BRITISH STANDARD

BS 1881 : Part 131 : 1998

Incorporating Amendment No. 1

Testing concrete

Part 131. Methods for testing cement in a reference concrete

ICS 91.100.10

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/517, Concrete, to Subcommittee B/517/1, Concrete production and testing, upon which the following bodies were represented:

Association of Lightweight Aggregate Manufacturers
British Cement Association
British Civil Engineering Test Equipment Manufacturers' Association
British Precast Concrete Federation Ltd.
Cement Admixtures Association
Cementitious Slag Makers' Association
Chartered Institution of Water and Environmental Management
Construction Confederation
County Surveyors' Society
Department of the Environment, Transport and the Regions
Department of the Environment, Transport and the Regions (Building Research Establishment)
Federation of Piling Specialists
Institute of Concrete Technology
Institution of Structural Engineers
National House-building Council
Quarry Products Association
Society of Chemical Industry
United Kingdom Quality Ash Association

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 May 1998

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The following BSI references relate to the work on this standard:
Committee reference B/517/1
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Contents

Foreword

This Part of BS 1881 has been prepared by Subcommittee B/517/1. It supersedes BS 4550 : Part 4 : 1978 and BS 4550 : Part 5 : 1978 which are withdrawn. It also supersedes clause **1** of BS 4550 : Section 3.4 : 1978.

The transfer of this test to BS 1881 allows its continued use in assessing the strength produced by a cement in a specified concrete. A procedure for mixing concrete based on that used in BS 1881 : Part 125 has been introduced as the reference procedure for mixing in this Part of BS 1881. The procedure described in BS 4550 : Section 3.4 has been retained in this standard as an alternative procedure to allow comparison with previous tests (see annex C).

It has become common practice to measure the slump of the concrete produced for this test to assess the effect of the cement on consistence. A procedure has been added to this standard (see **9.1**).

It has been shown that deviations from the specified raw materials, mixer, mixing procedure and curing conditions affect the slump result. As it may not always be possible to use the apparatus and materials specified in this British Standard, substitution of other apparatus and materials is permitted, but any such deviation should be reported detailing, where possible, the effect of the deviation.

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

Summary of pages

This document contains a front cover, an inside front cover, pages i and ii, pages 1 to 10, an inside back cover and a back cover.

Method

1 Scope

This British Standard gives methods for testing cement in a reference concrete. It includes provisions for the laboratory conditions, the mixer, materials and mix proportions together with the procedures for mixing and testing the concrete.

2 References

2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the publications apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this standard the definitions given in BS 1881 : Part 102, Part 108, Part 111, Part 114, Part 115, Part 116 and Part 125 apply.

4 Principle

A concrete is made with the cement to be tested, using specified constituent materials in specified proportions and mixed by machine. The consistence of the concrete is determined by its slump and its strength is measured by compressive strength tests on 100 mm concrete cubes.

5 Apparatus and materials

5.1 *Cube moulds*, of 100 mm size conforming to BS 1881 : Part 108.

5.2 *Concrete mixer*, comprising a rotating mixer pan with a contra-rotating mixing paddle and a scraper blade. The dimensions and tolerances shall be as shown in figure 1.

The mixing pan shall rotate at (18 $\pm$ 1) r/min. The mixing paddle (offset from the pan centre) shall rotate at (90 $\pm$ 5) r/min.

The mixing paddle and scraper blade shall be spring loaded to ensure they do not jam during mixing. Simple and positive means of vertical adjustment shall be provided on the mountings of the mixing paddle and scraper blade.

The mixer shall either be fitted with an automatic timing device or a stop clock shall be provided.

5.3 *Slump cone*, conforming to BS 1881 : Part 102.

5.4 *Slump rod*, conforming to BS 1881 : Part 102.

5.5 *Slump baseplate*, conforming to BS 1881 : Part 102.

5.6 *Slump scoop*, conforming to BS 1881 : Part 102.

5.7 *Trowel*, having a cast steel blade.

NOTE. A suitable type is shown in figure 2.

5.8 *Compacting equipment*, either a compacting bar, a vibrating hammer or a vibrating table in accordance with **3.3** of BS 1881 : Part 108 : 1983.

