BRITISH STANDARD

BS 1881 :
Part 128 : 1997

Testing concrete —

Part 128. Methods for analysis of fresh concrete

ICS 91.100.30

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 Aggregate Construction Materials Industries
British Cement Association
British Civil Engineering Test Equipment Manufacturers' Association
British Precast Concrete Federation Ltd
Building Employer's Confederation
Cement Admixtures Association
Cementitious Slag Makers' Association
Chartered Institution of Water and Environmental Management
County Surveyors' Society
Department of the Environment
Department of the Environment (Building Research Establishment)
Federation of Piling Specialists
Institute of Concrete Technology
Institution of Structural Engineers
National House-building Council
Quality Ash Association
Sand and Gravel Association Limited
Society of Chemical Industry

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Contents

Foreword

This Part of BS 1881 has been prepared under the direction of Subcommittee B/517/1, Concrete production and testing. It supersedes DD 83 : 1983, which is withdrawn. Three of the five different methods for analysis of fresh concrete described in DD 83 : 1983 which are in common use have been retained in this standard.

All determine the total cement content, but in only two methods can further tests be made to determine the proportions of pulverized-fuel ash (pfa) or ground granulated blastfurnace slag (ggbs) in blended cements. Water content may be obtained by calculation, or more directly on separate samples, by drying them in a microwave oven.

If the results are used to provide a water/cement ratio, it should be realized that the tolerance on accuracy will depend on the combination of the precision data for each test for cement and water contents.

Each test relies for accuracy on calibration using the materials in the concrete mix. The tests are not intended to be used for checks on random samples of concretes with unknown constituents. Although the tests refer to British Standards for sieve sizes, they will still be applicable when European Standards are adopted, however, the size limit between coarse and fine aggregate will change.

Fine aggregate is commonly known as sand in the UK and this term will be used throughout the text of this standard.

Changes to other European Standards for cements are unlikely to affect the tests.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 26, an inside back cover and a back cover.

Method

1 Scope

This Part of BS 1881 describes the sampling procedures, treatment of samples and test methods to be used on a sample of fresh concrete to determine the cement content, the aggregate content and the water content.

All the procedures described apply to concretes made with Portland cements. Some of the methods can also be used to determine the proportions of pulverized-fuel ash (pfa) and ground granulated blastfurnace slag (ggbs).

2 References

2.1 Normative references

This Part of BS 1881 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to, or revisions of the cited publications apply to this Part of BS 1881 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 Part of BS 1881 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 Part of BS 1881 the definitions in BS 6100 : Sections **6.2** and **6.3** apply, together with the following:

3.1 coarse aggregate

Aggregate retained on a 5 mm test sieve.

3.2 sand

Aggregate passing a 5 mm test sieve.

3.3 batch

Quantity of concrete mixed in one cycle of operations of a batch mixer, or the quantity discharged during 1 min from a continuous mixer, or where this is the greater volume, the quantity conveyed in a truck mixer.

3.4 concrete sample

Sample of concrete of mass sufficient to allow test samples to be extracted.

3.5 test sample

Portion of the concrete sample that is tested.

4 Sampling

4.1 General

For the test results to be valid, it is important that the procedure by which the initial concrete sample is taken from the concrete is as given in this standard. Any deviations from such procedure shall be reported.

4.2 Apparatus

4.2.1 *Scoop*, of galvanized steel or other suitable non-corrodible material, that when filled will contain about 2.5 kg of concrete.

4.2.2 *Sample containers*, made of non-corrodible metal or plastics of appropriate size, to contain the mass of concrete given in table 1.

4.3 Procedure

Using the method described in BS 1881 : Part 101, take the required number of scoopfuls of concrete necessary to provide concrete samples of appropriate mass shown in table 1 and transfer them to clean, dry containers (**4.2.2**).

Table 1. Concrete sample and test sample masses

Method of analysis	**Mass of test samples** kg
Buoyancy	4 ± 0.5
Constant volume (RAM)	8 ± 1
Pressure filter (Sandberg)	3 ± 0.5
Water content	2.5 ± 0.5

4.4 Certificate of sampling

Each sample shall be accompanied by a certificate of sampling, signed by the person responsible for the sampling, confirming that the sample was taken in accordance with the requirements of BS 1881 : Part 101.

5 Methods of analysis

5.1 General

Each of the three methods of analysis described in this British Standard have been used under site conditions for more than ten years and the test results have been found to be of value in the determination of the composition of fresh concrete.

Each test relies for accuracy on a calibration using the same materials as those in the concrete mix. In order to minimize the risk of an incorrect result due to operator error or apparatus malfunction, all tests shall be carried out twice. Calibrations shall be performed for each combination of constituent materials used and whenever significant changes to the materials occur, in particular the content of material finer than 150 μm.

The flow chart in figure 1 provides guidance on the appropriate method of analysis to be used for the determination of the cement, aggregate and water content.

5.2 Applicability

The methods of analysis described in this British Standard may not be of equal suitability or accuracy over the whole range of concretes that may be encountered in practice. Other factors, such as the number of tests to be carried out within a given time, ease of operation and cost, will also influence the choice of the most appropriate method of analysis for a given job.

5.3 Buoyancy method

In this method, described in annex A, the cement and water contents are determined by difference. The standard procedure does not provide a sample of material passing 150 µm for more detailed analysis.

A 4 kg concrete sample is weighed in air and water and then washed over a nest of sieves to separate the cement and aggregate passing a 150 µm test sieve. The washed aggregate is weighed in water and the proportions of cement, coarse aggregate and sand calculated on the basis of pre-determined values of particle densities.

5.4 Constant volume (RAM) method

In this method, described in annex B, the cement content is determined directly. It is recommended that the water content is determined on a separate sample. The quantity of coarse aggregate is obtained by direct weighing and there is a procedure for determining the sand content.

The operation of the Rapid Analysis Machine (RAM) is controlled automatically by an electronic sequence timer after loading with the test sample. At the end of the timed sequence (6 min) the constant volume vessel is removed from the machine and the cement content of the sample determined from a calibration graph.

5.5 Pressure filter (Sandberg) method

In this method, described in annex C, allowances are made for the aggregate passing 150 µm mixed with the cement and the solubility of the cement. The aggregate is collected from the sieves, dried and weighed. The water content can be determined on a separate sample and the particles passing 150 µm are available for more detailed analysis.

A 3 kg concrete sample is weighed, agitated with water and then washed over a nest of sieves to separate the cement and aggregate passing a 150 µm sieve. The washings are filtered through a filter paper using a pressure filter and then the solids are dried and weighed.

6 Determination of cement content

6.1 General

The analyses are primarily to determine the whole cement content. Further analyses can then be made to determine cement composition as applicable.

6.2 Applicability

The methods of analysis described in this standard use particle size to distinguish cement from aggregate. They give procedures to correct for aggregate particles passing a 125 µm sieve based on the analysis of the raw materials. Provided samples of raw materials are available, the methods are suitable for use on all concretes.

6.3 Procedure

Determine the total content of cement by the method described in annex A, annex B or annex C.

6.4 Pfa content

Determine the pfa content of the mix by the particle density method described in annex D.

NOTE. The measured pfa content will include any incorporated in the cement as a minor additional material

6.5 Ggbs content

Determine the ggbs content of the mix by the chemical method described in annex E.

NOTE 1. Other methods can be used by agreement between the purchaser and supplier of the concrete.

NOTE 2. The measured ggbs content will include any incorporated in the cement as a minor additional material.

7 Determination of water content

7.1 General

The determination of the water/cement ratio of concrete is normally based on the free water content of the concrete at the time of mixing, where the free water content equals the total water content less the water absorption of the fine and coarse aggregates.

BS 812 : Part 109 describes three methods for the determination of the moisture content of aggregates which can be used, with minor modifications, to determine the total water content of fresh concrete:

a) oven-drying method, see annex F;
b) high temperature method, see annex G;
c) microwave oven method, see annex H.

Table 2. Applicability of test methods

Method of analysis	Cement content	Aggregate content	Water content	Recovery of fraction finer than 150 µm
Buoyancy	Yes	Yes	1)	No
Constant volume (RAM)	Yes	Yes	1)	Yes
Pressure filter (Sandberg)	Yes	Yes	1)	Yes
Water content	No	No	Yes	No

1) Water content can be calculated by difference, but the accuracy of the result will reflect any errors in the determination of the cement and aggregate contents.

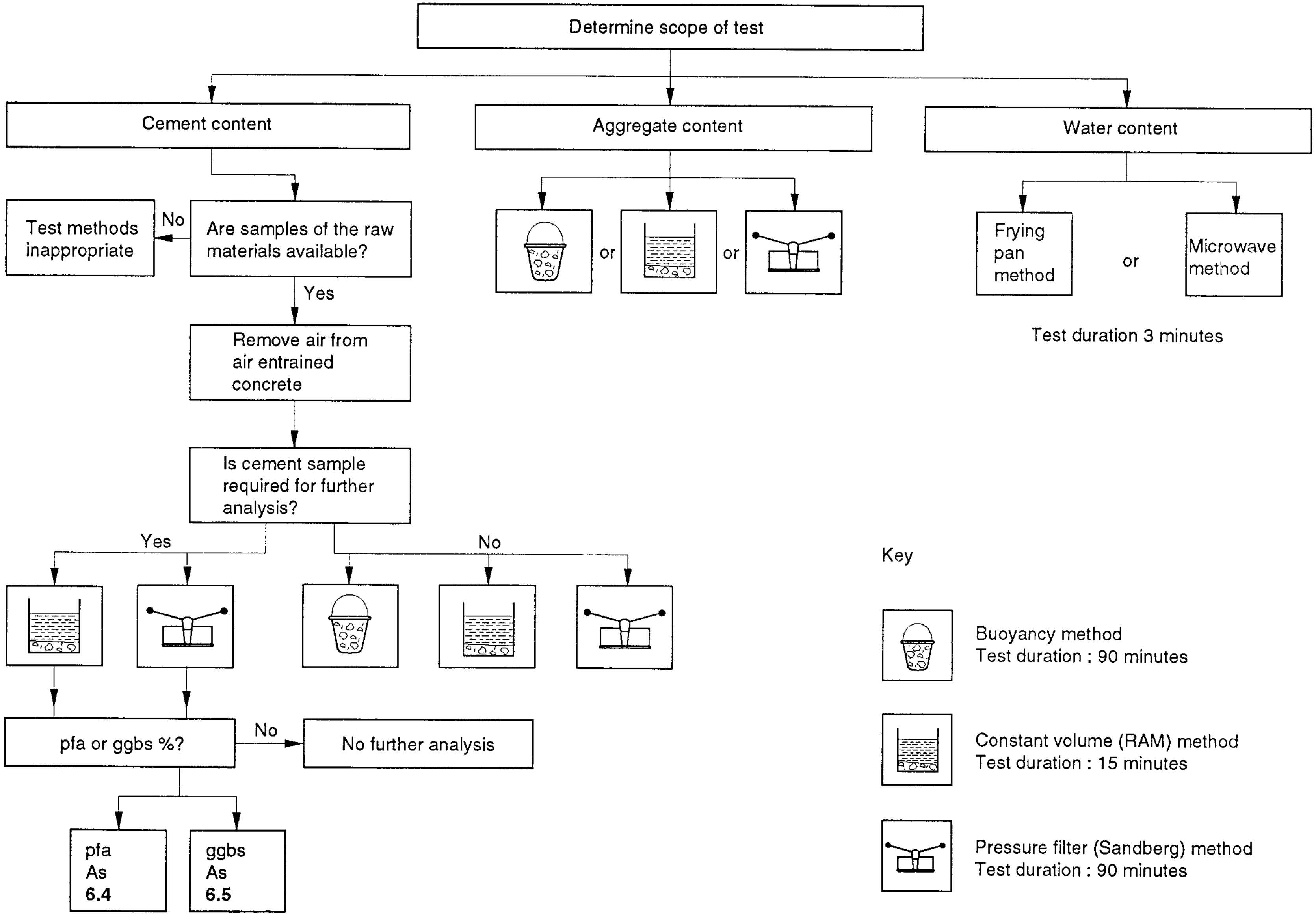


Figure 1. Flowchart for analysis of fresh concrete

8 Determination of aggregate content

8.1 General

All of the test methods outlined in clause **5** separate the total aggregate content into coarse, fine and passing 150 μm fractions which can be recovered and analysed in accordance with BS 812 : Section 103.1. The procedure for recovering the aggregate is specific to each test method.

8.2 Buoyancy method

Recover the total aggregate content of the concrete test sample retained on the 5 mm and 150 μm sieves for grading after weighing in water. Determine the mass of the particles passing the 150 μm sieve from the grading correction factor.

8.3 Constant volume (RAM) method

Recover the sand retained on the sieve and determine its grading. From these values calculate the total mass of sand carried away in the slurry using the RAM sampling factor. Recover the aggregate from the elutriation column of the RAM and sieve to obtain a sample grading. Determine the mass of material passing the 150 μm sieve using the fines correction factor.

