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Testing concrete —

Part 106: Methods for determination of air content of fresh concrete

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Committees responsible for this British Standard

This British Standard was published under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee CAB/–. Its preparation was entrusted to Technical Committee CAB/4 upon which the following bodies were represented:

British Aggregate Construction Materials Industries
British Precast Concrete Federation Ltd.
British Ready Mixed Concrete Association
Cement Admixtures Association
Cement and Concrete Association
Cement Makers' Federation
Concrete Society Limited
County Surveyor's Society
Department of the Environment (PSA)
Department of the Environment (Building Research Establishment)
Department of the Environment (Transport and Road Research Laboratory)
Department of Transport
Electricity Supply Industry in England and Wales
Federation of Civil Engineering Contractors
Greater London Council
Institute of Concrete Technology
Institution of Civil Engineers
Institution of Highway Engineers
Institution of Municipal Engineers
Institution of Structural Engineers
Institution of Water Engineers and Scientists
National Federation of Building Trades Employers
Royal Institute of British Architects
Royal Institution of Chartered Surveyors
Sand and Gravel Association Limited
Society of Chemical Industry

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Civil Engineering Test Equipment Manufacturers' Association
Coopted members

This British Standard, having been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee, was published under the authority of the Standards Board and comes into effect on 31 May 1983

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Contents

Foreword

This Part of this British Standard, prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee, is a revision of clause **6** of BS 1881-2:1970. This revision includes two methods of measuring the total air content, one of which is a revision of the method included in the 1970 edition.

Testing in accordance with both methods given in this Part of this standard will comply with ISO 4848. Together with Parts 102, 103, 104 and 107, this Part of BS 1881 supersedes BS 1881-2:1970, which is withdrawn.

No estimate of repeatability or reproducibility is given in this Part of this British Standard. Reference should be made to BS 5497-1 for further information on the determination of repeatability and reproducibility.

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

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Summary of pages

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

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

1 Scope

This Part of this British Standard describes two methods for determination of air content of compacted fresh concrete, made with normal weight or relatively dense aggregate having a nominal maximum size of 40 mm or less. Neither of the methods is applicable to aerated concrete, very stiff concrete which cannot be compacted by vibration alone nor to concrete made with lightweight aggregates, air cooled blast-furnace slag or aggregates of high porosity.

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

2 Definitions

For the purposes of this Part of this British Standard, the definitions given in BS 5328 and BS 1881-101 apply.

3 Sampling

Obtain the sample of fresh concrete by the procedure given in BS 1881-101 or BS 1881-125. Commence the determination of air content as soon as possible after sampling.

4 Preparing the sample for test

4.1 Apparatus

4.1.1 *Sampling tray*, minimum dimensions 900 mm × 900 mm × 50 mm deep of rigid construction and made from a non-absorbent material not readily attacked by cement paste.

4.1.2 *Square mouthed shovel*, size 2 in accordance with BS 3388.

4.2 Procedure. Empty the sample from the container(s) on to the sampling tray. Ensure that no more than a light covering of slurry is left adhering to the container(s).

Thoroughly mix the sample by shovelling it to form a cone on the sampling tray and turning this over with the shovel to form a new cone, the operation being carried out three times. When forming the cones deposit each shovelful of the material on the apex of the cone so that the portions which slide down the sides are distributed as evenly as possible and so that the centre of the cone is not displaced. Flatten the third cone by repeated vertical insertion of the shovel across the apex of the cone, lifting the shovel clear of the concrete after each insertion.

NOTE The following modifications to the mixing procedures may be necessary when preparing samples of very high workability concrete (e.g. superplasticized concrete) for test.

a) *Sampling tray*. The vertical lips on the edges of the tray may have to be larger to contain the sample without spillage during mixing.

b) *Mixing the sample*. The coning procedure is not suitable for very high workability concrete and the following alternative method of mixing is recommended. Having poured the concrete on to the sampling tray, use the shovel to turn the concrete from the outside toward the centre, working progressively once round all sides of the sampling tray.

CAUTION. When cement is mixed with water, alkali is released. Take precautions to avoid dry cement entering the eyes, mouth and nose when mixing concrete. Prevent skin contact with wet cement or concrete by wearing suitable protective clothing. If cement or concrete enters the eye, immediately wash it out thoroughly with clean water and seek medical treatment without delay. Wash wet concrete off the skin immediately.

5 Method A

5.1 General. In this method, the operational principle consists of introducing water to a predetermined height above a sample of concrete of known volume and the application of a predetermined air pressure over the water. The reduction in volume of the air in the concrete sample is measured by observing the amount the water level is lowered under the applied pressure, the latter amount being calibrated in terms of percentage of air in the concrete sample.