5.9 *Curing tank*, conforming to BS 1881 : Part 111.

NOTE. Specimens made with high alumina or super sulfated cements should not be placed in the same tank as specimens made with Portland cements.

5.10 *Balance*, capable of weighing to the nearest 1 g.

5.11 *Compression testing machine*, of suitable capacity for the test conforming to BS 1881 : Part 115.

NOTE. The lower limit of verification for the scale range used should be below the expected maximum load on any specimen tested on the scale range.

5.12 *Coarse aggregate*, conforming to the requirements of annex A.

5.13 *Sand*, conforming to the requirements of annex B.

5.14 *Water*, deionized or distilled.

6 Proportioning

The masses of the individual materials for batches of sufficient volume to produce three, six, nine or 12 cubes are given in table 1.

Table 1. Batch masses					
Constituent material	**Proportion by mass**	**Mass** g			
		Mix 1	**Mix 2**	**Mix 3**	**Mix 4**
		3 cubes	**6 cubes and/or 1 slump**	**9 cubes and/or 3 cubes and 1 slump**	**12 cubes and/or 6 cubes and 1 slump**
Cement	1.0	1100 ± 5	2200 ± 5	3200 ± 5	4200 ± 5
Sand	2.5				
A (2.36 mm to 1.18 mm)		275 ± 5	550 ± 5	800 ± 5	1050 ± 5
B (1.18 mm to 600 μm)		550 ± 5	1100 ± 5	1600 ± 5	2100 ± 5
C (600 μm to 300 μm)		825 ± 5	1650 ± 5	2400 ± 5	3150 ± 5
D (300 μm to 150 μm)		690 ± 5	1375 ± 5	2000 ± 5	2625 ± 5
E (150 μm to 90 μm)		410 ± 5	825 ± 5	1200 ± 5	1575 ± 5
Coarse aggregate	3.5	3850 ± 10	7700 ± 10	11200 ± 10	14700 ± 10
Water	0.60	660 ± 5	1320 ± 5	1920 ± 5	2520 ± 5

7 Temperature and humidity conditions

Before use, all materials and apparatus shall be brought to the same temperature as the air in the mixing room, by storing them in the room for a sufficient time.

The temperature throughout the entire test procedure shall be controlled about a mid-point of 20 °C with permitted variation as shown in table 2. The minimum relative humidity shall be as given in table 2.

Table 2. Temperature and humidity conditions		
Situation	**Permitted temperature variation** °C	**Minimum relative humidity** %
Mixing room	±2	50
Moist curing chamber	±2	90
Water curing tank	±2	—
Compression testing room	±2	50

NOTE 1. A record should be kept for reference purposes of the actual temperature and relative humidity conditions.

NOTE 2. The high humidity required in moist air curing rooms is normally produced by spraying water as a fine aerosol. The bacterium *Legionella pneumophila* is widespread in nature and is present in water systems of many buildings. Scale in pipework and chemical nutrients in the water supply may encourage growth of this organism which multiplies at temperatures above 20 °C. Inhaling infected aerosols is a known route for transmission of legionellosis. It is therefore advisable to maintain cold water supplies below 20 °C where possible and to store hot water above 60 °C. Cold water supplies may be disinfected by chlorination to a least 5 mg/l free chlorine. Regular periodic checking for the presence of *Legionella* species in industrial water supplies is a sensible precaution.

8 Procedure for mixing

NOTE. The procedure in this clause is based on that given in BS 1881 : Part 125. An alternative based on the procedure in BS 4550 : Section 3.4 is given in annex C. This alternative method is retained to allow comparison with historical records.

Add in order, about half the coarse aggregate, the sand and the remaining coarse aggregate by spreading them evenly in the pan. Start the mixer and run it for about 15 s. Continue mixing and add about half the water during the next 15 s. After mixing for a total of (120 ± 5) s, stop the mixer and leave the contents covered for (300 ± 10) s.

Record the time of commencement and add the cement by spreading it in an even layer over the aggregate. Start the mixer and mix for about 30 s. Stop the mixer and immediately clean off any material adhering to the mixer blades into the pan. Without delay, recommence mixing and slowly add the remaining mixing water within the next 30 s. Continue mixing after all materials have been added for a further (120 ± 5) s.