8.4 Pressure filter (Sandberg) method

Collect the aggregates from the sieves and determine the mass of the material passing the 150 μm sieve to obtain the fines content.

9 Other constituents

9.1 General

The fresh concrete sample obtained as described in clause **4** may also be used for the determination of chloride, sulfate and alkali contents but details of these chemical analysis methods are outside the present scope of this standard.

9.2 Entrained air

When air-entrained concrete is being analysed, the density and air content of the batch shall be determined.

The amount of air entrained by admixtures other than air-entraining admixtures is normally insignificant (0.5 % to 1.0 %). In cases of doubt, the concrete should be treated as being air-entrained.

NOTE. When calculating the mass of each constituent in a sample in kilograms per cubic metre (kg/m^3), use the density determined on the air-entrained concrete.

10 Report

10.1 General

The report shall affirm that the analysis was made in accordance with this Part of BS 1881. If alternative procedures are used, these should be described with the reason for their use.

A copy of the certificate of sampling shall be provided with the report.

The following information shall be included in the report:

a) method of analysis used;

b) method of determining water content;

c) density of fresh concrete used in calculation of results as determined by BS 1881 : Part 107;

d) the determined contents of constituents, in kg/m^3;

e) date and time of sampling to provide materials for the calibration tests;

f) date and time of last calibration tests for the test method used;

g) the assessment of the accuracy of the test, in accordance with annex J.

Annex A (normative)

Buoyancy method

A.1 Test principle

A.1.1 *General*

A test sample, obtained in accordance with clause **4**, is weighed in air and in water and then washed over a nest of sieves to separate the material passing a 150 µm test sieve from the aggregate. The washed aggregate is weighed in water and the proportions of cement, coarse aggregate, sand and water are then calculated. The addition of a chemical substance to disperse air is used when air-entrained concrete is to be analysed.

A.1.2 *Samples of raw materials required*

Samples of coarse aggregates and sand, typical of those used in the concrete to be analysed, are required for the determination of the proportion of the aggregate that passes a 150 µm test sieve, and for the determination of their particle densities. A sample of the cement, typical of that used in the concrete to be analysed, is required for the determination of its density.

A.2 Reagent

Tri-n-butyl phosphate, general purpose reagent grade (required for air-entrained concrete only).

A.3 Apparatus (see figure A.1)

A.3.1 *Balance*, of a suitable type for weighing the containers (**A.3.3**) in both air and water. The balance shall have a minimum capacity of 5 kg and be readable to within 0.5 g.

A.3.2 *Stirrup assembly*, such that the containers (**A.3.3**) can be suspended from the balance. The stirrup shall be marked in such a way as to ensure that the container when suspended on the stirrup can be fully immersed to a constant depth.

A.3.3 *Eight bucket shaped containers*, of corrosion-resisting metal, each of (200 ± 5) mm diameter at the top and (180 ± 5) mm deep, having smooth sloping sides and a rounded bottom to prevent the trapping of air during immersion. The eight containers shall have the same known mass in air to within ± 0.25 g

A.3.4 *Water tank*, of sufficient size to allow a container (**A.3.3**) on the stirrup (**A.3.2**) to be fully immersed to a constant depth.

A.3.5 *Two nesting sieves*, conforming to BS 410, approximately 450 mm in diameter and 300 mm deep, the upper sieve being fitted with a perforated plate of 5 mm square aperture size, and the lower sieve being fitted with woven wire cloth of 150 µm aperture size. The 150 µm sieve shall be provided with a wire support below the mesh.

A.3.6 *Funnel and support frame*, a typical design of which is shown in figure A.1.

A.3.7 *Hose*, fitted with a nozzle that, when fed with water at normal mains pressure, gives a fine spray strong enough to move the particles of sand over the surface of the 150 µm mesh sieve.

A.3.8 *Tamping rod*, as described in **3.5** of BS 1881 : Part 102.

A.4 Calibration tests

A.4.1 *General*

Determine the density of the cement, and the particle densities of the coarse aggregates and sand. Determine also a fines correction factor to allow for that fraction of the coarse aggregate and sand used in the concrete that passes a 150 µm sieve.

NOTE. The accuracy of the results depends to a great extent on the reliability of the estimates obtained from the above determinations. It cannot be assumed that the results of the calibration tests will remain constant.

A.4.2 *Density of the cement*

Determine the density of the cement by the method described in BS EN 196-6.

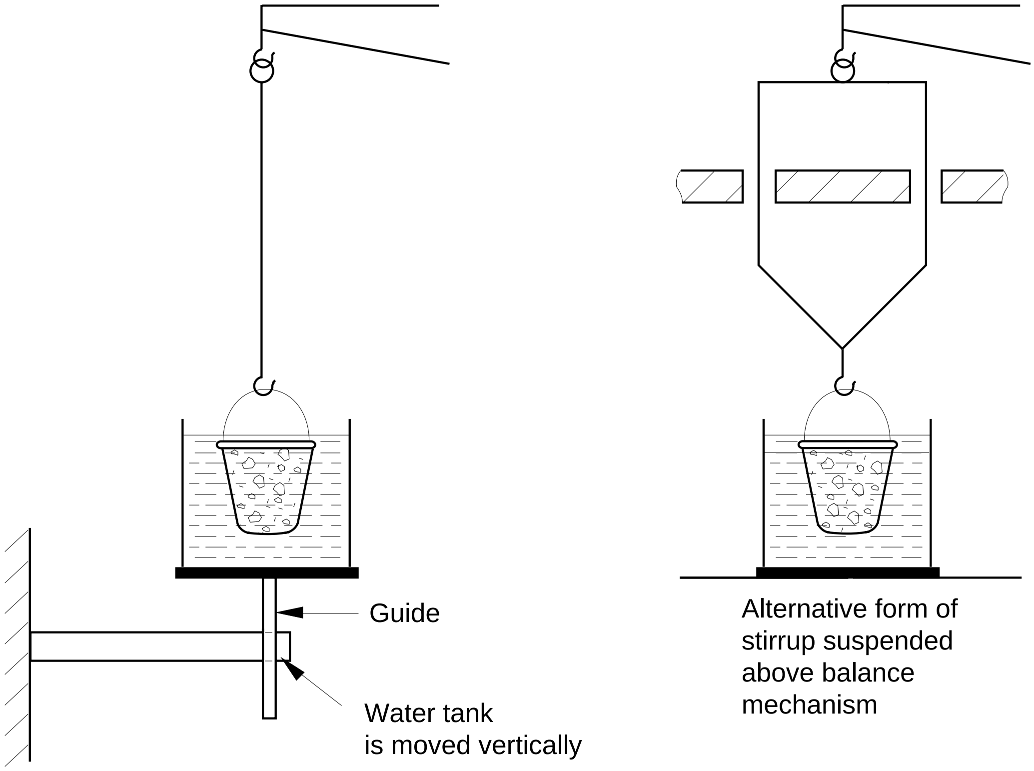
A.4.3 *Determination of the particle densities of the aggregates*

A.4.3.1 *Aggregate samples*

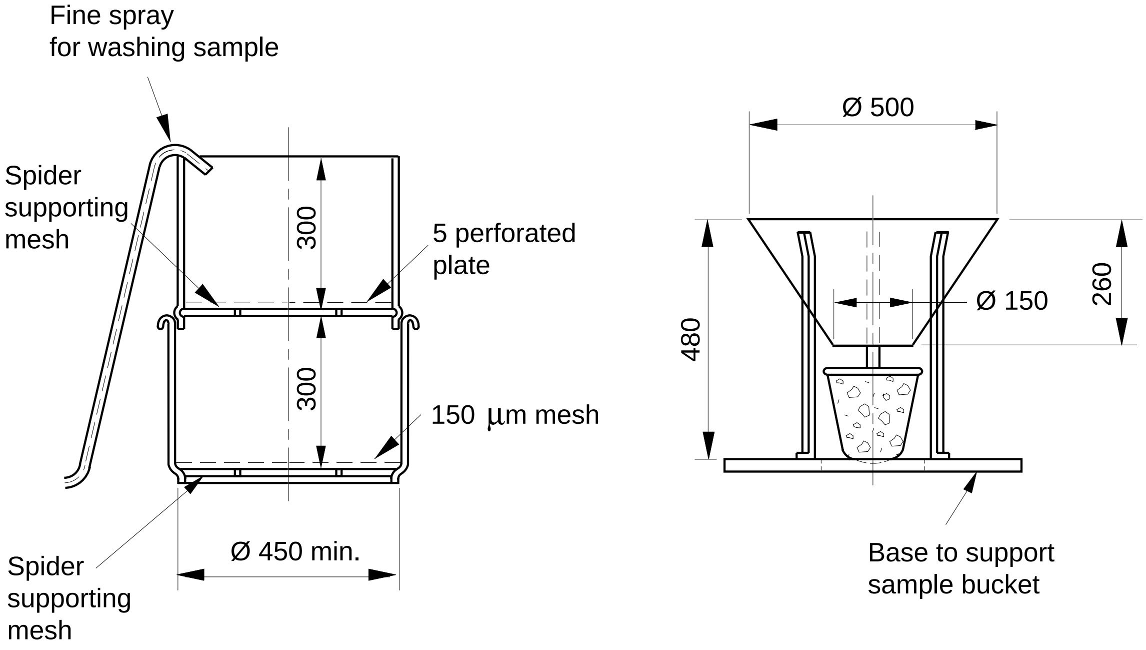
Obtain representative samples of the coarse aggregate and sand to be used in the concrete to be analysed, by the appropriate method described in BS 812 : Part 102.

A.4.3.2 *Sub-samples of aggregates*

Assuming a concrete test sample mass of 4 kg, calculate from the expected mix proportions the saturated surface dry (SSD) mass of the coarse aggregate and sand in such a sample. Then reduce each bulk sample of aggregate by the methods described in BS 812 : Part 102 to provide a sub-sample containing aggregate of between one and two times the appropriate calculated SSD mass. Take sub-samples of the coarse aggregate fractions, making any necessary allowance for the free water in the aggregate, to provide a composite coarse aggregate sample of the mass previously calculated for a 4 kg sample of concrete. Then, separately, repeat this operation for the sand.



a) Typical balance and support methods



b) Funnel and support method

All dimensions in millimetres, unless otherwise stated.

Figure A.1 Apparatus for buoyancy method

A.4.3.3 *Procedure*

Determine the particle densities of the coarse aggregate and sand under conditions identical with those to be applied when the concrete is to be analysed.

NOTE 1. The water temperature needs to be maintained within the same range when carrying out the analysis.

Treat the samples in pairs, one of coarse aggregate and one of sand, and carry out the following procedure on each of the pairs. Place the sample of sand in one of the clean containers. Support the 5.0 mm aperture sieve on the funnel, with the container beneath the funnel. Totally transfer the paired sample of coarse aggregate to the sieve. Then wash the coarse aggregate under a spray of water for 1 min to 2 min to ensure the removal of particles passing the 5.0 mm sieve, collecting this fraction in the container with the sand. Totally transfer the washed coarse aggregate to a second clean container using the funnel, then fill this container to within 25 mm of the lip with water. Stir the aggregate until any entrapped air is removed, i.e. for about 1 min. Suspend the container on the stirrup assembly fitted to the balance and steadily raise the water level or the tank until the level of water reaches the constant level mark on the stirrup.

Ensure that the stirrup does not touch the bottom of the tank and that air bubbles are not trapped on the surfaces of the container, specimen and stirrup assembly. Weigh the coarse aggregate in water. Follow the same balancing and weighing procedures with the first container holding the sand.

NOTE 2. During all weighings, limit the maximum vertical movement of the container to 5 mm to restrict the error caused by variations in its displacement.

If the aggregates have been oven dried, time will be required for water to be absorbed by the aggregates before a steady mass in water is obtained. In such a case, stir the aggregates, and weigh after 10 min immersion to ensure that the mass does not differ by more than 0.5 g from the previous weighing.

If necessary, stir and reweigh the container and contents at 10 min intervals until the above condition is met. Record the time taken to obtain this condition.

Record the final mass in water as B_a for the coarse aggregate, and B_s for the sand.

Carefully drain the water from each container, if necessary filtering the water from the sand through a filter paper and returning any retained material. Dry the coarse aggregate and sand separately to the saturated surface dry condition in accordance with BS 812 : Part 2 and weigh them. Record the mass in air as A_a for the coarse aggregate (SSD) and A_s for the sand (SSD).

A.4.3.4 *Calculation of particle densities*

Calculate the relative densities by the equations:

$$\text{particle density of coarse aggregate} = \frac{A_a}{(A_a - B_a)} \quad (1)$$

$$\text{particle density of sand} = \frac{A_s}{(A_s - B_s)} \quad (2)$$

where

A_a is the mass in air of the coarse aggregate (SSD), in kilograms;

A_s is the mass in air of the sand (SSD), in kilograms;

B_a is the mass in water of the coarse aggregate, in kilograms;

B_s is the mass in water of the sand, in kilograms.

