
Testing aggregates

Part 2. Methods for determination of physical properties

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Association of London Borough Engineers and Surveyors
Department of the Environment (Building Research Establishment)

Natural Environment Research Council—Institute of Geological Science

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Contents

	Page		Page
Co-operating organizations	Inside front cover	7.1 General	12
Foreword	2	7.2 Sampling	12
Methods		7.3 Standard (oven-drying) method	12
1. Scope	3	7.4 Siphon-can method for aggregate not exceeding 40 mm nominal size	13
2. References	3	7.5 Buoyancy method for aggregate not exceeding 40 mm nominal size	17
3. Reporting	3	7.6 Modified drying method	18
4. Significance of results	3	Appendix	
5. Determination of relative densities and water absorption	3	A. Repeatability and reproducibility of test results	19
5.1 General	3	Tables	
5.2 Sampling	3	1. Details of containers to be used for the bulk density tests	10
5.3 Method for aggregate all larger than 10 mm	3	2. Values of moisture content by dry mass (siphon-can method)	15
5.4 Method for aggregate between 40 mm and 5 mm	4	3. Values of moisture content by wet mass (siphon-can method)	16
5.5 Method for aggregate 10 mm nominal size and smaller	5	4. Estimates of the repeatability and reproducibility of a number of tests for aggregates	20
5.6 Alternative method for aggregate between 40 mm and 5 mm nominal size	8	Figures	
5.7 Method for determination of relative density of filler	8	1. Section of pycnometer made from preserving jar	6
6. Determination of bulk density, voids and bulking	9	2. Estimation of free running condition of fine aggregate	7
6.1 General	9	3. Filler compaction apparatus	11
6.2 Sampling	9	4. Siphon-can	13
6.3 Method for the determination of bulk density, and calculation of voids and bulking of aggregate	9	5. Buoyancy moisture meter	17
6.4 Method for the determination of bulk density of filler in toluene	10		
6.5 Method for the determination of voids of dry compacted filler	11		
7. Determination of moisture content of aggregate	12		

Foreword

This British Standard has been prepared under the authority of the Road Engineering Industry Standards Committee, using metric dimensions as part of the national policy to change to the metric system. BS 812 was first published in 1938 and subsequently revised in 1943, 1951, 1960 and 1967.

Guidance on sampling and testing aggregates, including procedures for assessing the precision of methods of test, is given in BS 812 : Part 101. Other Parts of BS 812 published are as follows.

Part 102 Methods for sampling

Part 1 Methods for determination of particle size and shape

Part 3 Methods for determination of mechanical properties

Part 4 Methods for determination of chemical properties

In this Part of the standard changes have been made in the symbols used in the determination of

relative density and water absorption so that each symbol has the same connotation in each method. New sizes of containers for the bulk density tests have been introduced and the filler compaction apparatus is now specified in rational metric dimensions. The voids and bulking tests have been redefined.

The modified drying method for moisture content which is intended primarily for quality control purposes has been amended to restrict its application to the determination of the total moisture content and to achieve better standardization of the drying regime.

Information on any other methods of test that are thought suitable for extensive use, or suggestions for improvement of the specified methods, are welcomed and will be considered when it becomes desirable again to revise the standard.

Attention is drawn to the companion standard BS 3681 'Methods for the sampling and testing of lightweight aggregates for concrete'.

British Standard

Testing aggregates

Part 2. Methods for determination of physical properties

1. Scope

This Part of the standard specifies methods for the determination of the relative density, water absorption, bulk density, voids, bulking and moisture content of aggregates and the relative density, bulk density and voids of filler.

Some of the tests are intended for use in obtaining assurance that material complies with British Standard or other requirements, for research, production control or assessment of variation. However, other methods are not intended for assurance testing and their suitability for other purposes is defined.

2. References

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

3. Reporting

3.1 General. The report shall affirm that the tests were done in accordance with this standard. Any departure from the specified test procedure shall be described with reasons for the departure and, if possible, estimates of its effect on the test results. The report shall also include details of any special processing of the sample, other than that required by the test methods, carried out in the laboratory. For example, crushing to provide larger quantities of smaller sizes or the separation of constituents from an as-dug gravel.