After completion of mixing, leave the contents of the mixer covered for (300 ± 10) s then remix for (30 ± 5) s. Transfer the whole of the batch onto the sampling tray. Ensure that no more than a light covering of slurry is left adhering to the mixer. Turn the concrete over a few times with the trowel to remove any slight segregation.

9 Testing the concrete

9.1 Consistence

The consistence shall be determined by carrying out a slump test in accordance with BS 1881 : Part 102. Testing shall be completed within 5 min of completion of remixing.

9.2 Strength

9.2.1 *Batches*

Make batches of three, six, nine or 12 cubes.

NOTE. For factory production control only, batches of three cubes may be made, one or two for testing at any of the specified ages.

9.2.2 *Filling the moulds*

Place the moulds on a rigid horizontal surface or on the vibrating table and approximately half fill with concrete, by means of the scoop, then compact. Repeat the operation to fill the moulds.

9.2.3 *Compacting*

The specimens shall be compacted either by compacting bar or by vibrator.

a) Using the compacting bar

Compact each layer with 35 strokes of the compacting bar. When compacting each layer, distribute the strokes of the compacting bar in a uniform manner over the cross-section of the mould, and ensure that the compacting bar does not forcibly strike the bottom of the mould when compacting the first layer nor penetrate significantly the first layer when compacting the second layer.

b) Using the vibrator

When compacting each layer by means of the vibrating hammer or vibrating table, use applied vibration of the minimum duration necessary to achieve full compaction of the concrete. Cease vibration as soon as the surface of the concrete becomes relatively smooth and has a glazed appearance. Record the duration of vibration.

9.2.4 *Finishing*

After the top layer has been compacted, smooth it level with the top of the mould using the trowel, and wipe clean the outside of the mould. Complete the entire process within 15 min from the completion of mixing.

9.2.5 *Storage of cubes*

9.2.5.1 *General requirements*

Immediately after preparation, place the moulds in a single layer on a level surface in the moist curing chamber. Cover the exposed tops of the cubes with an impervious sheet (e.g. of clean thin rubber or plastics, or lightly oiled steel) making contact with the upper edge of the mould. After (24 ± 0.5) h mark the cubes for later identification and remove them from the moulds. Immediately submerge all the cubes in water, except those to be tested at one day, in the curing tank and arrange them in such a way that the temperature variation specified in table 2 is not exceeded. Leave the cubes in the curing tank until just prior to the testing.

NOTE. If the concrete has not achieved sufficient strength to be handled without fear of damage after 24 h, delay the demoulding for a further period of 24 h but state this fact in the test report.

9.2.5.2 *Special requirements for testing at one day*

Mark and demould cubes to be tested at one day (15 to 20) min before testing and cover with a damp cloth so that they remain in the moist condition until tested.

9.2.6 *Testing for strength*

9.2.6.1 The age of each test is calculated from the time of adding the cement to the other materials. Test three cubes at an age selected from table 3 within the limits given.

Table 3. Ages for strength tests

Age days	**Limit** h
1	24 ± 0.5
3	72 ± 1
7	168 ± 2
28	672 ± 4

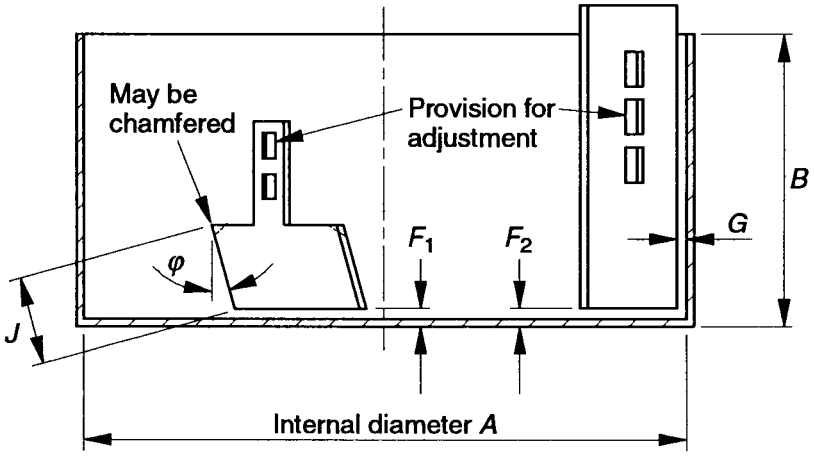
9.2.6.2 Determine the compressive strength of the cubes in accordance with BS 1881 : Part 116.