A.4.3.5 *Duplicate determination*

Repeat the operations, starting with the sub-samples (see **A.4.3.2**), three more times, then calculate the mean values of the particle densities for the coarse aggregates and sand.

A.4.4 *Determination of fines correction factor*

A.4.4.1 *Test samples*

Use the same test samples that had previously been used to determine the particle density of the sand for the determination of the fines correction factor.

A.4.4.2 *Procedure*

Totally transfer a sand sample to the 150 µm sieve. Wash the sand under the spray until the water passing through the sieve is clear, i.e. for about 10 min. Wash the aggregate retained on the sieve into a clean container through the funnel. Cover the aggregate with water to within 25 mm of the lip of the container and stir to remove entrapped air. Immerse the container in the water tank and determine the mass in water of the sand D_s as in **A.4.3.3**.

Calculate the fines correction factor C_s by the equation:

$$C_s = \frac{B_s}{D_s} \quad (3)$$

where

B_s is the mass in water of the sand, from **A.4.3.3**, in kilograms;

D_s is the mass in water of the sand, from **A.4.4.2**, in kilograms.

Repeat this operation three more times and calculate the mean of the four values to provide the value to be used in the calculation of the mass of the constituents.

A.5 Analysis of concrete

A.5.1 *Sampling*

Using the procedure described in clause **4** take duplicate test samples of mass (4 ± 0.5) kg.

A.5.2 *Procedure*

Place a test sample, obtained as in **A.5.1**, in a clean, dry container (**A.3.3**) and determine its mass in air W. Fill the container with water to within 25 mm of the lip. At this stage, add 10 ml of tri-*n*-butyl phosphate if air-entrained concrete is being analysed. Stir the contents of the container until as much entrained air as possible is removed, i.e. for 1 min to 2 min. Suspend the container on the stirrup assembly fitted to the balance, taking all necessary care to prevent the container lip from falling below the water level in the tank. Carefully fill the container with water to the lip and allow the contents to settle for 5 min. Steadily raise the water level or the tank until the level of water reaches the constant level mark on the stirrup. Take care during this operation not to disturb the sample. Ensure that the stirrup does not touch the bottom of the tank and that air bubbles are not trapped on the surfaces of the container, specimen and stirrup assembly. Determine the sample mass in water w.

Change the water in the tank, if it becomes contaminated, to prevent a change in its density.

Totally transfer the sample to the nest of sieves, the 5 mm above the 150 µm, and wash the concrete until it is free from cement, i.e. for at least 2 min. Transfer the clean coarse aggregate from the 5 mm sieve to a clean container through the funnel. Fill the container with water to within 25 mm of the lip and stir the contents to remove entrapped air. Immerse the container in the water and determine the mass in water of the coarse aggregate w_a.

Wash the sand on the 150 µm sieve for a further 10 min, or until it is free of cement and the washing water is clear. Determine the mass in water of the sand w_s by the same procedure as used for the coarse aggregate.

Repeat the above procedure with the second test sample.

A.5.3 *Calculation of mass of each constituent*

Calculate the mass of each constituent for each test sample as follows:

a) the mass of the coarse aggregate W_a in the sample is given by the equation:

$$W_a = w_a \times F_a \qquad (4)$$

b) the mass of sand W_s in the sample is given by the equation:

$$W_s = w_s \times F_s \times C_s \qquad (5)$$

c) the mass of cement W_c in the sample is given by the equation:

$$W_c = [w - w_a - (w_s \times C_s)] \times F_c \qquad (6)$$

d) the mass of water W_w in the sample is given by the equation:

$$W_w = W - (W_a + W_s + W_c) \qquad (7)$$

where

$F_a = \dfrac{\text{particle density}}{(\text{particle density} - 1)}$ for the coarse aggregate;

$F_s = \dfrac{\text{particle density}}{(\text{particle density} - 1)}$ for the fine aggregate;

$F_c = \dfrac{\text{density}}{(\text{density} - 1000)}$ for the cement;

C_s is the fines correction factor as determined in accordance with **A.4.4**;

W is the mass of the concrete sample in air;

w is the mass of the concrete sample in water;

w_a is the mass of coarse aggregate in water;

w_s is the mass of the sand in water.

A.6 Mass of constituents of the concrete

A.6.1 *Determination of mass per cubic metre of fresh concrete*

On a separate sample, taken at the same time and by the same procedure, determine the mass per cubic metre of the fully compacted fresh concrete using the method described in BS 1881 : Part 107.

A.6.2 *Calculation of mass of each constituent per cubic metre of concrete*

The mass of each constituent per cubic metre of concrete (in kg/m^3)

$$= \frac{\text{mass of constituent}}{\text{mass of test sample}} \times \text{mass per cubic metre of compacted fresh concrete}$$

A.7 Repeatability

If the difference between the two masses of cement per cubic metre determined on the duplicate test samples exceeds 20 kg/m^3, discard the test results.

A.8 Report

The data to be included in a test report are given in clause **10**.

Annex B (normative)

Constant volume (RAM) method

B.1 Test principle

A concrete test sample is weighed and transferred to the elutriation column of a Rapid Analysis Machine (RAM) which raises all particles of cement together with a minimum of sand particles. The resultant suspension is sub-sampled and screened through a vibrating 150 μm sieve to a conditioning vessel in which the suspension is flocculated. The suspension then settles in a removable constant volume vessel attached to the bottom of the conditioning vessel. The constant volume vessel is removed and weighed, and the mass of cement and fine sand in the total suspension is determined by reference to a calibration chart, based on tests on raw materials typical of those used in the concrete to be analysed. The aggregate remaining in the elutriation column is recovered and may be dried, sieved and weighed. The addition of a chemical substance to disperse air is used when air-entrained concrete is to be analysed.

B.2 Samples of raw materials required

Samples of the cement and aggregates, typical of those used in the concrete to be analysed, are required for the establishment of calibration lines for the determination of cement content.

B.3 Reagents

Tri-n-butyl phosphate, general purpose reagent grade (for air-entrained concrete only).

B.4 Apparatus

B.4.1 *Rapid Analysis Machine (RAM)*, a general assembly diagram of which is shown in figure B.1.

B.4.2 *Balance*, of at least 10 kg capacity, readable to 1 g.

B.4.3 *Balance*, of at least 2 kg capacity, readable to 0.1 g.

B.4.4 *Test sieve*, of 200 mm diameter, with woven wire cloth of 150 μm aperture size, conforming to the requirements of BS 410. The sieve is used with the RAM.

B.4.5 *Plastic buckets*, about 15 l capacity.

B.4.6 *Shallow plastic container*, approximately 300 mm in diameter by 120 mm deep. This is required for the analysis of air-entrained concrete.

B.4.7 *Drainage*, including a settling tank, suitable for coping with 80 l per test of waste water containing cement in suspension.

B.5 Procedure

Operate the machine in accordance with the manufacturer's instructions.

B.6 Calibration procedure for the machine

B.6.1 *General*

The machine is calibrated, using concrete samples made with 'prepared aggregate' and known masses of cement, by determining the mass of the constant volume vessel and contents.

NOTE. 'Prepared aggregate' (see **B.6.2**) is aggregate that has been processed to remove all fines. During a concrete analysis, any fines in the sub-samples suspension that pass through a 150 μm sieve are collected in the constant volume vessel together with the cement. Therefore, it is necessary to apply a fines correction to the measured cement content in order to obtain the actual cement content of the sample.

B.6.2 *'Prepared aggregate'*

B.6.2.1 *Aggregate samples*

Obtain representative samples of the coarse aggregate and sand to be used in the concrete to be analysed by the appropriate method specified in BS 812 : Part 102.

B.6.2.2 *Sub-samples of aggregates*

Assuming a concrete test sample mass of 8 kg, calculate from the expected mix proportions the saturated surface dry (SSD) mass of each individual type and size of aggregate in such a sample. Then reduce each bulk sample of aggregate by the method described in BS 812 : Part 102 to provide a sub-sample containing aggregate of between one and two times the appropriate calculated SSD mass.

B.6.2.3 *Treatment of aggregates*

Remove the 150 μm sieve and the constant volume vessel from the machine and position a plastic bucket under the conditioning vessel. From the aggregate sub-samples weigh out, making an appropriate allowance for the moisture content of the aggregates, a batch of aggregates in the proportions calculated in **B.6.2.2**. Operate the machine and recover the clean aggregate from the elutriation column into a clean plastic bucket. This is the 'prepared aggregate'.

B.6.3 *Determination of cement values*

B.6.3.1 *General*

Carry out five tests at each level of cement content, i.e. five with zero cement, five with 750 g of cement and five with 1500 g of cement.

B.6.3.2 *Determination of zero cement value*

Operate the machine as described in the manufacturer's instructions using 7 kg of 'prepared aggregate' and record the mass as W_0. If the range of the five values does not exceed 2.0 g, average the five results and record as the zero cement value. If the range of the five values is greater than 2.0 g, discard the results and carry out five more tests.

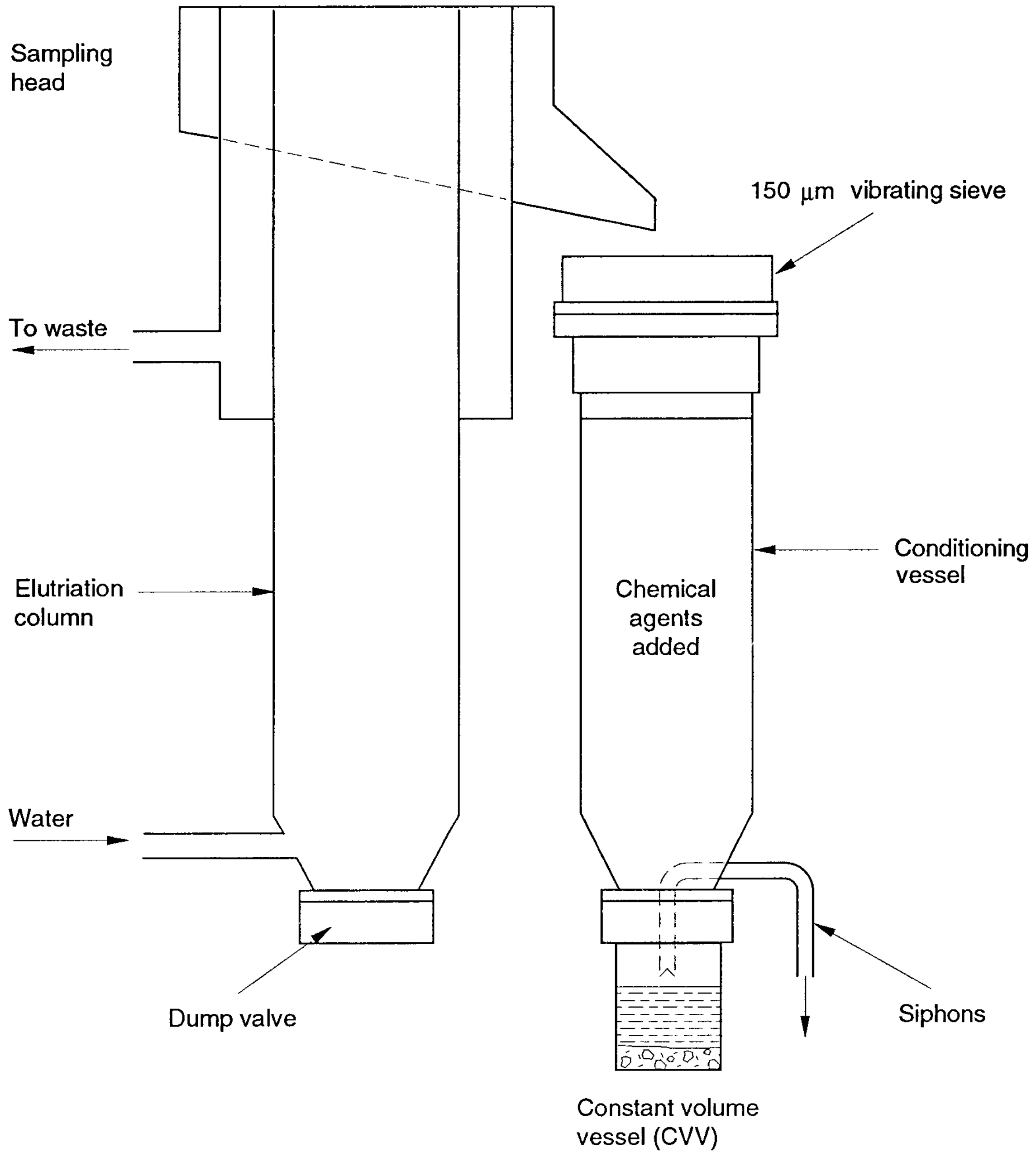


Figure B.1 Rapid analysis machine (RAM)

B.6.3.3 *Determination of 750 g cement value*

Mix approximately 7 kg of 'prepared aggregate' and 750 g of cement with sufficient water to give a workable mix. Operate the machine as described in the manufacturer's instructions and record the mass as W_{750}. If the range of five values is less than 3.5 g, average the five results and record as the 750 g cement value. If the range of the five values is greater than 3.5 g, discard the results and carry out five more tests. At the end of each test for cement value, recover the 'prepared aggregate' for reuse.