5.2 Apparatus

5.2.1 *General*. The apparatus, one form of which is shown diagrammatically in Figure 1, consists of the following.

5.2.2 *Container*. A flanged cylindrical vessel of steel or other hard metal, not readily attacked by cement paste, having a nominal capacity of at least 5 L and a ratio of diameter to height of not less than 0.75 nor more than 1.25. The outer rim and upper surface of the flange and the interior surfaces of the vessel shall be machined to a smooth finish. The container shall be watertight and in addition it and the cover assembly shall be suitable for an operating pressure of approximately 100 kN/m^2 and be sufficiently rigid to limit the pressure expansion constant, *D*, (see **5.3.4**) to not more than 0.1 % air content.

5.2.3 *Cover assembly*. A flanged rigid conical cover fitted with a standpipe. The cover shall be of steel or other hard metal not readily attacked by cement paste and shall have interior surfaces inclined at not less than 10° from the surface of the flange. The outer rim and lower surface of the flange and the sloping interior face shall be machined to a smooth finish. The cover shall have provision for being clamped to the container to make a pressure seal without entrapping air at the joint between the flanges of the cover and the container.

The standpipe shall consist of a graduated glass tube of uniform bore, or a metal tube of uniform bore with a glass gauge attached. The graduated scale shall indicate air content from 0 % to at least 8 % and preferable 10 %. The scale shall be graduated with divisions every 0.1 % air content, the divisions being not less than 2 mm apart. A scale in which 25 mm represents 1 % of air content is convenient.

The cover shall be fitted with a suitable device for venting of the air chamber, a non-return air inlet valve and a small valve for bleeding off water. The applied pressure shall be indicated by a pressure gauge connected to the air chamber above the water column. The gauge shall be graduated with divisions every 5 kN/m^2, the divisions not being less than 2 mm apart. The gauge shall have a full scale reading of 200 kN/m^2.

5.2.4 *Calibration cylinder*. A hollow cylindrical measure of brass or other strong non-corrodible metal, having a capacity of approximately 0.3 L. The rim of the cylinder shall be machined to a smooth plane surface at right angles to the axis of the cylinder.

5.2.5 *Support*. A support for the calibration cylinder made of non-corrodible material and which will allow free flow of water into and out of the cylinder in the inverted position.

5.2.6 *Spring*. A non-corrodible coil spring or equivalent for retaining the calibration cylinder in place.

5.2.7 *Transparent plates*. Two rigid transparent plates, one suitable for use as a closure for the calibration cylinder and one as a closure for the container.

5.2.8 *Deflecting plate or spray tube*. A thin non-corrodible disc of not less than 100 mm diameter to minimize disturbance of the concrete when water is added to the apparatus. Alternatively a brass spray tube of appropriate diameter which may be an integral part of the cover assembly or provided separately. The spray tube shall be constructed so that when water is added to the container it is sprayed on to the walls of the cover in such a manner as to flow down the sides causing minimum disturbance to the concrete.

5.2.9 *Air pump*. A hand pressure pump such as a bicycle tyre pump with a lead facilitating connection to the non-return air inlet valve on the cover assembly.

5.2.10 *Scoop*, as described in **3.1** of BS 1881-101:1983.

5.2.11 *Compacting bar or vibrator*. Compacting bar made from iron or steel, weighing 1.8 ± 0.1 kg, at least 380 mm long and having a ramming face 25.0 ± 0.5 mm square, or a vibrating hammer or table suitable for compacting the concrete in accordance with **5.5.2** or **5.5.3**.

5.2.12 *Container with spout*. A container fitted with a spout having a capacity of 2 L to 5 L to fill the apparatus with water.

5.2.13 *Mallet*. A soft-faced mallet with a mass of approximately 250 g.

5.2.14 *Balances*. A balance capable of weighing up to 1 kg to an accuracy of ± 0.5 g over the range used in the test and a balance capable of weighing up to 20 kg to an accuracy of ± 5 g over the range used in the test.