9.2.6.3 Calculate the average of the individual results of the set of three cubes tested at the same age, and express the result to the nearest 0.5 N/mm^2. If one result within the set varies by more than ± 5 % from the average of the set, discard the result and recalculate the average of the remaining two results. If more than one result varies by more than ± 5 % from the average, discard the set of results.

10 Report

The report shall state the slump measured (if tested), the individual compressive strength test results and the average compressive strength to the nearest 0.5 N/mm^2, indicating if any result has been discarded. Any deviations from the method shall be stated.

NOTE. If required, the density of each cube may be determined in accordance with BS 1881 : Part 114 before testing for compressive strength.



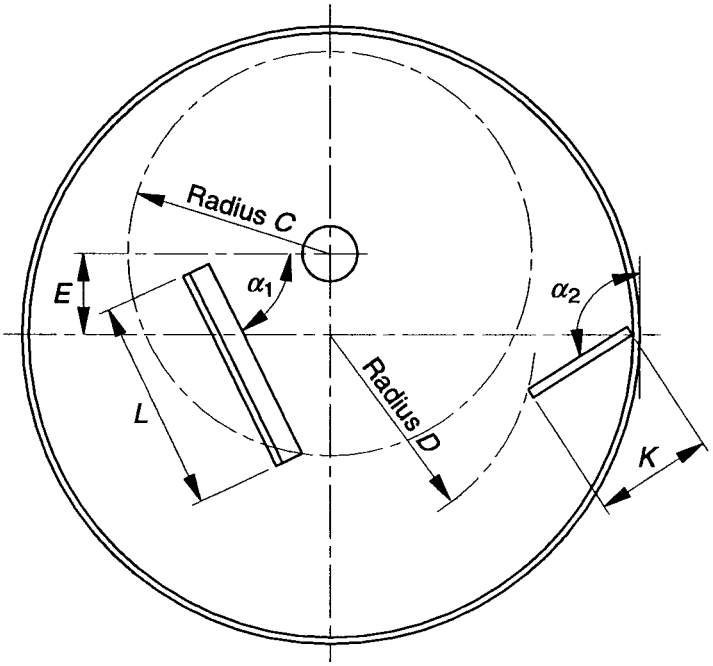
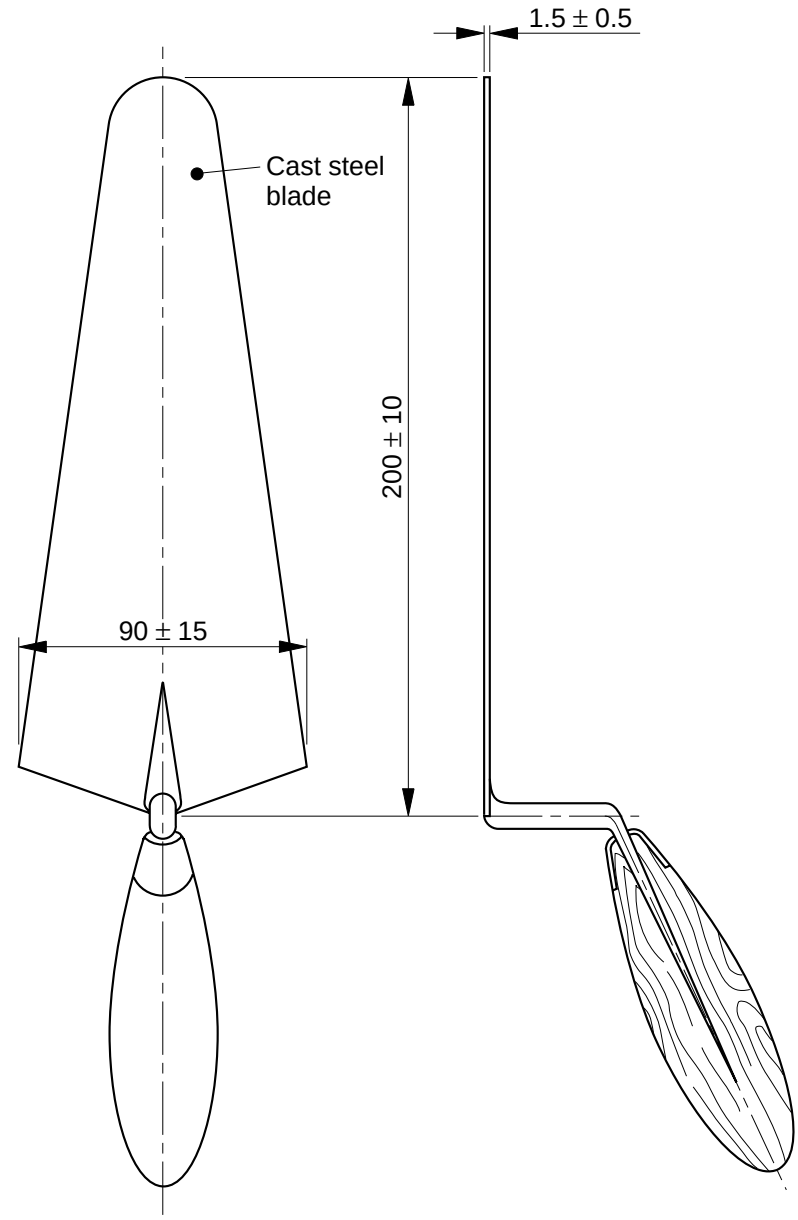