B.6.3.4 *Determination of 1500 g cement value*

Repeat the operations described in **B.6.3.3** using a mix containing 1500 g of cement. Record the mass of the constant volume vessel as W_{1500}.

If the range of the five values does not exceed 5.0 g, average the five results and record as the 1500 g cement value. If the range of the five values is greater than 5.0 g, discard the results and carry out five more tests.

B.6.4 *Construction of the cement calibration line*

Construct the cement calibration line, shown in figure B.2, as the straight line joining the points corresponding to the 750 g cement value, as determined in **B.6.3.3**, and the 1500 g cement value, as determined in **B.6.3.4**.

NOTE. D_1 or D_2 should fall within the range (50 ± 2) g, and ($D_2 - D_1$) within ± 2 g,

where

D_1 is the 750 g cement value minus the zero cement value;

D_2 is the 1500 g cement value minus the 750 g cement value.

B.6.5 *Determination of the fines correction value*

Obtain sufficient samples of each type and size of aggregate, by the appropriate method described in BS 812 : Part 102, to carry out five determinations of the fines correction value, i.e. about 50 kg in the necessary proportions. Ensure that the materials are representative of the aggregates to be used in the concrete to be analysed.

Carry out the following operations.

a) Make up a test sample containing 1000 g of cement and proportional amounts of fine and coarse aggregate in accordance with the mix proportions for the concrete to be tested for compliance.

b) Weigh the test sample.

c) Load the machine and carry out an analysis.

d) On completion of the analysis remove and weigh the constant volume vessel plus contents. By reference to the cement calibration line, determine the fines content in grams by difference:

fines content (g) =
apparent cement content (g) − 1000 g;

fines content (kg/m^3) =

$$\frac{\text{fines content (g)}}{\text{mass of test sample (g)}} \times \text{mass (kg) per cubic metre of compacted fresh concrete.}$$

e) Repeat to obtain five results. The range of the five results should not exceed 20 kg/m^3 (expressed in terms of quantities per cubic metre of concrete). The average of the five values is the fines correction value.

B.6.6 *The RAM sampling factor*

During a RAM test approximately 90 % of the slurry flows to waste and the remainder is directed through the sieve into the conditioning vessel. Hence only 10 % of the sand carried in the slurry will end up in the sieve, the remainder going to waste. The total mass of sand carried in the slurry is calculated using the RAM sampling factor which is determined using the method described in the operating manual of the machine.

B.7 Analysis of concrete

B.7.1 *Sampling and sample reduction*

Using the procedure described in clause **4**, take duplicate test samples of (8 ± 1) kg.

B.7.2 *Analysis of concrete without entrained air*

Carry out the following procedures.

a) Weigh the test sample and record the mass W.

b) Follow the manufacturer's instructions and record the mass of the constant volume vessel and contents W_{cvv}.

c) Read off apparent cement content W_{ac} by reference to the cement calibration line.

d) Apparent cement content (kg/m^3) =

$$\frac{W_{ac}}{W} \times \text{mass per cubic metre of compacted fresh concrete.}$$

e) Repeat for the duplicate test sample.

B.7.3 *Analysis of air-entrained concrete*

Carry out the following procedures.

a) Weigh the test sample of air-entrained concrete and record the mass W.

b) Transfer the weighed sample completely using the spray as necessary, to a shallow plastic container, cover the sample with water and add 10 ml of tri-*n*-butyl phosphate.

c) Mix the contents of the container thoroughly for 2 min to release as much as possible of the entrapped air.

d) Continue as described in **B.7.2**.

B.8 Calculation of cement content per cubic metre of concrete

Using the values from **B.6** and **B.7**, calculate the cement content, in kg/m^3, from the following equation:

cement content = apparent cement content –
fines correction value

If the difference in the two masses of cement per cubic metre on the duplicate test samples exceeds 20 kg/m^3, discard the test results.

B.9 Report

The data to be included in the test report are given in clause **10**.

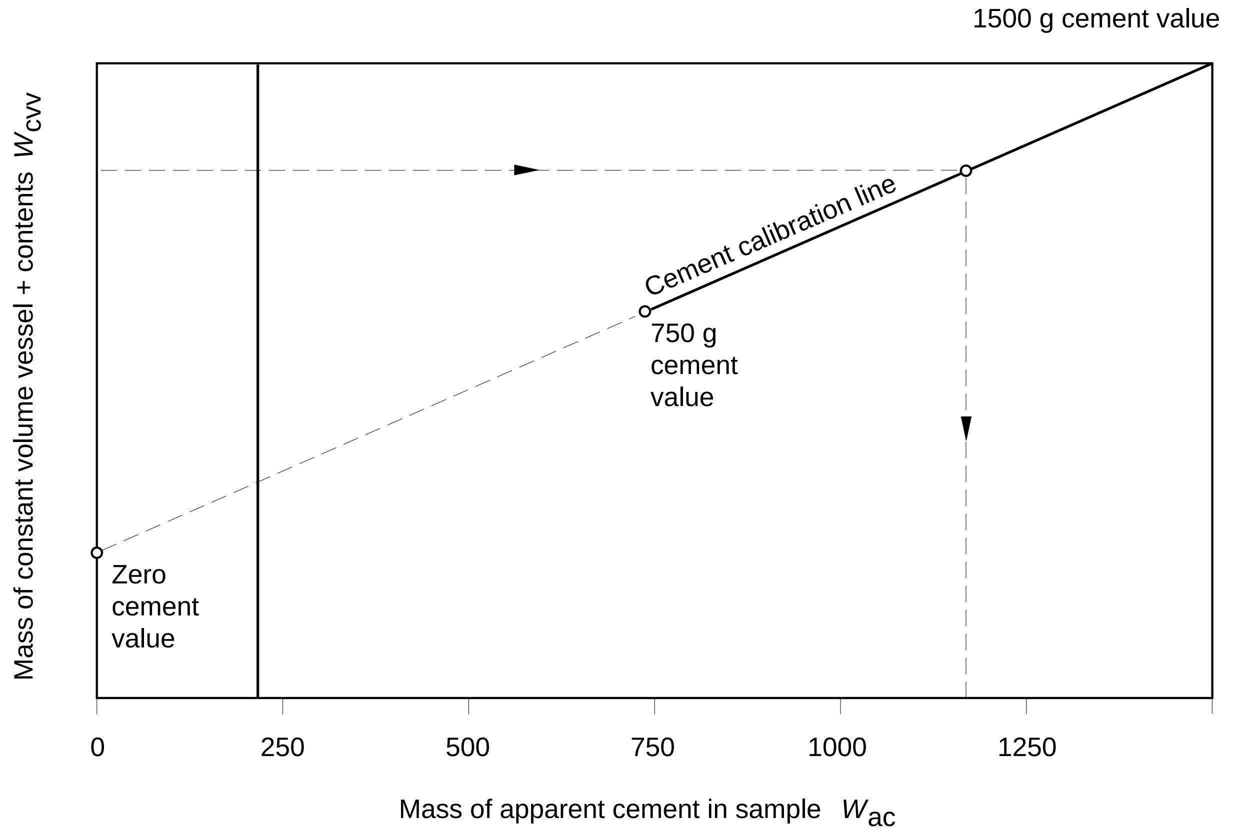


Figure B.2 Cement calibration chart

Annex C (normative)
Pressure filter (Sandberg) method

C.1 Test principle

C.1.1 *General*

A concrete test sample is weighed, agitated with water and then washed over a nest of sieves to separate the cement and fines passing a 150 µm sieve. The washings are filtered through a filter paper using a pressure filter, and the solids dried and weighed. Allowances are made for the fines mixed with the cement and for the solubility of the cement. The aggregate is collected from the sieves, dried and weighed.

C.1.2 *Samples of raw materials required*

Samples of the coarse aggregate and sand, typical of those to be used in the concrete to be analysed, are required for the determination of the proportion of the aggregate passing a 150 µm sieve. A sample of cement typical of that used in the concrete is also required for the determination of its solubility and the proportion of the cement retained on a 150 µm sieve.

C.2 Apparatus

C.2.1 *Balance*, of at least 10 kg capacity, readable to 1 g.

C.2.2 *Bottle*, about 7 l capacity, made of steel or other suitable material, with a wide mouth and an effective closure.

C.2.3 *Bottle roller*, capable of agitating the bottle when filled with materials weighing 7 kg. A suitable machine is one which will rotate the bottle about its longitudinal axis at a speed of (20 ± 10) r/min.

C.2.4 *Pressure filter*, of appropriate size (one taking a filter paper of 270 mm in diameter is suitable), see figure C.1.

C.2.5 *Fine retention filter papers*, slow flow, to fit the pressure filter.

C.2.6 *Air compressor or foot pump*, capable of supplying pressures in the range 0.15 MN/m^2 to 0.20 MN/m^2.

C.2.7 *Two test sieves*, conforming to BS 410, of 200 mm diameter, one fitted with perforated plate of 5 mm aperture size, the other fitted with woven wire mesh of 150 µm aperture size.

NOTE. It will be necessary to reduce the load on the 150 µm sieve by including other sieves in the nest used, e.g. sieves with meshes of 2.36 mm and 300 µm aperture sizes would be suitable.

C.2.8 *Metal charging funnel*, having a discharge diameter smaller than the pressure filter filling orifice, and capable of firmly supporting the nest of sieves.

C.2.9 *Trays*, which can be heated without damage or change in mass. A convenient size is about 300 mm × 300 mm × 40 mm.

C.2.10 *A drying oven*, capable of maintaining a temperature of (200 ± 5) °C, or a microwave oven with a minimum power output of 1400 W.

C.3 Calibration tests

C.3.1 *General*

Determine the fines content of the coarse aggregate and sand (see **C.3.2**).

Determine also the correction for the solubility of the cement in water and for the fraction of the cement retained on a 150 µm sieve (see **C.3.3**) and the water absorption of the coarse aggregate and sand (see **C.3.4**).

C.3.2 *Determination of the fines content of the aggregate*

C.3.2.1 *Aggregate samples*

Obtain representative samples of the coarse aggregate and sand to be used in the concrete to be analysed by the appropriate method specified in BS 812 : Part 102.

C.3.2.2 *Sub-samples of aggregate*

Assuming a concrete test sample mass of 3 kg, calculate from the expected mix proportions the mass, when the aggregate is dried to constant mass (see annex F), of each individual type and size of aggregate in such a sample. Then reduce each bulk sample of aggregates by the method described in BS 812 : Part 102 to provide sub-samples of between one and two times the appropriate calculated dry mass for each size of aggregate to be used in the concrete.

C.3.2.3 *Procedure*

Place two sub-samples of each size of aggregate in trays and dry to constant mass. Transfer a weighed sub-sample of aggregate to the bottle and add 2 l of water. Seal the bottle and rotate for 10 min to 20 min to ensure the separation of any passing 150 µm particles from the aggregate. Pour the liquid contents of the bottle, together with any fines, through a nest of sieves with the 5 mm sieve at the top and the 150 µm sieve at the bottom; also include any intermediate sieves that are considered necessary to protect the 150 µm sieve.

Continue rinsing the aggregate in the bottle and on the sieves until the wash water is free from fine material. Then transfer the aggregate remaining in the bottle to the top sieve and allow to drain for 2 min to 3 min. After draining, transfer the aggregate to a tray and dry to constant mass. To assist the drying process, move the aggregate around in the tray every 5 min to 10 min.

Grade the aggregate over a 5 mm sieve, any intermediate sieve(s), and a 150 µm sieve to complete the separation of the passing 150 µm aggregate. Weigh the aggregate larger than 150 µm and record the mass as W_2.

