7.2.1**) does not necessarily remove all the particles smaller than 75 µm because of capillary action of water on particle surfaces. It is therefore necessary to incorporate a 75 µm test sieve in the series of test sieves used to sieve the dried residue.

[1)] At the time of publication, BS 812-104 is in preparation. When published, it will supersede **7.2** of BS 812-1:1975.

7.2.2.2 When the mechanical sieve shaker is used, after sieving, check that separation is complete by briefly hand sieving. When sieving is done by hand alone start with the coarsest sieve and shake each sieve separately over a clean tray or receiver until not more than a trace passes, but in any case for a period of not less than 2 min. Do the shaking with a varied motion, backwards and forwards, left to right, circular, clockwise and anti-clockwise, and with frequent jarring so that the material is kept moving over the sieve surface in frequently changing directions. Do not force materials through the sieve by hand pressure but placing of particles is permitted. Break lumps of agglomerated material which consist of particles representative of the bulk by gentle pressure with the fingers against the side of the sieve.

7.2.2.3 Record any extraneous material not representative of the bulk that will not readily break down into individual particles, such as clay lumps, and remove from the sieve for separate weighing.

7.2.2.4 Do not apply pressure to the surface of the sieve to force particles through the mesh. Light brushing with a soft brush on the underside of the sieve may be used to clear sieve openings. Light brushing with a fine camel-hair brush may be used on the 150 μm and 75 μm sieves to prevent agglomeration of the powder and blinding of the apertures. Do not use stiff or worn-down brushes for this purpose.

7.2.2.5 In order to prevent blinding of the sieve apertures by overloading, ensure that the mass of aggregate retained on the sieve at completion of the operation does not exceed the value for that sieve shown in Table 3.

NOTE 1 Some sample masses shown in Table 1 will thus require additional operations on some sieves, as described in **7.1**.
NOTE 2 In some cases it may be possible to reduce sufficiently the load on a sieve by incorporating an intermediate sieve into the test series.

7.2.2.6 Weigh the material retained on each sieve, together with any material cleaned from the mesh, on completion of sieving on that sieve.

NOTE Samples containing dust should be sieved into a receiver to prevent loss.

7.2.2.7 Add the aggregate passing the sieve to the next sieve in the series before commencing the operation on that sieve.

7.3 Dry sieving method

Use the procedure described in **7.2.2**.

8 Calculation and expression of results

Calculate the mass retained on each sieve as a percentage of the original dry mass (M_1), For the mass of material passing the finest sieve, add that passing during washing ($M_1 - M_2$) to that found during the dry sieving.

Calculate the mass passing each sieve as a cumulative percentage of the total sample mass.

9 Precision

Estimates of the repeatability and reproducibility of sieve analysis using the methods described in this Section of BS 812 are given in Table 4 for a limited range of materials.

NOTE 1 Reference should be made to BS 812-101 for guidance on assessing the precision of the methods given in this standard.
NOTE 2 There is insufficient data available to permit the inclusion of values for V_s (variance arising from sampling errors) in Table 4. When data is available it will be incorporated by amendment. Some values of V_s for a single experiment are given in Supplementary Report 831 published by the Transport and Road Research Laboratory.

10 Test report

The report shall affirm that the particle size distribution was determined in accordance with this Section of BS 812 and whether or not a certificate of sampling is available. If available, a copy of the certificate of sampling shall be provided. The test report shall include the following additional information:

a) sample identification;

b) either the cumulative percentage of the mass of the total sample passing each of the sieves, to the nearest whole number; or the percentage of the mass of the total sample passing one sieve and retained on the next smaller sieve, to the nearest whole number;

NOTE A specimen chart which may be used for illustrating the results graphically is shown in Figure 3.

c) the method used by reference to either **7.2** or **7.3** of this Section of BS 812;

d) whether or not lumps of material not representative of the bulk, such as clay lumps, were found to be present and the sieve sizes on which they were retained, together with the total amount present expressed as an overall percentage by mass of the total sample.

Table 3 — Maximum mass to be retained at the completion of sieving

BS test sieve nominal aperture size	Maximum mass		BS test sieve nominal aperture size		Maximum mass	
	450 mm diameter sieves	300 mm diameter sieves			300 mm diameter sieves	200 mm diameter sieves
mm	kg	kg	mm	µm	g	g
50.0	14	5	5.00		750	350
37.5	10	4	3.35		550	250
			2.36		45O	200
28.0	8	3	1.70		375	150
20.0	6	2.5	1.18		300	125
14.0	4	2				
10.0	3	1.5		850	260	115
				600	225	100
				425	180	80
6.30	2	1		300	150	65
5.00	1.5	0.75		212	130	60
3.35	1	0.55		150	110	50
				75	75	30