Table 4. Dimensions

A mm	*B*[1)] mm	*C* mm	*D* mm	*E* mm	F_1 mm	F_2 mm	*G* mm	*J* mm	*K* mm	*L* mm	α_1 °	α_2 °	φ °
450	220	150	155	60	5 ± 5	2 ± 2	2 ± 2	65	95	165	65	120	15

[1)] 260 required for 12 cube batches.
NOTE. Where tolerances are not given, sizes indicated are for guidance only and are not critical.

Figure 1. Typical rotating pan concrete mixer



All dimensions are in millimetres

Figure 2. Suitable trowel

Annex A (normative)
Coarse aggregate

A.1 General

The coarse aggregate shall consist of clean, dry crushed granite, substantially free from dust in one fraction 10 mm to 5 mm nominal size.

NOTE 1. This coarse aggregate is designated as 'Coarse aggregate. Material required for cement testing in compliance with BS 1881 : Part 131'.

NOTE 2. For information on the availability of coarse aggregates contact the BSI Information Centre, BSI, 389 Chiswick High Road, London W4 4AL.

A.2 Sampling

For the purpose of checking conformity to the grading requirement in **A.3**, a sample shall be obtained using the method of sampling specified in BS 812 : Part 102. A main sample of about 30 kg shall be taken from a consignment and shall be reduced to approximately 500 g by a total of six passes through a sample divider.

A.3 Grading

The grading of a sample, obtained as in **A.2**, shall be within the limits specified in table 1 when determined by the normal test procedure for sieve analysis as specified in BS 812 : Part 103 using square hole perforated plate test sieves of nominal aperture size of 10.0 mm and 5.00 mm conforming to the requirements of BS 410.

Table A.1 Coarse aggregate grading

Test sieve as specified in BS 410	Percentage by mass passing sieve
10.0 mm	90 to 100
5.00 mm	0 to 10
2.36 mm	0 to 1
75 μm	0 to 0.5

Annex B (normative)
Sand

B.1 General

The sand shall consist of natural (un-crushed) silica sand in five fractions obtained by extracting them from sands conforming to this standard derived from suitable sources.

NOTE. For information on the availability of sand contact the BSI Information Centre, BSI, 389 Chiswick High Road, London W4 4AL.