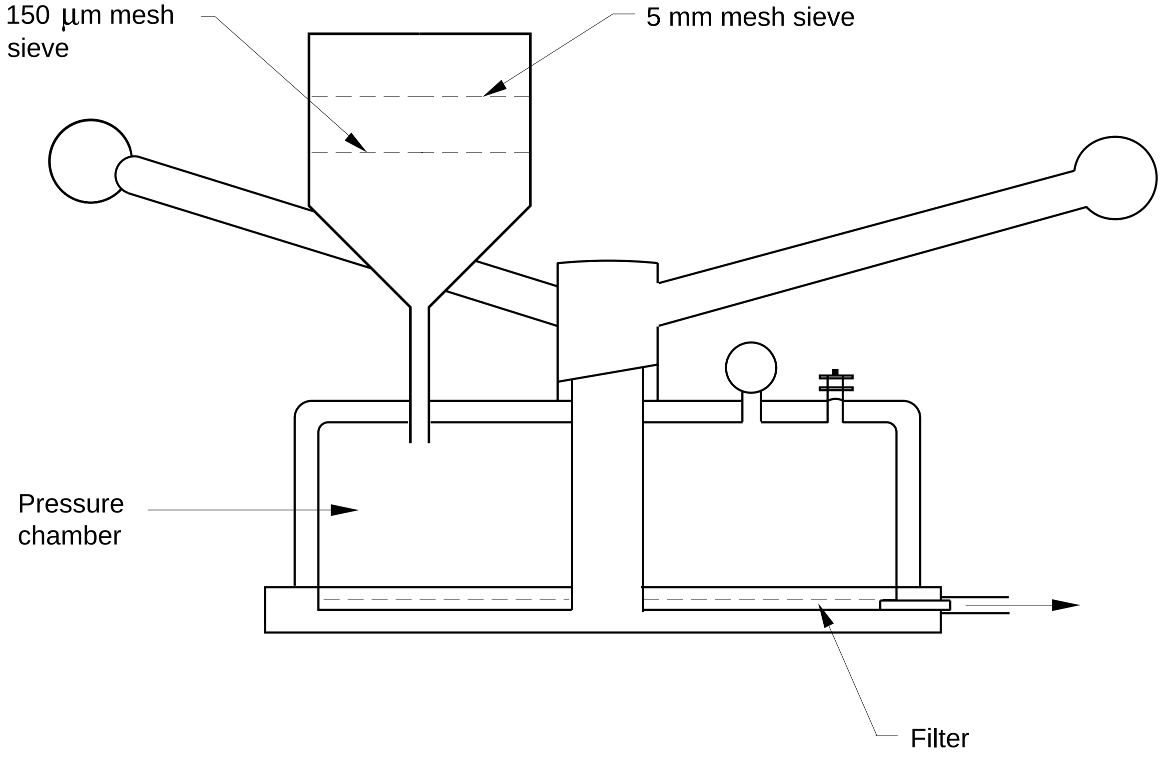


Figure C.1 Pressure filter (Sandberg) method

C.3.2.4 *Calculation of the fines content of the aggregates*

Calculate the percentage fines content of each aggregate as follows:

$$W_{s1} = \frac{W_1 - W_2}{W_2} \times 100$$

where

W_{s1} is the percentage of fines content; for convenience this is based on the dry, washed aggregate;

W_1 is the mass of dry aggregate before washing;

W_2 is the mass of dry aggregate after washing.

Repeat the operations described in **C.3.2.2** to **C.3.2.4** for all sub-samples.

C.3.2.5 *Fines content*

Calculate the average percentage fines content of each aggregate size to be used in the concrete and record as W_s for fine and coarse aggregate respectively.

C.3.3 *Determination of the cement correction factor*

C.3.3.1 *Sample of cement*

Take a sample of cement by the method specified in BS EN 196-7.

C.3.3.2 *Procedure*

Place a 1 kg sub-sample of the cement in a tray and dry in an oven at (200 ± 5) °C for (60 ± 10) min. Weigh a test sample of the cement W_3 equal to the amount expected in a 3 kg concrete test sample. Prepare a slurry of the test sample of cement with half of its mass of water by mixing for 10 min to 20 min in the bottle.

Place a weighed filter paper, dried for not more than 1 h, in the pressure filter and assemble the filter. Insert the neck of the charging funnel into the top opening of the pressure filter, and support the 150 μm sieve on the funnel. Wash the cement slurry through the 150 μm sieve into the pressure filter and continue washing until the wash water becomes clear. If any cement is retained on the sieve it shall be recovered and weighed to determine a correction factor for the sand (see **C.3.3.3**). Remove the funnel, seal the pressure filter and apply a pressure of 0.20 MN/m^2 until filtration is complete.

Dismantle the pressure filter and carefully transfer the paper and retained cement, on a tray, to the oven. Dry at (200 ± 5) °C for (60 ± 10) min.

Weigh the filter paper and cement, deduct the mass of the paper and record the mass of recovered cement as W_4.

C.3.3.3 *Calculation of the percentage cement correction factor*

Calculate the cement correction factor as follows:

$$W_{t1} = \frac{W_3 - W_4}{W_3} \times 100$$

where

W_3 is the mass of the dry cement test sample;

W_4 is the mass of dry cement retained on the filter paper.

C.3.3.4 *Duplicate determination of the cement correction factor*

Repeat the operations described in **C.3.3.2** and **C.3.3.3** and record the cement correction factor as W_{t2}.

C.3.3.5 *Percentage cement correction factor*

Calculate the percentage cement correction factor, to be used in the calculation of the cement content, as the average of W_{t1} and W_{t2} and record as W_t.

C.3.3.6 *Calculation of the cement aggregate correction factor*

If any cement is retained on the 150 μm sieve (see **C.3.3.2**), this shall be determined by drying and weighing. Record the mass of dry cement retained as W_5.

Calculate the cement aggregate correction factor W_{u1} as follows:

$$W_{u1} = \frac{W_5}{W_3} \times 100$$

where

W_3 is the mass of the dry cement test sample;

W_5 is the mass of dry cement retained on the 150 μm sieve.

C.3.3.7 *Duplicate determination of cement aggregate correction factor*

Repeat the operation described in **C.3.3.6** for the duplicate sample and record the correction factor as W_{u2}.

C.3.3.8 *Percentage cement aggregate correction factor*

Calculate the percentage cement aggregate correction factor, to be used to correct the sand content, as the average of W_{u1} and W_{u2} and record as W_u.

C.3.4 *Determination of the water absorption of the coarse aggregate and sand*

Determine the water absorption of the coarse aggregate and sand in accordance with BS 812 : Part 2 : 1995.

C.4 Analysis of concrete

C.4.1 *Sampling*

Using the procedures described in clause **4**, take duplicate test samples of (3 ± 0.5) kg.

C.4.2 *Procedure*

Weigh a test sample W_s and immediately transfer it to the bottle. Add 2 l of water, seal the bottle and agitate on the mechanical shaker for 10 min to 20 min. Place a weighed filter paper, dried for not more than 1 h, in the pressure filter and assemble the filter. Insert the neck of the charging funnel into the top opening of the pressure filter and support the 150 µm sieve, protected by other appropriate sieves, on the funnel. Arrange to collect the filtrate from the pressure filter in a clean container, then pour the liquid contents of the bottle through the sieves and into the pressure filter, retaining as much of the aggregate as possible in the bottle. Rinse the contents of the bottle until the washings are free of cement, pouring the washings through the sieves and into the pressure filter. Wash the aggregate retained on the sieves until free of cement.

On completion of the separation of the cement, transfer the whole of the aggregate from the bottle to the nest of sieves, wash the bottle as necessary, and allow the aggregate to drain for 2 min to 3 min. Place the sieves aside, for treatment as described in **C.4.3**, and remove the funnel, then seal the pressure filter and apply a pressure of 0.20 MN/m^2 until filtration is completed. Inspect the collected filtrate to ensure that no cement particles have passed the filter paper; if any cement is present in the filtrate, recycle the filtrate through the filter paper.

Dismantle the pressure filter and dry the paper and retained solids to constant mass.

Weigh the filter paper and solids, deduct the mass of the filter paper and record the mass of the solids as W_6.

C.4.3 *Determination of the mass of coarse aggregate and sand*

Transfer the whole of the aggregate on the sieves to drying pans or trays. Dry the aggregate to constant mass.

Grade the recovered aggregate. Record the mass of the coarse aggregate as W_7 and the mass of sand as W_8.

C.5 Calculation of the mass of each constituent

The mass of each constituent should then be corrected for absorption, fines passing a 150 µm sieve and cement retained on the 150 µm sieve.

Mass of coarse aggregate in the test sample, W_9:

$$W_9 = W_7 \times \left(\frac{100 + A_{\text{coarse}}}{100}\right)$$

Mass of sand in the test sample, W_{10}:

$$W_{10} = (W_8 + \mu)\left(\frac{100 + A_{\text{sand}}}{100}\right)$$

Mass of cement in test sample, W_{11}:

$$W_{11} = (W_6 - \mu)\left(\frac{100 + W_t}{100}\right)$$

where

$$\mu = x + y - z$$

and

$$x = W_7 \times \left(\frac{100 + W_s\ (\text{coarse})}{100}\right)$$

i.e., the fraction of coarse aggregate passing the 150 µm sieve;

$$y = W_8 \times \left(\frac{100 + W_s\ (\text{sand})}{100}\right)$$

i.e., the fraction of sand passing the 150 µm sieve;

$$z = (W_6 - x - y)\left(\frac{100 \times W_u}{100}\right)$$

i.e., any cement retained on the 150 µm sieve;

A_{coarse} is the percentage water absorption of the coarse aggregate;

A_{sand} is the percentage water absorption of the sand;

W_s (coarse) is the percentage of coarse aggregate passing a 150 µm sieve;

W_s(sand) is the percentage of sand passing a 150 µm sieve;

W_u is the percentage cement retained on a 150 µm sieve;

W_6 is the mass of solids retained on the filter paper in grams;

W_t is the percentage cement correction factor;

W_7 is the mass of coarse aggregate, in grams;

W_8 is the mass of sand, in grams.

C.6 Mass of constituents of the concrete

C.6.1 *Determination of mass per cubic metre of fresh concrete*

On a separate sample, taken at the same time and by the same procedure as the sample for analysis, determine the mass per cubic metre of the fully compacted fresh concrete using the method described in BS 1881 : Part 107.

C.6.2 *Calculation of mass of each constituent per cubic metre of concrete*

The mass of each constituent per cubic metre of concrete in kg/m^3

$$= \frac{\text{mass of constituent}}{\text{mass of test sample}} \times \text{mass per cubic metre of compacted fresh concrete.}$$

C.7 Repeatability

If the difference between the two masses of cement per cubic metre on the duplicate test samples exceeds 20 kg/m^3, discard the test results.

C.8 Report

The data to be included in a test report are given in clause **10**.

Annex D (normative)

Pulverized-fuel ash content

D.1 General

The pulverized-fuel ash content of concrete is expressed as a percentage of the total cement content. Before the pfa content is determined, the total cement content of the concrete is determined as described in clause **5**. The material passing 150 µm recovered is subjected to a test procedure which determines particle density, using the apparatus listed in **D.2**.

D.2 Apparatus

D.2.1 *Balance*, of at least 10 kg capacity, readable to 0.1 g.

D.2.2 *Balance insulation*, to protect the balance from the hot oven tray during weighing.

D.2.3 *Gas jar and cover plate*, 400 ml to 500 ml capacity.

D.2.4 *Glass cloth*, 500 mm × 500 mm, used to contain particles of cement or pfa that violently fracture during drying.

D.2.5 *Microwave oven*, with the following essential features:

a) a minimum power output of 1400 W;

b) an integral timer capable of being set up to 10 min in 1 min intervals and reading to an accuracy of 1 s;

c) capable of enclosing a 300 mm × 200 mm × 40 mm oven tray.

D.2.6 *Heat resistant glass oven tray*, suitable for use at microwave oven temperatures.

D.2.7 *Wash bottles*, with fine and large diameter nozzles.

D.3 Pfa content test procedure

D.3.1 *General*

The test procedure consists of obtaining the mass of the cement in water and in air. As the material obtained from the tests can be either:

– dry (pressure filter (Sandberg) method); or

– wet (RAM method);

the sequence of the test depends on which of these two methods was used.

D.3.2 *Dry material*

D.3.2.1 The mass of the dry material has already been determined as part of the pressure filter test.

D.3.2.2 *Mass of material in water*

D.3.2.2.1 Fill the gas jar with water until a convex meniscus forms around the rim. Slide the cover plate across the top, ensuring no air bubbles are trapped. Wipe the external surfaces with the absorbent cloths and weigh and record its mass, then discard the water. Transfer the material from the filter paper to the gas jar. Re-weigh the filter paper to determine the dry mass of the sample tested. The jar is topped up to a point where a convex meniscus forms at the brim. Slide the gas jar cover plate across the top of the gas jar, ensuring that no air bubbles are trapped beneath the plate. Dry the outside, then weigh and record the mass of the gas jar, cover plate and contents to the nearest 0.1 g.

D.3.2.2.2 Calculate the particle density as described in **D.4**.

D.3.3 *Recovery of flocculated slurry from RAM test method*

D.3.3.1 The flocculated slurry in the constant volume vessel is recovered after an analysis machine test procedure has been carried out.

D.3.3.2 *Mass of flocculated slurry, water and gas jar*

After checking that the mass of the constant volume vessel and contents has been recorded, pour off the clear water above the flocculated slurry. Use a fine jet washer bottle to wash all the slurry from the constant volume vessel into the gas jar. After waiting at least 1 min for the slurry to partially settle in the jar gently top up the gas jar with water to a point where a convex meniscus forms at the brim. Slide the gas jar cover plate across the top of the gas jar, ensuring no air bubbles are trapped. Dry the outside and weigh the gas jar, cover plate and contents to the nearest 0.1 g.

D.3.3.3 *Mass of dried slurry*

Weigh and record the mass of the glass oven tray and glass cloth to the nearest 0.1 g. Spread the cloth over the tray so that there is an even lap over the sides of the tray. Wash all the contents of the gas jar into the oven tray using a fine jet wash bottle. Prop the tray at a shallow slope, about 1:10, for approximately 1 min to allow the solid particles to settle. Then remove excess clear water by carefully sucking it into the wide jet wash bottle. Fold the loose ends of wrapper to cover the sample and place the oven tray in the microwave oven. Drying is achieved by initially heating the flocculated slurry in the oven for 6 min at full power. Remove the tray and contents from the oven, weigh and record the mass to the nearest 0.1 g.