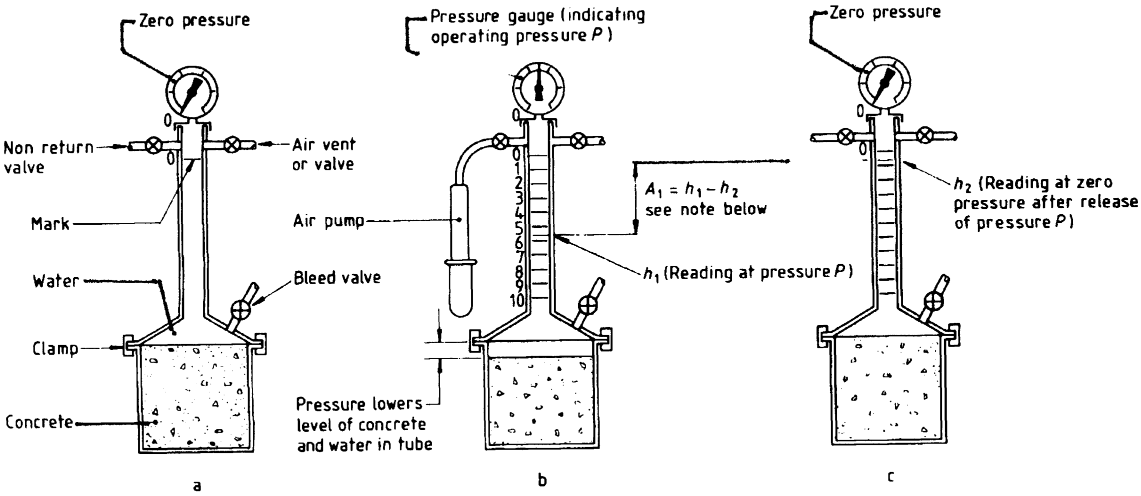
These balances shall be calibrated on initial commissioning and at least annually thereafter using weights of which the accuracy can be traced to the national standard of mass.

The balances shall be checked after relocation or disturbance. A certificate stating the accuracy shall be obtained from the organization carrying out the check.

5.3 Calibration of apparatus

5.3.1 *General*. The calibration tests described in **5.3.2**, **5.3.3**, **5.3.4** and **5.3.5** shall be made at the time of the initial calibration of the apparatus and at any time when it is necessary to check whether the capacity of the calibration cylinder or container may have changed. The calibration test described in **5.3.6** and **5.3.7** shall be made as frequently as necessary to check the pressure gauge so as to ensure that the proper gauge pressure, P, is being used. Recalibration of the apparatus will also be required when the location at which it is to be used varies in elevation by more than 200 m from that at which it was last calibrated.

5.3.2 *Capacity of the calibration cylinder*. Using the 1 kg balance, determine the capacity of the calibration cylinder by measuring the mass of water required to fill it. For this purpose, fill the weighed cylinder with water at ambient temperature (15 °C to 25 °C) and carefully cover it with the previously weighed transparent plate, ensuring that no air bubbles are trapped under the plate and that surplus water is wiped away before weighing the assembly. By repeating this procedure, make a total of three weighings of the covered cylinder filled with water. Calculate the average mass of water, m_1, contained in the full cylinder and record it to the nearest 0.5 g.



NOTE. $A_1 = h_1 - h_2$ when the container holds concrete as shown in this figure: when the container holds only aggregate and water $h_1 - h_2 = G$ (aggregate correction factor). $A_1 - G = A_c$ (air content of concrete).

Figure 1 — Method A apparatus

5.3.3 *Capacity of the container.* Using the 20 kg balance, determine the capacity of the container by measuring the mass of water required to fill it. For this purpose, smear a thin film of grease on the flange of the container, and, after weighing empty, fill with water at ambient temperature (15 °C to 25 °C) and make a watertight joint by sliding the weighed transparent plate over the top of the container, ensuring that no air bubbles are trapped under the plate and that surplus water is wiped away before weighing the assemply. By repeating this procedure, make a total of three weighings of the covered container filled with water. Calculate the average mass of water, m_2, contained in the full container and record it to the nearest 5 g.

5.3.4 *Pressure expansion constant, e.* The pressure expansion constant is determined by filling the apparatus with water, making sure that all entrapped air has been removed and the water level is exactly on the zero mark, and applying an air pressure of 100 kPa (100 kN/m^2). The reading of the water column (in percent air content) will be the pressure expansion constant, e, for the apparatus.

NOTE Strictly speaking, the air pressure applied during this procedure should be the required operating pressure P determined as in **5.3.6**. However, as the value of e is needed to determine P by way of the calibration constant K a logically closed cycle of operations exists. In practice, the change in e due to a change in P is small enough to be ignored. As P is commonly about 100 kPa, this value is prescribed to overcome the problem. Its use will lead to a value of e that is sufficiently accurate for the test.

5.3.5 *Calibration constant, K.* The calibration constant is the reading needed on the air content scale during the routine calibration procedure to obtain the gauge pressure required to make the graduations on the air content scale correspond directly to the percentage of air introduced into the container by the calibration cylinder when the container is full of water.