B.2 Sampling

Using a suitable scoop or similar device, take a main sample of about 8 kg from a single bag selected at random from each of the fractions of sand comprising a delivery not exceeding 500 kg of each fraction. For either of the tests specified in **B.3** and **B.4** reduce the main sample of each fraction to about 250 g by five passes through a sample divider. For the purpose of the test specified in **B.5**, split the main sample of each fraction into eight 1 kg samples by three passes through a sample divider. Pass six of these samples through a sample divider to produce six pairs of nominally identical sub-samples of about 500 g of each of the five fractions. Use the remaining two 1 kg samples for the tests specified in **B.3** and **B.4**.

B.3 Moisture content

The moisture content of the sample of each sand fraction obtained as specified in **B.4** shall not exceed 0.1 % by dry mass when tested by the (oven drying) method specified in BS 812 : Part 109.

B.4 Grading

The grading of the sample of each sand fraction weighing not less than 200 g, obtained as specified in **B.2**, shall be within the limits given in figure B.1 when determined by the normal test procedure for sieve analysis specified in BS 812 : Part 103, using the appropriate woven wire test sieves conforming to the full tolerances of BS 410.

B.5 Test for air-entraining characteristics

B.5.1 *Test principle*

The sand shall show limited air-entrainment propensity when tested using the materials, apparatus and procedure specified in **B.5.2** to **B.5.6**. The test compares the air content, calculated from determined densities, of fresh mortar mixes without and with the addition of an air-detraining agent. The difference between the air content of a fresh mortar mix using the sand as received and that of a similar mortar mix containing an air detraining agent is evaluated from a pair of mortar mixes prepared and tested as closely together as possible under the same conditions. The average difference in air content obtained from six such pairs of mortar mixes shall not exceed 1.5 %.

B.5.2 *Apparatus and materials*

B.5.2.1 *Mixer*, conforming to **4.4** of BS EN 196-1 : 1995.

B.5.2.2 *Scraper*, flexible, of rubber or plastics material, suitable for removing mortar adhering to the mixer blade and to the inside surfaces of the mixing bowl.

B.5.2.3 *Balance*, of sufficient capacity and an accuracy of ± 0.1 g.

B.5.2.4 *Container*, rigid, thick walled, cylindrical brass container, of about 0.5 l capacity, with an internal diameter of about 75 mm. The internal surfaces shall be smooth.

NOTE. The joint between the bottom and the walls should have a slight radius.

B.5.2.5 *Glass plate*, of sufficient size to cover the container.

B.5.2.6 *Tamper*, cylindrical, (37.5 ± 0.5) mm in diameter weighing approximately 250 g and composed of nylon or similar hard plastics.

The tamping face shall be flat and at right angles to the length of the tamper.

B.5.2.7 *Straight-edge*, suitable length of metal to strike off the surface of the mortar in the container.

B.5.2.8 *Reference Portland cement*, conforming to BS 12 Class 42.5 N, that has been specially selected for the purpose of checking the air-entraining characteristics of sand.

NOTE. It can be obtained from the UK Portland cement manufacturer who will supply data on its conformity to the requirements of BS 12. It should be identified as BS 1881 : Part 131 Reference Portland cement, and be stored in a sealed container.

B.5.2.9 *Sand*, sampled in accordance with **B.2**.

B.5.2.10 *Water*, distilled or deionized.

B.5.2.11 *Air-detraining agent*, laboratory reagent grade tri-*n*-butyl orthophosphate.

B.5.3 *Calibration of container*

Weigh the brass container and the glass plate cover in a clean and dry condition to the nearest ± 0.1 g. Fill the container with freshly cooled boiled distilled water at the mixing room temperature. Slide the glass plate cover over the top of the container, making certain that no air bubbles are trapped under the glass plate. Wipe dry the exposed surfaces of the container and the glass plate, and weigh to the nearest ± 0.1 g. Make two additional weighings of the container filled with water by removing the glass plate and topping up the container with more distilled water and proceeding as before. Calculate the average mass of water in the full container, and determine the capacity of the container, *V*, to the nearest 0.1 ml, taking the density of water as 1.0 t/m^3.

B.5.4 *Composition of mortar*

The amounts of the individual materials for each mortar mix are given in table B.1. When necessary 1.0 ml of the air detraining agent is added.