3.2 Certificate of sampling. The report shall affirm that a certificate of sampling was received with the sample and shall declare all the information given on the certificate. If a certificate was not received this shall be stated in the report.

4. Significance of results

The distribution of the results of any test on any material stems from a number of contributing factors. In assessing the significance of the results the repeatability and reproducibility of the test should be recognized. Estimates of these are given in appendix A and should be used in assessing test results.

5. Determination of relative densities and water absorption

5.1 General. Three main methods are described for aggregates, a wire basket method for aggregates larger than 10 mm, a gas jar method for aggregates between 40 mm and 5 mm and a pycnometer or gas jar method for aggregates 10 mm nominal size and smaller. A buoyancy method using a bucket, as described in BS 1881, is allowed as an alternative for aggregates between 40 mm and 5 mm nominal size.

The method for filler is by use of a density bottle.

As with any porous material the value obtained for the relative density of an aggregate depends on the details of the method of test. Furthermore, different sizes of the same aggregate often have different values of relative density and absorption. Therefore, when comparing different aggregates it is essential that the test be made on samples sensibly of the same grading.

The wire basket method for aggregates larger than 10 mm is not suitable for testing friable aggregates which may break down during the test and therefore the gas jar method for aggregates between 40 mm and 5 mm should be used for such material.

5.2 Sampling. The sample for these tests shall be taken in accordance with Part 102 of this standard.

5.3 Method for aggregate all larger than 10 mm.

5.3.1 Apparatus. The following apparatus is required.

5.3.1.1 A balance of capacity not less than 3 kg, accurate to 0.5 g, and of such a type and size as to permit the basket containing the sample to be suspended from the beam and weighed in water.

5.3.1.2 A well ventilated oven, thermostatically controlled to maintain a temperature of $105 \pm 5^\circ\text{C}$.

5.3.1.3 A wire mesh basket having apertures not larger than 6.5 mm, or a perforated container of convenient size, preferably chromium plated and polished, with wire hangers (not thicker than 1 mm) suspending it from the balance.

5.3.1.4 A stout watertight container in which the basket may be freely suspended.

5.3.1.5 Two dry soft absorbent cloths, each not less than 750 mm $\times$ 450 mm.

5.3.1.6 A shallow tray of area not less than 0.065 m².

5.3.1.7 *An airtight container* of similar capacity to the basket.

5.3.1.8 *A 10.0 mm BS test sieve* (see 7.1.3.1 of Part 1 of this standard).

5.3.1.9 *A supply of water* free from any impurity (e.g. dissolved air) that would significantly affect its density. If distilled or deionized water is not available in sufficient quantity, tap water which has been freshly boiled and cooled to room temperature may be used. This water shall be used throughout the test.

5.3.2 *Sample for test.* A sample of not less than 2 kg of aggregate shall be tested. Aggregates which have been artificially heated shall not normally be used; if such material is used, the fact shall be stated in the report. Two tests shall be made.

The sample for test shall be thoroughly washed on the test sieve to remove finer particles, particularly clay, silt and dust, which would otherwise be lost during the test thereby affecting the result, and drained.

5.3.3 *Test procedure.* Place the prepared test sample in the wire basket and immerse it in the water described in 5.3.1.9 at a temperature of $20 \pm 5^\circ\text{C}$ 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 sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at about once per second. The basket and aggregate shall remain completely immersed during this operation and for a period of 24 ± 0.5 h.

Again jolt the basket and sample and weigh them in water at a temperature of $20 \pm 5^\circ\text{C}$. If it is necessary for them to be transferred to a different tank for weighing, jolt them 25 times as described above in the new tank before weighing (mass *B*).

Then remove the basket and aggregate from the water and allow them to drain for a few minutes, after which gently empty the aggregate from the basket on to one of the dry cloths, and return the empty basket to the water, jolt it 25 times and weigh it in water (mass *C*).

With the cloth gently surface-dry the aggregate placed on the dry cloth, transferring it to a second dry cloth when the first will remove no further moisture. Then spread it out not more than one stone deep on the second cloth, and leave it exposed to the atmosphere away from direct sunlight or any other source of heat until all visible films of water are removed, but the aggregate still has a damp appearance. Then weigh the aggregate (mass *A*). If the apparent relative density only is required the operations described in this paragraph may be omitted.