Continue drying in 1 min intervals until the reduction in mass is less than 0.3 g. Under no circumstances should drying continue beyond this point as excessively high temperatures can be generated that could damage the apparatus. The dry mass of the slurry is calculated by subtracting the mass of the oven tray and cloth from the final mass of the oven tray, cloth and slurry.

D.4 Calculation of particle density

The particle density is calculated thus:

$$PD = \frac{M}{M + M_0 - M_1}$$

where

PD is the particle density of the solids in the slurry in kg/l;

M is the mass of the dried slurry;

M_0 is the mass of the water-filled gas jar and cover plate;

M_1 is the mass of the gas jar, water, slurry and cover plate.

Having calculated the particle density, the proportion of pulverized-fuel ash in the test sample is determined using the calibration chart prepared in accordance with **D.6**.

D.5 Duplicate test

Sample and test duplicate samples in accordance with the procedure described in **D.3**. Where the difference between the pfa content results for both samples is less than 5 %, the test is valid and the mean of the two results is reported as the measured pfa content. Where the difference between the two pfa content results exceeds 5 %, a valid result has not been obtained and a pfa content value cannot be reported.

D.6 Pfa calibration

D.6.1 *Frequency of pfa calibration and checking*

A full pfa calibration is required prior to testing, and also:

a) where the source or sources of any of the constituent materials change;

b) when a calibration check indicates that the established calibration is not valid.

A calibration check is required:

1) at intervals not exceeding one week when the concrete mix is continually tested;

2) when a concrete mix has not been tested for over a week;

3) when there is a change in concrete mix proportions;

4) when there is a change in the fines content.

D.6.2 *Sampling materials*

Obtain representative samples of the aggregates by the method described in BS 812 : Part 102. Obtain representative samples of the cement and pfa as used at the place of batching.

Quantities required for 10 samples are shown in table D.1.

Table D.1 Material quantities for pfa calibration

Coarse aggregate kg	Sand kg	Portland cement kg	Pfa kg
100	100	15	15

After sampling, each type of aggregate sampled is mixed thoroughly on a non-absorbent surface ready for weigh batching into samples.

D.6.3 *Batching samples*

Calculate the mix proportions required to make samples with 1000 g of cement, where the cement includes pfa. Weigh batch the aggregate for each sample directly into a bucket. Where a full calibration is required, the number of samples and the quantities of Portland cement (PC) and pfa are shown in table D.2.

Table D.2 Number and composition of pfa calibration samples

Number of samples	Mass of cement per sample g	Mass of pfa per sample g
5 at 0 % pfa	1000	0
5 at 80 % pfa	200	800

D.6.4 *Testing pfa calibration samples*

Test the ten pfa calibration samples using one of the total cement content test procedures set out in clause **5**. Carry out the additional pfa content test procedure as described in **D.3** to **D.4**, recording all the particle density results. Calculate the mean and range of each set of five results at both the 0 % pfa and 80 % pfa contents. The pfa calibration is the line between the 0 % pfa and 80 % pfa contents providing the range of each set of results does not exceed 0.12 kg/l. Where either range exceeds this value, a valid pfa calibration cannot be reported and the set or sets of five pfa calibration samples shall be repeated.

D.6.5 *Pfa calibration chart*

The pfa calibration chart is constructed as a chart, as shown in figure D.1.

NOTE. The vertical axis of the charts is not linear.

D.6.6 *Pfa calibration check*

Test one calibration sample at 0 % pfa and one calibration sample at 80 % pfa. If either result, when combined with the previous calibration results exceeds 0.12 kg/l then a full calibration shall be done.

D.7 Report

The data to be included in a test report are given in clause **10**.

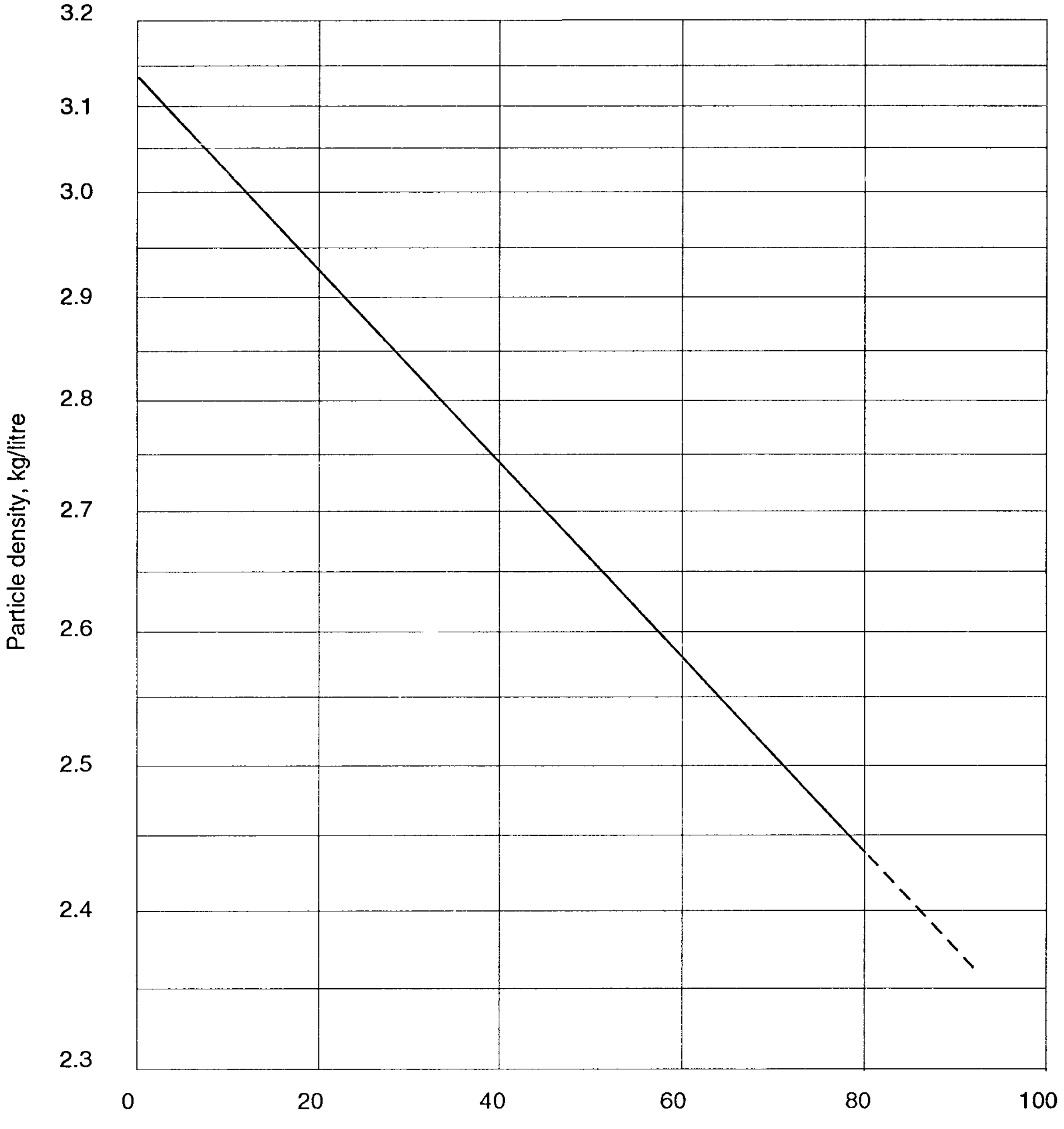


Figure D.1 Typical pfa calibration chart

Annex E (normative)

Ggbs determination: chemical method

E.1 General

The ground granulated blastfurnace slag (ggbs) content of concrete is expressed as a percentage of the total cement content. Before the ggbs content can be determined, the total cement content of the concrete is determined as described in clause **5**. A chemical test is then carried out on the recovered material to determine the ggbs content, using the apparatus described in **E.2**.

E.2 Apparatus

E.2.1 *Balance*, of at least 2 kg capacity, readable to 0.01 g.

E.2.2 *Balance insulation*, to protect the balance from the heat dissipated from the hot oven tray.

E.2.3 *Glass cloth*, 500 mm × 500 mm, used to contain particles of cement or ggbs that violently fracture during drying.

E.2.4 *Grinder*, with a capacity between 200 ml and 300 ml.

E.2.5 *Microwave oven*, with the following features:

a) a minimum power output of 1400 W;

b) integral timer capable of being set up to 10 min in 1 min intervals and reading to an accuracy of 1 s;

c) capable of enclosing a 300 mm × 200 mm × 40 mm deep oven tray.

E.2.6 *Oven tray*, made of heat-resistant glass and suitable for microwave oven temperatures.

E.2.7 *Oven gloves.*

E.2.8 *Wash bottles*, with fine and wide diameter nozzles.

E.2.9 *Chemical test apparatus*, similar to that shown in figure E.1, consisting of:

E.2.9.1 *Measuring cylinder*, 50 ml capacity, for measuring water and hydrochloric acid;

E.2.9.2 *Pliers*, used to break the sealed end of indicator tubes;

E.2.9.3 *Reaction vessel*, 500 ml capacity;

E.2.9.4 *Reaction vessel stopper assembly*, as shown in figure E.1 with the parts listed:

E.2.9.4.1 *Inflow funnel*, connected to the inflow pipe;

E.2.9.4.2 *Inflow pipe*, to the base of the reaction vessel when the stopper assembly is located in the reaction vessel;

E.2.9.4.3 *Outflow pipe*, from the stopper to the vacuum pump;

E.2.9.4.4 *Stopper*, which locates the inflow and outflow pipes.

E.2.9.5 *Sampling spoon*, a metal spoon to sample 1 g of dried slurry;

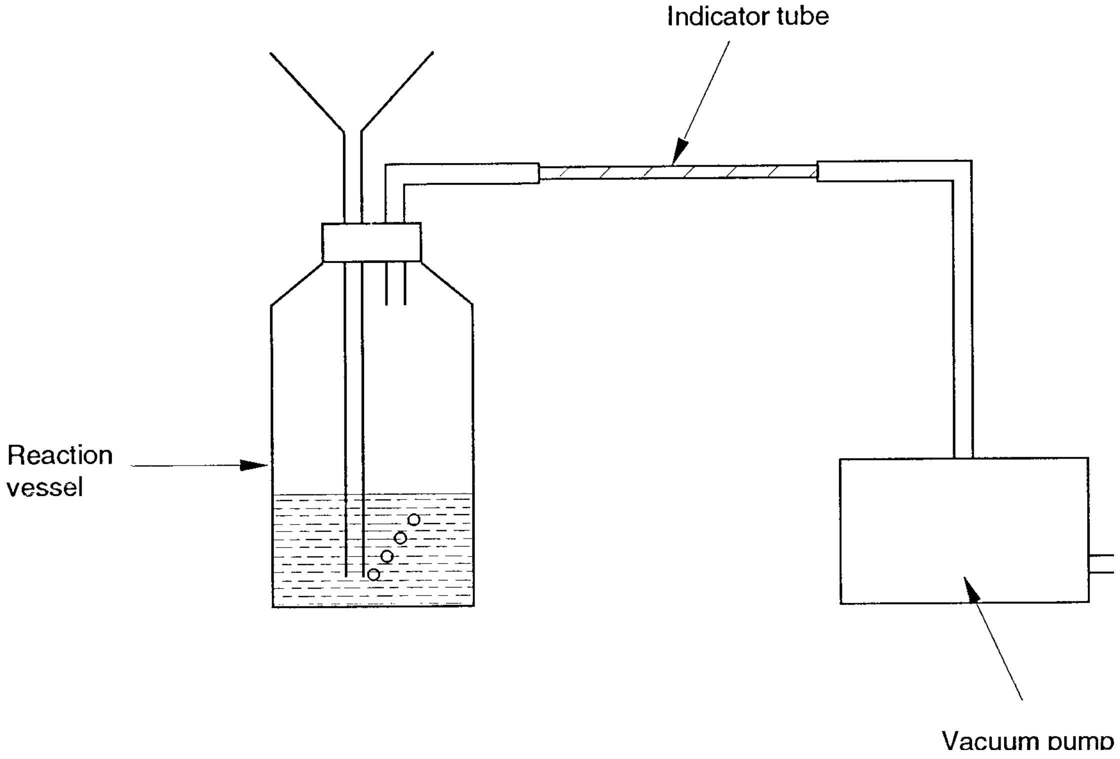


Figure E.1 Apparatus for chemical test

E.2.9.6 *Sample containers*, 300 ml to 500 ml capacity and air-tight to store dried slurry;

E.2.9.7 *Stopwatch*, reading to an hour and accurate to 1 s;

E.2.9.8 *Vacuum pump*, to draw off hydrogen sulfide gas from the reaction vessel through the chemical indicator tube.