The constant, K, is generally calculated as follows (see note):

$$K = 0.98\,R + e$$

where

e is the pressure expansion constant (see **5.3.4**);

R is the capacity of the calibration cylinder expressed relative to the capacity of the container and is calculated as follows:

$$R = \frac{m_1}{m_2} \cdot 100\ \% \quad \text{(see \textbf{5.3.2} and \textbf{5.3.3})}$$

NOTE The factor 0.98 is used to correct for the reduction in the volume of air in the calibration vessel when it is compressed by a depth of water equal to the depth of the container. This factor is approximately 0.98 for a 200 mm deep container at sea level. Its value decreases to approximately 0.975 at 1 500 m above sea level and 0.970 at 4 000 m above sea level. The value of the constant will decrease by about 0.01 for each 100 mm increase in bowl depth. Hence the term 0.98R represents the effective volume of the calibration vessel expressed as a percentage of the container under normal operating conditions.

5.3.6 *Required operating pressure*. Place the calibration cylinder support centrally on the bottom of the clean container and place the cylinder on the support with its open end downward. Place the coil spring on the cylinder and clamp the cover assembly carefully in place.

Fill the apparatus with water at ambient temperature to a level above the zero mark on the air content scale. Close the air vent and pump air into the apparatus approximately to the operating pressure (about 100 kPa). Lightly tap the sides and cover with the mallet to remove as much entrapped air as possible adhering to the interior surfaces of the apparatus and gradually reduce the pressure by opening the vent. Bring the water level exactly to the zero mark by bleeding water through the small valve in the conical cover and close the air vent. Apply pressure by means of the pump until the reading of the water level equals the calibration constant, K (see **5.3.5**). Record the pressure, P, indicated on the pressure gauge. Gradually release the pressure by opening the vent until zero pressure is indicated. If the water level returns to a reading less than 0.05 % air content, take the pressure, P, as the operating pressure. If the water level fails to return to a reading below 0.05 % air content, check the apparatus for leakage and repeat the procedure.

5.3.7 *Alternative operating pressure*. The range of air contents which can be measured with a particular apparatus can be extended by determining an appropriate alternative operating pressure, e.g. if the range is to be doubled the alternative operating pressure, P_1, is that for which the apparatus indicates half of the calibration reading, K, (see **5.3.5**).

Exact calibration will require the determination of the pressure expansion constant, e (see **5.3.4**) for the reduced operating pressure but, since the change in the pressure expansion constant can normally be disregarded, the alternative operating pressure can be determined during the determination of the normal operating pressure (see **5.3.6**).

5.4 Aggregate correction factor

5.4.1 *General*. The aggregate correction factor will vary with different aggregates and although it will remain reasonably constant for a particular aggregate an occasional check should be carried out. The aggregate correction factor can be determined only by test as it is not directly related to the water absorption of the particles.

5.4.2 *Aggregate sample size*. Determine the aggregate correction factor by applying the operating pressure on a combined sample of the coarse and fine aggregates in the approximate proportions and moisture conditions that exist in the concrete sample. Obtain the sample of aggregates either by washing the cement from the concrete sample tested for air content, through a 150 µm BS 410 sieve, or by using a combined sample of fine and coarse aggregate similar to that used in the concrete. In the latter case calculate the masses of fine and coarse aggregates to be used, m_f and m_c, respectively as follows:

$$m_f = V_o D p_f$$

$$m_c = V_o D p_c$$

where

p_f and p_c are the proportions of fine and coarse aggregates, respectively, expressed as fractions by mass of the total concrete mix (aggregates, cement and water);

V_o is the capacity of the container (in m^3) (see **5.3.3**);

D is the density of the concrete to be tested (in kg/m^3), determined in accordance with BS 1881-107 or calculated from the known proportions and densities of the materials and the nominal air content.

5.4.3 *Filling the container*. Partially fill the container of the apparatus with water and introduce the combined sample of aggregate in small scoopfuls. This shall be done in such a manner as to entrap as little air as possible and if necessary add additional water to inundate all of the aggregate. After the addition of each scoopful remove any foam promptly then stir the aggregate with the compacting bar and tap the container with the mallet to release any entrapped air.

5.4.4 *Determination of aggregate correction factor*. When all the aggregate has been placed in the container wipe clean the flanges of the container and clamp the cover in position. Fill the apparatus with water and tap lightly with the mallet to remove air adhering to the interior surfaces of the apparatus. Bring the level of the water in the standpipe to zero by bleeding through the small valve with the air vent open. Close the air vent and apply the operating pressure, P, by means of the air pump.

Record the reading of the gauge tube as h_1, release the pressure and take a further reading, h_2. Repeat the entire procedure once, obtaining a second pair of readings, h_1 and h_2. Take the average value of $h_1 - h_2$ as the aggregate correction factor, G, unless the two values of $h_1 - h_2$ differ by more than 0.1 % air content in which case carry out further determinations until consistent results are obtained.