Table 4 — Precision data for determination of particle size distribution

Description of material used	All values as cumulative percentage passing stated sieve							Details of precision experiment		
								Number of		
	Sieve size	Mean value	r	r_1	R	R_1	R_2	Participating laboratories	Outliers	Date
Chippings (1)	75 µm	0.38	—	0.2	—	0.35	—	17	—	1982
(2)	75 µm	0.81	—	0.2	—	0.35	—	17	1	1982
Type 2 granular sub-base	20 mm	90	—	5	5	6	9	9	—	1983
	10 mm	75	—	7	6	9	12			
	5 mm	65	—	6	3	9	11			
	600 µm	35	—	4	3	5	7			
	150 µm	15	—	2	—	3	4			
	75 µm	10	—	1	2	2	3			
20 mm crushed rock	600 µm	6.6	—	1.6	—	1.6	—	8	—	1983
	150 µm	3.6	—	0.3	—	1.0	—			
	75 µm	2.6	—	0.5	—	1.1	—			
14 mm single sized basalt or sandstone	14 mm	90	—	4.3	—	5.6	—	8	—	1982
	10 mm	25	—	5.2	—	8.5	—			
	2.36 mm	1.0	—	0.2	—	1.1	—			
	75 µm	0.75	—	0.2	—	1.0	—			
Building sands (means of 11 different sands)	600 µm	90	—	0.8	—	1.4	—	11	—	1981
	300 µm	57	—	1.8	—	4.8	—			
	150 µm	19	—	1.8	—	6.6	—			
	75 µm	5.5	—	0.8	—	1.5	—			

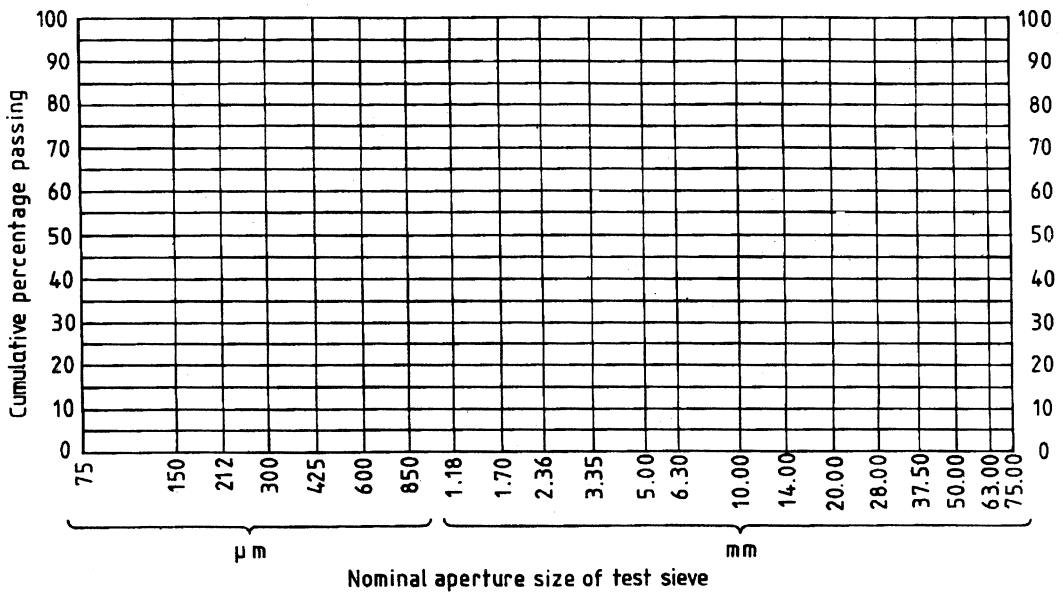

Figure 1 — Chart for recording sieve analysis results

Appendix A Preparation and cleaning of test sieves

Before and after each use the sieving medium and the frame should be cleaned and inspected and degreased if necessary. The cleaning of the sieve should be carried out with great care so that the sieving medium is not damaged.

A useful method for the removal of entrapped material, particularly from finer apertures, is immersion in a bath of water agitated by an ultrasonic transducer.

Appendix B Checking of test sieves

Test sieves may be checked against certified master sieves, reserved for that purpose, at regular intervals. This can be achieved by checking the number of sieves used during that month. Checking should be in accordance with **E.3** of BS 410:1976 using spherical particles, such as glass beads. The charge on the sieve should be the maximum allowed by BS 1796 and the checking material used for each sieve should be chosen so that between 40 % and 60 % passes the sieve.

The difference between the percentage material passing the master sieve and the working sieve should not exceed 2 %.

Publications referred to

BS 410, *Specification for test sieves.*
BS 812, *Testing aggregates.*
BS 812-101, *Guide to sampling and testing aggregates.*
BS 812-102, *Methods for sampling.*
BS 812-104, *Method for determination of the nature and content of material finer than 75 μm*[2)].
BS 1796, *Method for test sieving.*
BS 3681, *Methods for the sampling and testing of lightweight aggregates for concrete.*
Transport and Road Research Laboratory *Supplementary report 831.*

[2)] In preparation.

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