Then place the aggregate in the oven in the shallow tray at a temperature of $105 \pm 5^\circ\text{C}$ and maintain it at this temperature for 24 ± 0.5 h. Then remove it from the oven, cool it in the airtight container, and weigh it (mass *D*). If the relative

density on a saturated and surface-dried basis only is required, the operations described in this paragraph may be omitted.

5.3.4 Calculations

$$\text{Relative density on an oven-dried basis} = \frac{D}{A - (B - C)}$$

$$\text{Relative density on a saturated and surface-dried basis} = \frac{A}{A - (B - C)}$$

$$\text{Apparent relative density} = \frac{D}{D - (B - C)}$$

$$\text{Water absorption (\% of dry mass)} = \frac{100(A - D)}{D}$$

where

A is the mass of the saturated surface-dry aggregate in air (g);

B is the apparent mass in water of the basket containing the sample of saturated aggregate (g);

C is the apparent mass in water of the empty basket (g);

D is the mass of the oven-dried aggregate in air (g).

5.3.5 *Reporting of results.* The mean result shall be reported for each form of relative density determined, the title of which shall be quoted in full. In no circumstances shall the shortened title 'relative density' be used in relation to any values quoted. The size of aggregate tested, and whether it has been artificially heated before the start of the test shall be stated. Values of relative density shall be reported to the nearest 0.01 and those for water absorption to the nearest 0.1 %.

5.4 Method for aggregate between 40 mm and 5 mm

5.4.1 *Apparatus.* The following apparatus is required.

5.4.1.1 *A balance* of capacity not less than 3 kg, accurate to 0.5 g and of such a type as to permit the weighing of the vessel containing the aggregate and water.

5.4.1.2 *A well ventilated oven*, thermostatically controlled to maintain a temperature of $105 \pm 5^\circ\text{C}$.

5.4.1.3 *A wide mouthed glass vessel* such as a gas jar, of 1.0 litres to 1.5 litres capacity, with a flat ground lip and a plane ground disc of plate glass to cover it, giving a watertight fit.

5.4.1.4 *Two dry soft absorbent cloths*, each not less than 750 mm by 450 mm.

5.4.1.5 *A shallow tray* of area not less than 0.03 m².

5.4.1.6 *An airtight container* large enough to take the sample.

5.4.1.7 *A 5.00 mm BS test sieve* (see 7.1.3.1 of Part 1 of this standard).

5.4.1.8 *A supply of water* free from any impurity (e.g. dissolved air) that would significantly affect its density. If distilled or deionized water is not available in sufficient quantity, tap water which

has been freshly boiled and cooled to room temperature may be used. This water shall be used throughout the test.

5.4.2 Sample for test. A sample of about 1 kg of the aggregate shall be used. Aggregates which have been artificially heated shall not normally be used; if such material is used, the fact shall be stated in the report. Two tests shall be made. The sample for test shall be thoroughly washed on the test sieve to remove finer particles, particularly clay, silt and dust, which would otherwise be lost during the test thereby affecting the result, and drained.

5.4.3 Test procedure. Immerse the prepared test sample in water in the glass vessel; it shall remain immersed at a temperature of $20 \pm 5^\circ\text{C}$ for 24 ± 0.5 h. Soon after immersion and again at the end of the soaking period, remove air entrapped in, or bubbles on the surface of, the aggregate by gentle agitation. This may be achieved by rapid clockwise and anti-clockwise rotation of the vessel between the operator's hands.

Overfill the vessel by adding water and slide the plane ground glass disc over the mouth so as to ensure that no air is trapped in the vessel. Then dry the vessel on the outside and weigh it (mass *B*).

Then empty the vessel and allow the aggregate to drain while the vessel is refilled with water, sliding the glass disc into position as before. Then dry the vessel on the outside and weigh it (mass *C*).

The difference in the temperature of the water in the vessel during the first and second weighings shall not exceed 2°C .