E.2.10 *Consumables*, as listed below:

a) *hydrochloric acid*, 10 % dilute solution used to react with the sulfides in the dried slurry to produce hydrogen sulfide gas;

b) *indicator tubes*, which indicate the amount of hydrogen sulfide gas by the colour change of crystals.

E.3 Ggbs content test procedure

E.3.1 *General*

The ggbs test has to be carried out on the material recovered from one of the cement content tests detailed in clause **5**. As this material can be either:

- dry (pressure filter method); or
- wet (RAM method);

the sequence of the test depends on which of these two methods was used.

E.3.2 *Dry material*

Dry material is removed from the filter paper at the end of the pressure filter test. It is then ground and tested as described in **E.3.4** onwards.

E.3.3 *Recovery of flocculated slurry*

E.3.3.1 The flocculated slurry in the constant volume vessel is recovered after a RAM analysis machine test.

E.3.3.2 *Drying of flocculated slurry*

Weigh and record the mass of the glass oven tray and glass cloth. Spread the cloth over the tray so that there is an even lap over the sides of the tray. Transfer the flocculated slurry from the constant volume vessel into the cloth and oven tray, using a fine jet wash bottle to ensure that it is all recovered. Prop the tray at a slope of not more than 1:10 for approximately 1 min to allow the contents to settle, then remove excess clear water by carefully sucking into the wide jet wash bottle. Fold the loose ends of wrapper to cover the sample, then place the tray with its contents in the microwave oven.

The total drying time required depends on the amount of water that remains with the residue and the mass of the residue. Drying is achieved by initially drying the residue in the oven for 6 min at full power, removing the tray and contents from the oven, weighing it and recording the mass to the nearest 0.1 g. Drying continues in 1 min intervals until the reduction in mass is less than 0.3 g. A drying time of about 9 min is required for calibration samples containing 1000 g of cement. The dry mass of the slurry is calculated by subtracting the mass of the tray and cloth from the final mass of the tray, cloth and dried slurry.

E.3.4 Place the dry material into the coffee grinder and grind for 15 s, so that the dried powder is broken down to a uniform powder. Transfer the material to an air-tight container, ensuring that the lid is firmly located.

NOTE. The dried residue can be stored for seven days without any significant effect on the results obtained. However, after 28 days the sample may be significantly oxidized and produce erroneous results.

E.4 Preparation of chemical test apparatus

Prepare the chemical test apparatus as shown in figure E.1 as follows:

a) ensure the reaction vessel, the reaction vessel inflow funnel and pipe, and the 50 ml measuring cylinder are all clean;

b) measure 50 ml of tap water into the reaction vessel;

c) measure 50 ml of hydrochloric acid into the 50 ml cylinder;

d) record the indicator tube correction factor as supplied on the box of tubes, ensuring that the use by date has not passed;

e) using the pliers, break off the sealed ends of the indicator tube and locate the outflow end (the end to which the arrow points) into the plastic tube that goes to the suction side of the pump;

f) connect the other end of the indicator tube (the end with the scale reading zero) to the reaction vessel outflow tube. Do not place the reaction vessel stopper assembly on the reaction vessel at this stage;

g) turn on the pump and check it is functioning correctly.

E.5 Sampling dried material

Sample the dried material as follows:

a) remove the lid of the airtight container holding the material;

b) using a sample spoon, weigh out a 1 g sample to an accuracy of 0.01 g;

c) place the 1 g sample in the reaction vessel and gently rotate the vessel to ensure the sample is evenly dispersed in the water;

d) locate the reaction vessel stopper assembly into the reaction vessel ensuring that the lower end of the reaction vessel inflow pipe is below the surface of the water;

e) ensure that air is sucked into the reaction vessel inflow tube by checking that air bubbles are emerging from the lower end of the tube in the water at the bottom of the reaction vessel. Also check that no acid is in the reaction vessel funnel by observing that no colour change occurs in the indicator tube. If any colour change is observed then the apparatus is contaminated and should be cleaned. Pour the acid into the reaction vessel through the funnel and start the stopwatch;

f) agitate the sample by gently rocking the reaction vessel for 2 min;

g) record the length of colour change of the indicator tube to the nearest 1 mm, every 5 min, until two consecutive results at the same value are obtained. The time required to attain a constant reading is between 15 min and 25 min for residue samples at 20 % to 80 % ggbs respectively.

E.6 Calculation

The corrected indicator tube reading *R*, in mm, is calculated thus:

$$R = \frac{T}{F}$$

where

T is the measured tube reading, in mm;

F is the manufacturer's calibration factor for the batch of tubes.

Record the corrected indicator tube reading result.

E.7 Ggbs calibration

E.7.1 *Frequency of ggbs calibration and checking*

A full ggbs calibration is required:

a) where the source or sources of any of the constituent materials change;

b) when a calibration check indicates that the established calibration is not valid.

A calibration check is required:

1) at intervals not exceeding one week when the concrete mix is continually tested;

2) when a concrete mix has not been tested for over a week;

3) when there is a change in concrete mix proportions;

4) when there is a change in the silt content.

E.7.2 *Sampling materials*

Obtain representative samples of the aggregates by the method described in BS 812 : Part 102. Obtain representative samples of the cement and ggbs as used at the place of batching. Quantities required are shown in table E.1.

Table E.1 Materials required for ggbs calibration and calibration check

	Coarse aggregate kg	**Sand** kg	**Portland cement** kg	**Ggbs** kg
Ggbs calibration or ggbs calibration check (two samples)	20	20	5	5

After sampling each type of aggregate sampled is mixed thoroughly on a non-absorbent surface ready for weigh batching into samples.

E.7.3 *Batching samples*

Calculate the mix proportions required to make samples with 1000 g of cement, where the cement includes ggbs. Weigh batch the aggregate for each sample directly into a bucket.

A full ggbs calibration consists of:

- five test samples 20 % ggbs, 80 % Portland cement;
- five test samples 80 % ggbs, 20 % Portland cement.

E.7.4 *Testing ggbs calibration samples*

Test the 10 ggbs calibration samples using one of the total cement content test procedures detailed in clause **5**.

Carry out the additional ggbs chemical test procedure set out in **E.3**. Calculate the range and mean of each set of five results, one at the 20 % ggbs content, and one at the 80 % ggbs content. Where the ranges do not exceed 3.3 mm, the results are acceptable for a ggbs calibration.

E.7.5 *Ggbs calibration chart*

The ggbs calibration is constructed as a chart, as shown in figure E.2.

E.7.6 *Results from duplicate samples*

Where the difference between the ggbs content results for both samples is less than 5 %, the test is valid and the mean of the two results is reported as the ggbs content. Where the difference between the two ggbs content results exceeds 5 %, a valid result has not been obtained and a ggbs content cannot be reported.

E.8 Report

The data to be included in a test report are given in clause **10**.

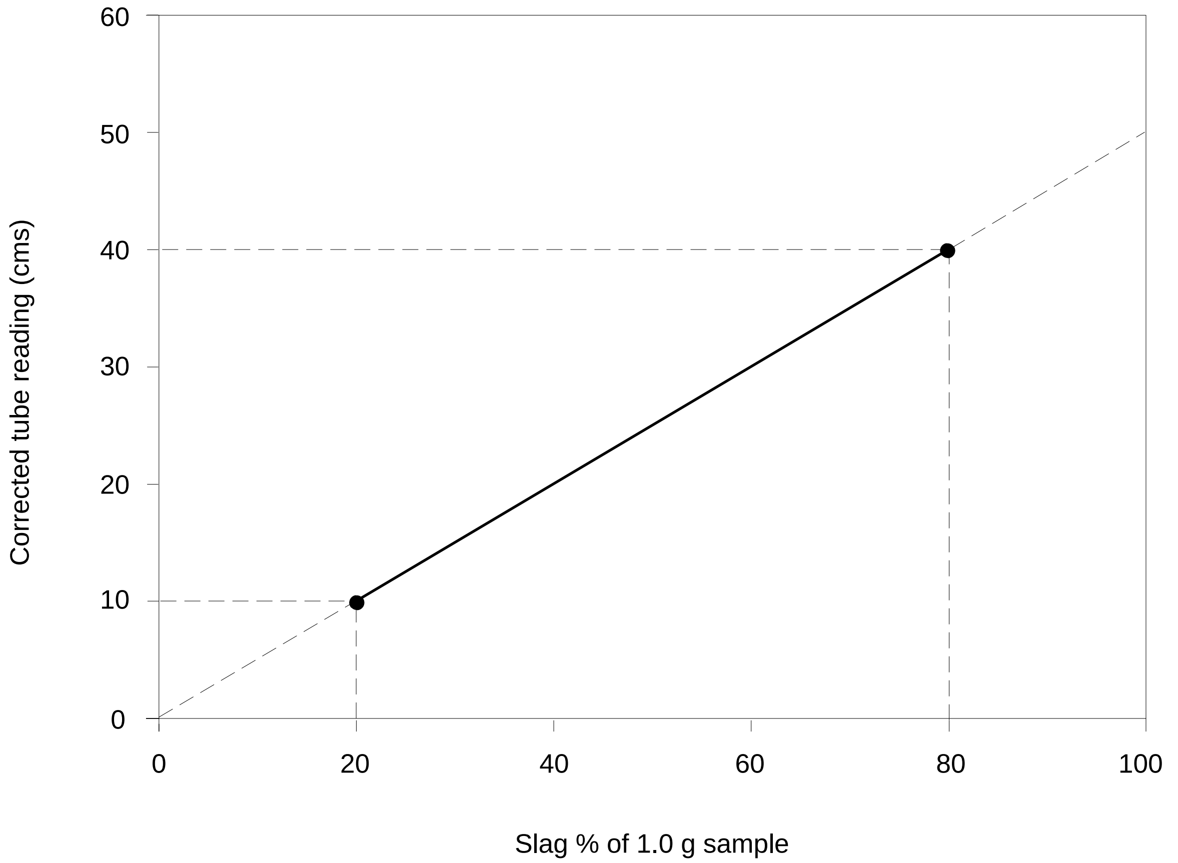


Figure E.2 Typical ggbs calibration chart

Annex F (normative)

Water content determination: oven drying method

F.1 General

This method is a modification of the method described in BS 812 : Part 109.

F.2 Apparatus

F.2.1 *Balance*, of at least 10 kg capacity, readable to 1 g.

F.2.2 *Balance insulation*, to protect the balance from the hot oven tray during weighing.

F.2.3 *Ventilated oven*, thermostatically controlled to maintain a temperature of (200 ± 5) °C.

F.2.4 *Heat resistant trays*, a convenient size is 400 mm × 300 mm × 75 mm.

F.2.5 *Air-tight cabinet*, in which the tray of concrete can be allowed to cool.

NOTE. Alternatively, containers with lids may be used.

F.3 Procedure

Weigh a clean, dry tray, and record its mass as M_1. Place a test sample, obtained as described in clause **4**, in the tray, weigh it and record the mass, M_2. Put the tray with the test sample in the oven and dry at a temperature of (200 ± 5) °C for at least 16 h. Remove the tray and sample from the oven and allow to cool in sealed conditions. Then weigh again and record the mass, M_3.

F.4 Calculation and expression of results

F.4.1 *Total water content*

Calculate the total water content as a percentage of the weight of the fresh concrete from the following equation:

$$\text{total water content} = \left(\frac{M_2 - M_3}{M_2 - M_1}\right) \times 100$$

where

M_1 is the mass of the tray;

M_2 is the mass of the tray and the fresh concrete;

M_3 is the mass of the tray and dried concrete.

F.4.2 ***Absorbed water content***

Calculate the dried to constant weight masses per cubic metre of the coarse aggregate W_A and the sand W_F on the basis of the nominal mix proportions or the results from clause **8**. Then:

absorbed water content (kg/m^3) = $(W_A \times F_A) + (W_F \times F_F)$

where

F_A is the water absorption (% of dry mass) of coarse aggregate;

F_F is the water absorption (% of dry mass) of sand.

NOTE. F_A and F_F are determined in accordance BS 812 : Part 2.

F.4.3 ***Free water content***

Free water content (kg/m^3) = Total water content (**F.4.1**) – Absorbed water content (**F.4.2**).

The result shall be reported to the nearest 5 kg/m^3.

F.5 Repeatability

If the difference between the two results is less than 10 kg/m^3, calculate the mean of the results and record as the free water content in kg/m^3 of the sample. If the difference exceeds 10 kg/m^3, discard the results.

F.6 Report

The data to be included in a test report are given in clause **10**.

Annex G (normative)

Water content determination: high temperature method

G.1 General

The total water content of fresh concrete is determined by drying samples to constant mass over a radiant heater or hot-plate. The free water content is the total water content less the water absorption of the aggregates.

G.2 Apparatus

G.2.1 *Balance*, of at least 10 kg capacity, readable to 1 g.

G.2.2 *Balance insulation*, to protect the balance from the hot oven tray during weighing.

G.2.3 *Heat resistant trays*, a convenient size is 400 mm × 300 mm × 75 mm.