5.5 Compaction of the concrete

5.5.1 *General*. Place the sample of concrete to be tested in the container in such a way as to remove as much entrapped air as possible (without significantly reducing the amount of entrained air, if present) and to produce full compaction of the concrete with neither excessive segregation nor laitance. For this purpose, by means of the scoop, place the concrete in the container in three layers approximately equal in depth and compact each layer by using either the compacting bar or the vibrator in the manner described below in **5.5.2** or **5.5.3**. If the concrete has a slump greater than approximately 75 mm, do not use vibration.

The quantity of material used in the final layer shall be, as nearly as possible, just sufficient to fill the container without having to remove excess material. A small quantity of additional concrete may be added if necessary and further compacted in order to just fill the container, but the removal of excess material should be avoided.

5.5.2 *Compacting with compacting bar*. When compacting each layer with the compacting bar, distribute the strokes of the compacting bar in a uniform manner over the cross section of the container, and ensure that the compacting bar does not penetrate significantly any previous layer nor forcibly strike the bottom of the container when compacting the first layer. The number of strokes per layer required to produce full compaction will depend upon the consistence of the concrete but in no case shall the concrete be subjected to fewer than 25 strokes per layer. In order to remove pockets of entrapped air but not the entrained air, after compaction of each layer tap the sides of the container smartly with the mallet until large bubbles of air cease to appear on the surface and depressions left by the compacting bar are removed. Record the number of strokes.

5.5.3 *Compacting with the vibrator*. When compacting each layer by means of the vibrating hammer or table use applied vibration of the minimum duration necessary to achieve full compaction of the concrete. Over-vibration may cause excessive segregation and laitance or loss of entrained air, if present. The required duration of vibration will depend upon the consistency of the concrete and the effectiveness of the vibrator and vibration shall cease as soon as the surface of the concrete becomes relatively smooth and has a glazed appearance. Record the duration of vibration.

5.6 Procedure. Wipe the flanges of the container and of the cover assembly thoroughly clean and in the absence of the spray tube, place the deflecting plate, if used, centrally on the concrete and pressed into contact with it. Clamp the cover assembly in place, care being taken to ensure that there is a good pressure seal between the cover and the container. Fill the apparatus with water and tap lightly with the mallet to remove air adhering to the interior surfaces of the cover. Bring the level of water in the standpipe to zero by bleeding through the small valve with the air vent open. Close the air vent and apply the operating pressure, P, by means of the air pump.

Record the reading on the gauge tube, h_1, and release the pressure. Read the gauge tube again and if the reading, h_2 is 0.2 % air content or less record the value $h_1 - h_2$ as the apparent air content, A_1, to the nearest 0.1 % air content. If h_2 is greater than 0.2 % air content apply the operating pressure, P, again, giving a gauge tube reading h_3 and a final reading h_4 after release of the pressure. If $h_4 - h_2$ is 0.1 % air content or less record the value $h_3 - h_4$ as the apparent air content. If $h_4 - h_2$ is greater than 0.1 % air content it is probable that leakage is occurring and the test shall be disregarded.

6 Method B

6.1 General. In this method the operational principle consists of merging a known volume of air at a known pressure in a sealed air chamber with the unknown volume of air in the concrete sample, the dial on the pressure gauge being calibrated in terms of percentage of air for the resultant pressure.

6.2 Apparatus

6.2.1 *General*. The apparatus, one form of which is shown diagrammatically in Figure 2 consists of the following.

6.2.2 *Container*. A flanged cylindrical vessel of steel or other hard metal, not readily attacked by cement paste, having a nominal capacity of at least 5 L and a ratio of diameter to height of not less than 0.75 or more than 1.25. The outer rim and the interior surfaces of the vessel shall be machined to a smooth finish. The container shall be watertight and in addition it and the cover assembly shall be suitable for an operating pressure of approximately 200 kN/m^2.

6.2.3 *Cover assembly*. A flanged rigid cover of steel or other hard metal not readily attacked by cement paste. The outer rim and lower surface of the flange as well as the interior surfaces shall be machined to a smooth finish. The cover shall have provision for being clamped to the container to make a pressure seal without entrapping air at the joint between flanges of the cover and the container.

The cover assembly shall be fitted with a pressure gauge calibrated to indicate air content from 0 % to at least 8 % and preferably 10 %. Up to an air content of 6 % the scale of the gauge shall be graduated with divisions every 0.1 % air content.

6.2.4 *Calibration cylinder*. A hollow cylindrical measure of brass or other non-corrodible metal having a capacity of approximately 0.3 L, which may be integral with the cover assembly.

6.2.5 *Transparent plate*. A rigid transparent plate, suitable for use as a closure for the container.

6.2.6 *Air pump*. A hand pressure pump such as a bicycle tyre pump with a lead facilitating connection to the non-return air inlet valve on the cover assembly.

6.2.7 *Scoop*, as described in **3.1** of BS 1881-101:1983.