Then place the aggregate on a dry cloth and gently surface-dry it with the cloth, transferring it to a second dry cloth when the first will remove no further moisture. Then spread it out not more than one stone deep on the second cloth and leave it exposed to the atmosphere away from direct sunlight or any other source of heat until all visible films of water are removed but the aggregate still has a damp appearance. Then weigh the aggregate (mass *A*). If the apparent relative density only is required the operations described in this paragraph may be omitted.

Then place the aggregate in the shallow tray in the oven at a temperature of $105 \pm 5^\circ\text{C}$ for 24 ± 0.5 h. Then cool it in the airtight container and weigh it (mass *D*). If the relative density on a saturated and surface-dried basis only is required, the operations described in this paragraph may be omitted.

5.4.4 Calculations

$$\text{Relative density on an oven-dried basis} = \frac{D}{A - (B - C)}$$

$$\text{Relative density on a saturated and surface-dried basis} = \frac{A}{A - (B - C)}$$

$$\text{Apparent relative density} = \frac{D}{D - (B - C)}$$

$$\text{Water absorption (\% of dry mass)} = \frac{100(A - D)}{D}$$

where

A is the mass of saturated surface-dry sample in air (g);

B is the mass of vessel containing sample and filled with water (g);

C is the mass of vessel filled with water only (g);

D is the mass of oven-dry sample in air (g).

5.4.5 Reporting of results. The mean result shall be reported for each form of relative density determined, the title of which shall be quoted in full. In no circumstances shall the shortened title 'relative density' be used in relation to any values quoted. The size of aggregate tested, and whether it had been artificially heated before the start of the test shall be stated. The values of relative density shall be reported to the nearest 0.01 and those for water absorption to the nearest 0.1 %.

5.5 Method for aggregate 10 mm nominal size and smaller

5.5.1 Apparatus. The following apparatus is required.

5.5.1.1 A balance of capacity not less than 3 kg, accurate to 0.5 g, and of such a type as to permit the weighing of the vessel containing the aggregate and water.

5.5.1.2 A well ventilated oven, thermostatically controlled to maintain a temperature of $105 \pm 5^\circ\text{C}$.

5.5.1.3 Any form of apparatus capable of holding 0.5 kg to 1.0 kg of material up to 10 mm nominal size and capable of being filled with water to a constant volume with an accuracy of ± 0.5 ml. Both of the following vessels are suitable.

(a) *A glass vessel, referred to later as a pycnometer* of about one litre capacity having a metal conical screw top with an approximately 6 mm diameter hole at its apex. The screw top shall be watertight when it is screwed on to the jar, and, if necessary, a rubber or fibre washer shall be inserted in the joint. If such a washer is used, a mark shall be made on the jar to correspond with a mark on the screw top so that the screw is tightened to the same position every time and the volume contained by the jar is constant throughout the test. A suitable vessel can be made from a 1 kg fruit preserving jar in which the glass lid normally used is replaced by a sheet metal cone as shown in figure 1.

(b) *A wide-mouthed glass vessel such as a gas jar*, of 1.0 litres to 1.5 litres capacity, with a flat ground lip and a plane ground disc of plate glass to cover it, giving a watertight fit.

5.5.1.4 A means of supplying a current of warm air, such as a hairdrier.

5.5.1.5 A watertight tray of area not less than 0.03 m^2 .

5.5.1.6 An airtight container large enough to take the sample.

5.5.1.7 A container of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.

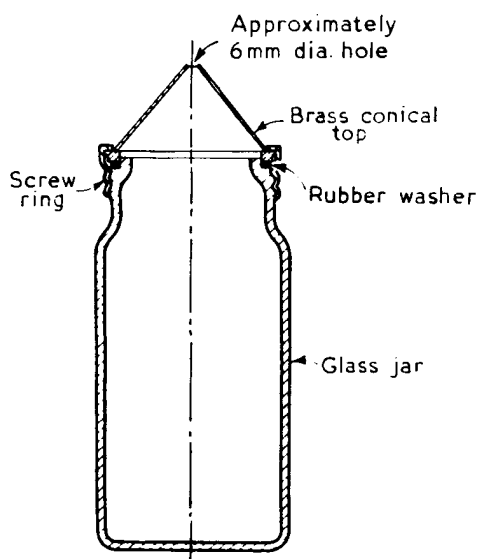


Figure 1. Section of pycnometer made from preserving jar

5.5.1.8 A 75 μm BS test sieve (see 7.1.3.1. of Part 1 of this Standard) and a nesting sieve to protect the 75 μm test sieve, e.g. a 1.18 mm sieve.