G.2.4 *Spatula*, or other implement for stirring the test sample during drying.

G.2.5 *Oven gloves.*

G.2.6 *Heat source*, e.g. a radiant heater or hot-plate.

G.3 Procedure

G.3.1 Determine the total water content of each sub-sample of concrete obtained as described in clause **4**, by drying a (2.5 ± 0.5) kg test sample.

G.3.2 Weigh the test sample W_1, place it in the tray and heat it, taking care to ensure that the aggregate does not reach a temperature where spitting or decomposition occurs. During heating, stir the test sample with a spatula to avoid local overheating.

G.3.3 When all the water is considered to have been driven off, say after 20 min, weigh the test sample and record the mass. Continue heating and re-weighing at 5 min intervals until the difference between consecutive weighings is less than 0.1 % of the last recorded mass.

Record the final dry mass W_2.

G.4 Calculation of results

G.4.1 ***Total water content***

Total water content, in kg/m^3 =

$$\frac{W_1 - W_2}{W_1} \times \text{mass per cubic metre of compacted fresh concrete}$$

where

W_1 is the mass of the test sample as in **G.3.2**;

W_2 is the mass of the dried sample as in **G.3.3**.

G.4.2 ***Absorbed water content***

Calculate the dried to constant weight masses per cubic metre of the coarse aggregate W_A and the sand W_F on the basis of the nominal mix proportions or the results from clause **8**, then:

absorbed water content (kg/m^3) = $(W_A \times F_A) + (W_F \times F_F)$

where

F_A is the water absorption (% of dry mass) of coarse aggregate;

F_F is the water absorption (% of dry mass) of sand.

NOTE. F_A and F_F are determined in accordance BS 812 : Part 2.

G.4.3 ***Free water content***

Free water content (kg/m^3) = total water content (**G.4.1**) – absorbed water content (**G.4.2**).

The result shall be reported to nearest 5 kg/m^3.

G.5 Repeatability

If the difference between the two results is less than 10 kg/m^3, calculate the mean of the results and record as the free water content in kg/m^3 of the sample. If the difference exceeds 10 kg/m^3, discard the results.

G.6 Report

The data to be included in a test report are given in clause **10**.

Annex H (normative)

Water content determination: microwave oven method

H.1 General

The total water content of fresh concrete is determined by drying samples to constant mass in a microwave oven. The free water content, which is the amount of water that is free to react with cement, is the total water content less the water absorption of the aggregates.

H.2 Apparatus

H.2.1 *Balance*, of at least 10 kg capacity, readable to 0.1 g.

H.2.2 *Balance insulation*, to protect the balance from the hot oven tray during weighing.

H.2.3 *Glass cloth*, used to contain particles of cement or pfa that violently fracture during drying in the microwave oven.

H.2.4 *Microwave oven*, with the following features:

a) minimum power output of 1400 W;

b) integral timer capable of being set up to 10 min in 1 min intervals and reading to an accuracy of 1 s;

c) capable of enclosing a 300 mm × 200 mm × 40 mm oven tray.

H.2.5 *Oven tray*, made of heat-resistant glass and suitable for use at microwave oven working temperatures. The tray to have a nominal area of 0.06 m^2 and be at least 30 mm deep.

H.2.6 *Oven gloves*.

H.2.7 *Scoop*, made from non-corrodible metal or plastics suitable for taking scoopfuls of concrete weighing 2 kg to 3 kg.

H.2.8 *Splitting pan*, 180 mm deep and 400 mm diameter with smooth internal surfaces and carrying handles. Only required if concrete is sampled indirectly.

H.2.9 *Squeegee*, rubber or plastic pad used to recover fine particles and water from the inside of the splitting pan and surfaces of sampling scoops.

H.3 Procedure

H.3.1 *Preparation of apparatus*

Weigh and record the mass of both oven tray and glass cloths, to the nearest 0.1 g. Spread the cloths over each tray so that there is an even lap over the sides of the tray.

H.3.2 *Concrete samples*

Collect a sample mass of between 4 kg and 6 kg in accordance with clause **4**. Thoroughly mix this sample, divide into two equal halves and place on the glass cloths in the two oven trays. Recover all fines and water from the container and the scoop using the squeegee, ensuring that this material is also equally divided into the two trays.

NOTE. The amount of non-recoverable water and fines left must not exceed 50 g.

Weigh and record the mass of each sample, cloth and tray. Calculate the wet mass W_1 of each sample by subtracting the appropriate mass of the cloth and tray.

H.3.3 *Drying to constant mass*

Fold the loose ends of wrapper over to cover the sample, and place the tray with its contents in the microwave oven. Dry the residue in the oven for 6 min at full power. Remove the tray and contents from the oven, weigh and record the mass to the nearest 0.1 g. As the oven tray is hot the balance should be protected with insulation. Continue drying and re-weighing in 1 min intervals until the reduction in mass is less than 1.0 g. Under no circumstances should drying continue beyond this point as excessively high temperatures can be generated that could damage the apparatus.

NOTE. The total drying time of concrete samples is normally less than 20 min.

Weigh and record the mass W_2 of each dry sample, cloth and tray. Calculate the mass of water lost from each sample by subtracting the dry mass of each sample, cloth and tray from the mass of wet sample, cloth and tray.

H.4 Calculation of results

H.4.1 *Total water content*

Total water content(kg/m^3) =

$$\frac{W_1 - W_2}{W_1} \times \text{mass per cubic metre of compacted fresh concrete}$$

where

W_1 is mass of test sample as in **H.3.2**;

W_2 is mass of dried sample as in **H.3.3**.

H.4.2 *Absorbed water content*

Calculate the oven-dry masses per cubic metre of the coarse aggregate W_A and the sand W_F on the basis of nominal mix proportions or the result from clause **8**, then:

$$\text{absorbed water content (kg/m}^3\text{)} = (W_A \times F_A) + (W_F \times F_F)$$

where

F_A is the water absorption (% of dry mass) of coarse aggregate;

F_F is the water absorption (% of dry mass) of sand.

NOTE. F_A and F_F are determined in accordance with BS 812 : Part 2.

H.4.3 *Free water content*

Free water content = total water content (**H.4.1**.) – absorbed water content (**H.4.2**).

The result shall be reported to the nearest 5 kg/m^3.

H.5 Repeatability

If the difference between the two results is less than 10 kg/m^3, calculate the mean of the results and record the free water content of the sample. If the difference exceeds 10 kg/m^3, discard the results.

H.6 Report

The data to be included in a test report are given in clause **10**.

Annex J (informative)

Laboratory assessment of accuracy and repeatability of test methods

J.1 General

J.1.1 ***Description***

This procedure involves preparing 20 batches of concrete in a laboratory, dividing each batch into two test samples, and measuring the required results for the test method under examination. The batches prepared in this procedure are of a similar size to the samples that would be taken in practice from production batches of concrete. Duplicate determinations of the density of fresh concrete are also carried out.

J.1.2 ***Applicability***

This procedure measures the bias and repeatability of an analysis method. The procedure should be used by a laboratory to gain experience with an analysis method. A numerical criterion is given in the calculations which can be used to judge whether the repeatability achieved is satisfactory.

J.2 Preparations

J.2.1 ***Materials***

Obtain sufficient aggregates and cement for the calibration tests if required by the analysis method, for the two batches required for density determinations and for the 20 batches required by the laboratory procedure. It is essential to prevent, as far as possible, segregation of very fine material from the fine and coarse aggregate. For this reason it is recommended that the aggregates should be kept damp, in sealed containers.

J.2.2 ***Apparatus***

J.2.2.1 *Mechanical mixer*, capable of producing well mixed batches of concrete of the size required by the test procedure.

J.2.2.2 The apparatus required by the analysis method.

J.2.2.3 The apparatus required for the determination of plastic density, as described in BS 1881 : Part 107.

J.2.3 ***Batch size and batch mass***

Using the specified mix proportions, calculate the batch mass to provide samples for the analysis method under examination. Choose the amount of water to be added to a batch so as to produce a mix of medium workability unless it is considered necessary to obtain results for mixes of high or low workability. Calculate the batch mass required to satisfy these conditions, and use the same throughout the series of tests. If the batch size of approximately 25 kg required for the plastic density determinations is larger than that required for the cement content determinations, calculate the batch mass similarly, using the same mix proportions.

J.3 Test programme

J.3.1 ***Calibration tests***

If necessary, carry out the calibration tests required by the analysis method, using representative samples of the materials.

J.3.2 ***Batching and mixing***

Reduce the bulk samples of the aggregates as described in BS 812 : Part 102. Weigh each aggregate fraction, the cement and the added water, to an accuracy of ± 0.1 % or 5 g, whichever is the larger, using the batch mass calculated in **J.2.3**.

J.3.3 ***Determination of the density of fresh concrete***

Prepare two batches for this purpose and measure the density of each, using the method described in BS 1881 : Part 107. Record the average of the two results.

J.3.4 ***Examination of test methods***

Carry out the test method as described in clause **5** on each of the duplicate samples taken from the 20 batches prepared for this purpose. Measure the results for each duplicate sample by the analysis method under examination before the subsequent batch is mixed. Note the overall time from mixing the concrete to completing the analysis of the duplicate samples.

J.3.5 ***Recording of data***

Record the following:

a) the plastic density;

b) the batch mass used for cement content determinations;

c) the mass of each test sample;

d) the measured cement content of each test sample;

e) the time taken to prepare and analyse the batch.

J.4 Calculations

J.4.1 ***Labelling***

Number the batches 1 to 20 and the duplicate test samples a and b.

J.4.2 ***Conversion of cement content to mass per cubic metre of concrete***

Using the mass of cement batched and the measured density of the fresh concrete, calculate the cement content of each batch of concrete in kilograms per cubic metre. Calculate the analysis result for each test sample.

J.4.3 *Statistical analysis*

The procedure for carrying out the calculations is as follows. A worked example is given in table J.1.

a) *Estimate of bias.* The average of the values in column (5) of table J.1 is the bias of the analysis method due to testing. In table J.1, the bias is less than 1.0 kg/m^3 which is not unexpected with an analysis method based on a calibration procedure.

b) *Estimate of repeatability.* Repeatability r is calculated from the following equation:

$$r = \sqrt{2} \times 1.96 \times \text{standard deviation for duplicate results}$$

$$= \sqrt{2} \times 1.96 \times \sqrt{\frac{984}{20}}$$

$$= 19\ \text{kg/m}^3.$$

If r is less than 20 kg/m^3, the repeatability of the analysis method is satisfactory. By this criterion the repeatability of the method used to obtain the results in table J.1 is satisfactory.

Table J.1 Estimate of repeatability

Batch number	**Batched cement content** kg/m^3	**Measured cement content** kg/m^3		**Derived values**		
		Test sample a	**Test sample b**	$\frac{(3) + (4)}{2} - (2)$	(3) − (4)	[(3) − (4)]^2
(1)	(2)	(3)	(4)	(5)	(5)	(7)
1	350	344	340	− 8	4	16
2	350	339	328	−16	11	121
3	350	356	360	+ 8	4	16
4	350	365	373	+ 19	8	64
5	350	346	353	0	7	49
6	350	349	348	− 1	1	1
7	350	345	346	− 4	1	1
8	350	342	346	− 6	4	16
9	350	339	348	− 6	9	81
10	350	355	359	+ 7	4	16
11	350	330	335	−17	5	25
12	350	357	372	+ 15	15	225
13	350	346	348	− 3	2	4
14	350	345	341	− 7	4	16
15	350	355	338	− 3	17	289
16	350	350	345	− 2	5	25
17	350	355	355	+ 5	0	0
18	350	358	355	+ 7	3	9
19	350	347	344	− 4	3	9
20	350	350	352	+ 1	1	1
		Mean = 349 kg/m^3				Σ = 984

List of references (see clause **2**)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 410 : 1986	*Specification for test sieves*
BS 812	*Testing aggregates*
BS 812 : Part 2 : 1995	*Methods for determination of density*
BS 812 : Part 102 : 1989	*Methods for sampling*
BS 812 : Part 103	*Method for determination of particle size distribution*
BS 812 : Section 103.1 : 1985	*Sieve tests*
BS 812 : Part 109 : 1990	*Methods for determination of moisture content*
BS 1881	*Testing concrete*
BS 1881 : Part 101 : 1983	*Method of sampling fresh concrete on site*
BS 1881 : Part 102 : 1983	*Method for determination of slump*
BS 1881 : Part 107 : 1983	*Method for determination of density of compacted fresh concrete*
BS 6100	*Glossary of building and civil engineering terms*
BS 6100 : Part 6	*Concrete and plaster*
BS 6100 : Section 6.2 : 1986	*Concrete*
BS 6100 : Section 6.3 : 1986	*Aggregates*
BS 6610 : 1996	*Specification for Pozzolanic pulverized-fuel ash cement*
BS EN 196	*Methods of testing cement*
BS EN 196 : Part 6 : 1992	*Determination of fineness*
BS EN 196 : Part 7 : 1992	*Methods of taking and preparing samples of cement*

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