Table B.1 Composition of mortar

Material	Proportions by mass	Mass g
Reference Portland cement	1.0	450 ± 1
Sand fraction		
A (2.36 mm to 1.18 mm)		350 ± 1
B (1.18 mm to 600 μm)		500 ± 1
C (600 μm to 300 μm)	3.0	200 ± 1
D (300 μm to 150 μm)		200 ± 1
E (150 μm to 90 μm)		100 ± 1
Total		1350
Distilled water	0.5	225 ± 1

B.5.5 *Temperature and relative humidity*

For the preparation of each mortar mix, the mixing room, apparatus and all the materials shall be at a temperature of (20 ± 2) °C. The relative humidity of the air in the mixing room shall be not less than 50 %.

B.5.6 *Procedure*

B.5.6.1 *General*

Prepare six pairs of mortar samples in accordance with **B.5.6.2** and **B.5.6.3**.

B.5.6.2 *Preparation of mortar using sand as received*

NOTE. Ensure the timing of the various mixing stages is within ± 1 s.

Pour 225 g of water into the dry mixing bowl and add the cement.

Immediately start the mixer (see **B.5.2.1**) at the lower speed and after 30 s add the sand steadily over a period of 30 s. Switch the mixer to the higher speed and continue the mixing for an additional 30 s.

Stop the mixer for 90 s. During the first 15 s, remove by means of the scraper all the mortar adhering to the wall and bottom part of the bowl and place in the middle of the bowl. Cover the bowl during the remaining 75 s.

Continue the mixing at the higher speed for 60 s. Immediately afterwards, test the mortar in accordance with **B.5.6.4**.

B.5.6.3 *Preparation of mortar with addition of air-detraining agent*

Prepare and test this mortar mix immediately after completion of the preparation and testing of the mortar mix using the sand as received (see **B.5.6.2**). Follow the procedure specified in **B.5.6.1**, except that 1.0 ml of the air-detraining agent is added from a burette, syringe or suitable pipette directly to the water in the mixing bowl before the cement is added. Ensure all apparatus coming into contact with this mortar is thoroughly washed and cleaned after use.

B.5.6.4 *Determination of density of fresh mortar*

Weigh the clean and dry container to the nearest $\pm$ 0.1 g. Immediately after completion of mixing of the mortar in accordance with **B.5.6.2** or **B.5.6.3**, fill the container with mortar in four layers each about 25 mm deep. After the addition of the first increment, gently tamp the surface 20 times with the tamper. Distribute the strokes evenly, over the surface only, to give an essentially flat surface. Then place further layers and tamp each in turn in the same way. Adjust the final layer so that the excess to be struck off is small. With the straight-edge held almost vertical, strike off the surface plane and level with the top of the container with a sawing action, making one pass in each of two directions at right angles. Clean and dry the outside of the filled container (see **B.5.2.4**) and determine the mass of the fresh mortar, m, to the nearest $\pm$ 0.1 g.

B.6 Calculation and expression of results

B.6.1 Calculate the air content A, to the nearest 0.1 %, of each sample of mortar using the following equation:

$$A = 100 - 0.04336\,\frac{m}{V}$$ [1)]

B.6.2 Calculate the average difference in air content between the samples without, and the samples with, air detraining agent.

B.6.3 The sand shall be deemed to conform to the specified requirements if the difference in air content does not exceed 1.5 %.

B.7 Marking

Each of the prepared sand fractions processed in accordance with this British Standard shall be supplied in suitable containers marked with the following details:

a) the name, trade mark or other means of identification of the processor;

b) the designation of the sand fraction;

c) the number of this British Standard i.e. BS 1881 : Part 131.