5.5.1.9 A supply of water free from any impurity (e.g. dissolved air) that would significantly affect its density. If distilled or deionized water is not available in sufficient quantity, tap water which has been freshly boiled and cooled to room temperature may be used. This water shall be used throughout the test.

5.5.1.10 (optional item) A metal mould in the form of a frustum of a cone 40 mm diameter at the top, 90 mm at the bottom and 75 mm high, the metal to have a minimum thickness of 900 μm .

5.5.1.11 (If item 5.5.1.10 is to be used) A metal tamper weighing 340 ± 15 g and having a flat circular tamping face 25 ± 3 mm in diameter.

5.5.1.12 (optional item) A plain glass funnel.

5.5.2 Sample for test. A sample of about 1 kg for material having a nominal size from 10 mm to 5 mm inclusive, or about 500 g if finer than 5 mm, shall be used. Aggregates which have been artificially heated shall not normally be used. If such material is used, the fact shall be stated in the report. Two tests shall be made.

The sample shall be thoroughly washed to remove all material finer than 75 μm BS test sieve using the following procedure.

Place the test sample in the container and add enough water to cover it. Agitate vigorously the contents of the container and immediately pour the wash water over the sieves, which have previously been wetted on both sides and arranged with the coarser sieve on top.

The agitation shall be sufficiently vigorous to result in the complete separation from the coarse particles of all particles finer than the 75 μm BS test sieve, and to bring the fine material into

suspension in order that it will be removed by decantation of the wash water. Take care to avoid, as far as possible, decantation of the coarse particles of the sample. Repeat the operation until the wash water is clear. Return all material retained on the sieves to the washed sample.

5.5.3 Test procedure. The test procedure shall be as specified in 5.5.3.1 or 5.5.3.2.

5.5.3.1 Using the pycnometer. Transfer the washed aggregate to the tray and add further water to ensure that the sample is completely immersed. Soon after immersion, remove bubbles of entrapped air by gentle agitation with a rod.

Keep the sample immersed in water for 24 ± 0.5 h, the water temperature being maintained at 20 ± 5 °C for at least the last 20 h of immersion.

Then carefully drain the water from the sample by decantation through a 75 μm BS test sieve, covered by the protective coarser sieve, any material retained being returned to the sample.

Then expose the aggregate to a gentle current of warm air to evaporate surface moisture and stir it at frequent intervals to ensure uniform drying until no free surface moisture can be seen and, in the case of aggregate finer than 5 mm, it just attains a 'free-running' condition (see Note 1).

Then weigh the saturated and surface-dry sample (mass *A*).

If the apparent relative density only is required the draining and drying operations described above may be omitted, although for material finer than 5 mm some surface drying may be desirable to facilitate handling.

Then place the aggregate in the pycnometer and fill the pycnometer with water. Screw the cone into place and eliminate any trapped air by rotating the pycnometer on its side, the hole in the apex of the cone being covered with a finger. Top up the pycnometer with water to remove any froth from the surface and so that the surface of the water in the hole is flat. Then dry the pycnometer on the outside and weigh it (mass *B*).

Empty the contents of the pycnometer into the tray, taking care to ensure that all the aggregate is transferred. Refill the pycnometer with water (see note 2) to the same level as before, dry it on the outside and weigh it (mass *C*). The difference in the temperature of the water in the pycnometer during the first and second weighing shall not exceed 2 °C.

Then carefully drain the water from the sample by decantation through a 75 μm BS test sieve and return any material retained to the sample. Then place the sample in the tray, in the oven at a temperature of 105 ± 5 °C for 24 ± 0.5 h, during which period it shall be stirred occasionally to facilitate drying. Then cool it in the airtight container and weigh it (mass *D*). Two tests shall be made. If the relative density on a saturated and surface-dried basis only is required, the operations described in this paragraph may be omitted.