6.2.8 *Compacting bar or vibrator*. Compacting bar made out of straight steel bar weighing 1.8 kg, 380 mm long and having a ramming face 25 mm square, or a vibrating hammer or table suitable for compacting the concrete in accordance with **6.5**.

6.2.9 *Mallet*. A soft-faced mallet with a mass of approximately 250 g.

6.2.10 *Syringe*. A rubber syringe, suitable for injecting water into the container either through valve A or valve B.

6.2.11 *Balance*. A balance capable of weighing up to 1 kg to an accuracy of ± 0.5 g for use in calibrating the apparatus.

The balance shall be calibrated on initial commissioning and at least annually thereafter using weights of which the accuracy can be traced to the national standard of mass. The balance shall be checked after relocation or disturbance. A certificate stating the accuracy shall be obtained from the organization carrying out the check.

Fill the container with water at ambient temperature and place the transparent plate over it to eliminate any convex meniscus. Smear a thin film of grease on the flange of the container to effect a water tight joint between the transparent plate and the top of the container. Wipe away surplus water and determine the mass of the container filled with water by weighing on the balance. Screw the extension tubing (see Figure 2) into the threaded hole beneath valve A on the underside of the cover assembly and clamp the cover assembly into place, care being taken to ensure that there is a good pressure seal between cover and container. Close the main air valve and open valves A and B. Add water through valve A until all trapped air has been expelled through valve B. Pump air into the air chamber until the pressure reaches the indicated initial pressure line. After allowing a few seconds for the compressed air to cool to ambient temperature, stabilize the hand on the pressure gauge at the initial pressure line by further pumping in or bleeding off air as necessary. During this process lightly tap the gauge and close valve B.

Remove water from the apparatus to the calibration cylinder in just sufficient quantity to fill it full or up to a predetermined line marked on it, then determine the mass of water displaced, m_3, by weighing on the balance.

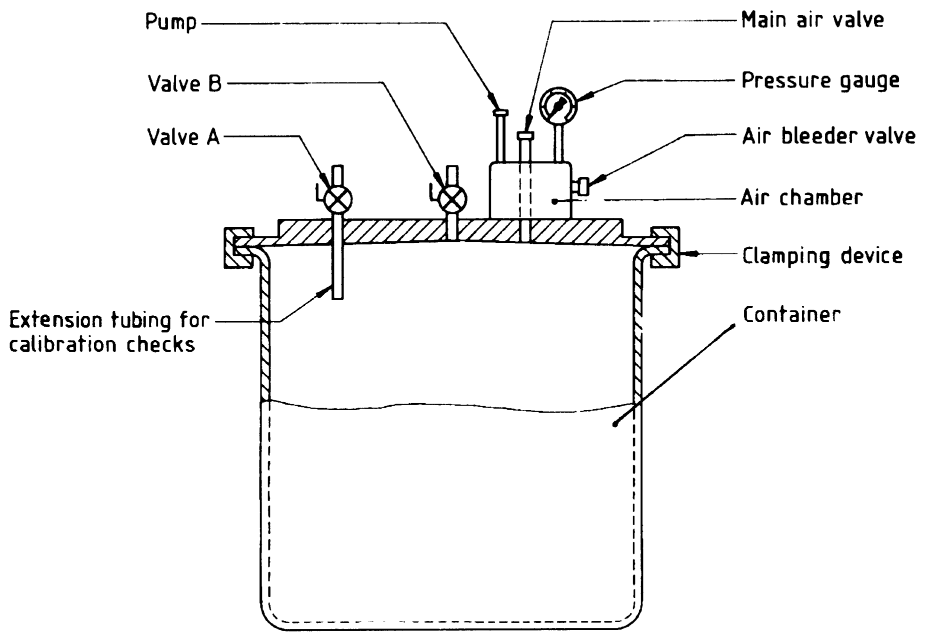


Figure 2 — Method B apparatus

Depending upon the particular apparatus design, control the flow of water either by opening valve A and using the main air valve to control flow, or by opening the main air valve and using valve A to control flow. Then release the pressure in the container by opening valve B (if the apparatus employs an auxiliary tube for filling the calibration cylinder, open valve A so that the tube is drained back into the container, or alternatively if the calibration cylinder is an integral part of the cover assembly close valve A immediately after filling the calibration vessel and leave it closed until the test has been completed). The volume of air in the container is now equal to the volume of the displaced water; close all valves, pump air into the air chamber until the pressure reaches the initial pressure line, and then open the main air valve. The air content indicated by the pressure gauge corresponds to the percentage of air, A_1, determined to be in the container, where $A_1 = m_3/m_2 \times 100$ %. If two or more determinations show the same variation from the correct air content, reset the hand on the pressure gauge to the correct air content and repeat the test until the gauge reading corresponds to the calibrated air content within 0.1 % air content.