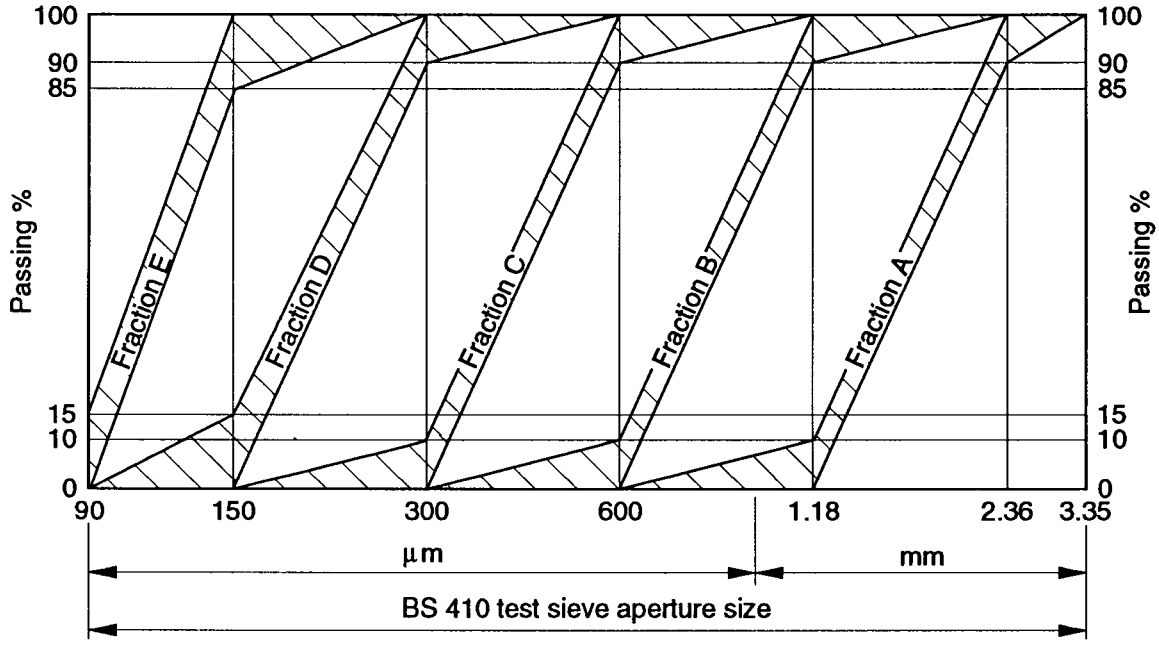


Figure B.1 Grading of sand fractions for concrete cubes

[1)] The factor 0.04336 is based on a density of 3130 kg/m^3 for the cement and 2650 kg/m^3 for the sand.

Annex C (informative)
Alternative mixing

C.1 Place the weighed materials in the mixer pan in the following order: sand, cement, coarse aggregate.

Have the mixing water ready and start the mixer. After 15 s add the water uniformly during the next 15 s; then continue mixing for a total time of (180 ± 5) s. Stop the machine and turn the concrete over in the pan a few times with a trowel to remove any slight segregation. If this is not possible, transfer the concrete to another suitable vessel and turn it over similarly therein.

C.2 If cubes are to be made from the concrete used for the determination of the slump, return the concrete to the mixer bowl after the slump test and remix for 15 s.

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 12 : 1996	*Specification for Portland cement*
BS 410 : 1986	*Specification for test sieves*
BS 812 :	*Testing aggregates*
BS 812 : Part 102 : 1989	*Methods for sampling*
BS 812 : Part 103	*Method for determination of particle size distribution*
BS 812 : Part 109 : 1990	*Methods for determination of moisture content*
BS 1881 :	*Testing concrete*
BS 1881 : Part 102 : 1983	*Method for determination of slump*
BS 1881 : Part 108 : 1983	*Method for making test cubes from fresh concrete*
BS 1881 : Part 111 : 1983	*Method of normal curing of test specimens (20 °C method)*
BS 1881 : Part 114 : 1983	*Methods for determination of density of hardened concrete*
BS 1881 : Part 115 : 1986	*Specification for compression testing machines for concrete*
BS 1881 : Part 116 : 1983	*Method for determination of compression strength of concrete cubes*
BS 1881 : Part 125 : 1986	*Methods for mixing and sampling fresh concrete in the laboratory*
BS EN 196 :	*Methods of testing cement*
BS EN 196-1 : 1995	*Determination of strength*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 4550 :	*Methods of tesing cement*
BS 4550 : Section 3.4 : 1978	*Strength tests*

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