6.4 Aggregate correction factor

6.4.1 *General*. The aggregate correction factor will vary with different aggregates and although ordinarily it will remain reasonably constant for a particular aggregate an occasional check is recommended. The aggregate correction factor can be determined only by test as it is not directly related to the water absorption of the particles.

6.4.2 *Aggregate sample size*. Determine the aggregate correction factor by applying the operating pressure on a combined sample of the coarse and fine aggregates in the approximate amounts, proportions and moisture conditions that exist in the concrete sample. Obtain the sample of aggregates either by washing the cement through a 150 µm BS 410 sieve from the concrete sample tested for air content or by using a combined sample of fine and coarse aggregate similar to that used in the concrete. In the latter case calculate the masses of fine and coarse aggregates to be used, m_f and m_c respectively, as follows:

$$m_f = V_o D p_f$$

$$m_c = V_o D p_c$$

where

P_f and P_c are the proportions of fine and coarse aggregates, respectively, expressed as fractions by mass of the total concrete mix (aggregates, cement and water);

V_o is the capacity of the container (in m^3) determined as described in **6.3.2**;

D is the density of the concrete to be tested (in kg/m^3), determined in accordance with BS 1881-107 or calculated from the known properties and densities of the materials and the nominal air content.

6.4.3 *Filling the container*. Partially fill the container of the apparatus with water and introduce the combined sample of aggregate in small scoopfuls. This shall be done in such a manner as to entrap as little air as possible.

If necessary add additional water to inundate all of the aggregate. After the addition of each scoopful remove any foam promptly and stir the aggregate with the compacting bar and tap the container with the mallet to release any entrapped air.

6.4.4 *Determination of aggregate correction factor*. When all the aggregate has been placed in the container wipe clean the flanges of the container and the cover assembly thoroughly and clamp the cover assembly into position so that a pressure-tight seal is obtained. Close the main air valve and open valves A and B. Using the rubber syringe, inject water through either valve A or valve B until water emerges from the other valve. Tap the apparatus lightly with the mallet until all entrapped air is expelled from this same valve. Remove a volume of water from the container approximately equivalent to the volume of air that would be contained in a typical concrete sample of a size equal to the volume of the container. Remove the water in the apparatus in the manner described in **6.3.2** for the calibration test. Complete the test using the procedure described in **6.6**.

The aggregate correction factor, G, is equal to the reading on the air content scale minus the volume of water removed from the container expressed as a percentage of the capacity of the container.

6.5 Compaction of the concrete

6.5.1 *General*. Place the sample of concrete to be tested in the container in such a way as to remove as much entrapped air as possible (without significantly reducing the amount of entrained air, if present) and to produce full compaction of the concrete with neither excessive segregation nor laitance. For this purpose, by means of the scoop, place the concrete in the container in three layers approximately equal in depth and compact each layer by using either the compacting bar or the vibrator in the manner described in **6.5.2** or **6.5.3**. If the concrete has a slump greater than approximately 75 mm, do not use vibration.

The quantity of material used in the final layer shall be, as nearly as possible, just sufficient to fill the container without having to remove excess material. A small quantity of additional concrete may be added if necessary and further compacted in order to just fill the container, but the removal of excess material should be avoided.

6.5.2 *Compacting with compacting bar*. When compacting each layer with the compacting bar, distribute the strokes of the compacting bar in a uniform manner over the cross section of the container, and ensure that the compacting bar does not penetrate significantly any previous layer nor forcibly strike the bottom of the container when compacting the first layer. The number of strokes per layer required to produce full compaction will depend upon the consistence of the concrete but in no case shall the concrete be subjected to fewer than 25 strokes per layer. In order to remove pockets of entrapped air but not the entrained air, after compaction of each layer tap the sides of the container smartly with the mallet until large bubbles of air cease to appear on the surface and depressions left by the compacting bar are removed. Record the number of strokes.

6.5.3 *Compacting with vibrator*. When compacting each layer by means of the vibrating hammer or table use applied vibration of the minimum duration necessary to achieve full compaction of the concrete. Over-vibration may cause excessive segregation and laitance or loss of entrained air, if present. The required duration of vibration will depend upon the consistence of the concrete and the effectiveness of the vibrator and vibration shall cease as soon as the surface of the concrete becomes relatively smooth and has a glazed appearance. Record the duration of vibration.

6.6 Procedure. Wipe the flanges of the container and of the cover assembly thoroughly clean. Clamp the cover assembly in place, care being taken to ensure that there is a good pressure seal between the cover and the container. Close the main air valve and open valve A and valve B. Using a rubber syringe, inject water through either valve A or valve B until water emerges from the other valve. Lightly tap the apparatus with the mallet until all entrapped air is expelled from this same valve.

Close the air bleeder valve on the air chamber and pump air into the air chamber until the hand on the pressure gauge is on the initial pressure line. After allowing a few seconds for the compressed air to cool to ambient temperature stabilize the hand on the pressure gauge at the initial pressure line by further pumping in or bleeding off air as necessary. During this process lightly tap the gauge. Close both valve A and valve B and then open the main air valve. Tap the sides of the container sharply. Lightly tap the pressure gauge to stabilize it and then the reading of the pressure gauge is equal to the apparent percentage of air, A. Open valves A and B in order to release the pressure before the cover assembly is removed.

7 Calculation and expression of results

7.1 Air content of the sample tested. Calculate the air content of the concrete in the container, A_c, from the formula:

$$A_c = A_1 - G$$

where

A_1 is the apparent air content of the sample tested, to the nearest 0.1 % (see **5.6** and **6.6**);

G is the aggregate correction factor to the nearest 0.1 % (see **5.4.4** and **6.4.4**).

Express the air content as a percentage to the nearest 0.1 %.

7.2 Air content of the mortar fraction. If required, calculate the air content of the mortar fraction of the concrete, A_m, from the formula:

$$A_m = \frac{100 A_c V_c}{100 V_m + A_c(V_c - V_m)}$$

where

V_m is the absolute volume of the ingredients of the mortar fraction (i.e. cement, water and fine aggregate) of the concrete, air free, as determined from the original batch masses (in m^3);

V_c is the absolute volume of the ingredients of the concrete, air free, as determined from the original batch masses (in m^3).

Express the air content as a percentage to the nearest 0.1 %.

7.3 Precision. Precision data are given in Table 1. These apply to air content measurements made by method A on concrete taken from the same sample when each test result is obtained from a single air content determination

Table 1 — Precision data for air content measurements

Level	Repeatability conditions		Reproducibility conditions	
	s_r	r	s_R	R
%	%	%	%	%
5.6	0.16	0.4	0.45	1.3

NOTE 1 The precision data were determined as part of an experiment carried out in 1987 in which precision data were obtained for several of the tests described in BS 1881. The experiment involved 16 operators. The concretes were made using an ordinary Portland cement, Thames Valley sand, and Thames Valley 10 mm and 20 mm coarse aggregates.

NOTE 2 The difference between two tests results from the same sample by one operator using the same apparatus within the shortest feasible time interval will exceed the repeatability value r on average not more than once in 20 cases in the normal and correct operation of the method.

NOTE 3 Test results on the same sample obtained within the shortest feasible time interval by two operators each using their own apparatus will differ by the reproducibility value R on average not more than once in 20 cases in the normal and correct operation of the method.

NOTE 4 For further information on precision, and for definitions of the statistical terms used in connection with precision, see BS 5497-1.

8 Report

8.1 General. The report shall affirm that the air content was determined in accordance with this Part of this British Standard. The report shall state whether or not a certificate of sampling is available. If available, a copy of the certificate shall be provided.

8.2 Information to be included in the test report

8.2.1 *Mandatory information*. The following information shall be included in the test report:

a) date, time and place of sampling and sample identity number;

b) time and place of test;

c) type of apparatus used (method A or B);

d) date of latest calibration check;

e) aggregate correction factor;

f) method of compaction (by hand or vibration) including type of equipment used and the number of strokes of the compacting bar or the duration of vibration;

g) measured air content of sample tested;

h) name of person carrying out test.

8.2.2 *Optional information*. If requested the following information shall be included in the test report:

a) name of project and place where concrete used;

b) name of supplier and source of concrete;

c) date and time of production of concrete or delivery to site;

d) specification of concrete mix (e.g. strength grade and nominal air content);

e) temperature of the concrete at the time of sampling;

f) density of the concrete;

g) workability of the concrete;

h) calculated air content of mortar fraction of the concrete.

Publications referred to

BS 410, *Specification for test sieves*.
BS 1881, *Testing concrete*.
BS 1881-101, *Method of sampling fresh concrete on site*.
BS 1881-102, *Method for determination of slump*[1].
BS 1881-103, *Method for determination of compacting factor*[1].
BS 1881-104, *Method for determination of Vebe time*[1].
BS 1881-107, *Method for determination of density of compacted fresh concrete*.
BS 1881-125, *Methods for mixing and sampling fresh concrete in the laboratory*.
BS 3388, *Forks, shovels and spades*.
BS 5328, *Methods for specifying concrete, including ready-mixed concrete*.
BS 5497, *Precision of test methods*[1].
BS 5497-1, *Guide for the determination of repeatability and reproducibility for a standard test method*.
ISO 4848, *Concrete – Determination of air content of freshly mixed concrete – Pressure method*[1].

[1] Referred to in the foreword only.

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