BS 6463 : Part 4 : 1987

UDC [666.924+546.41'246−112]:666.924.3/4:
620.1:54.03

British Standard

Quicklime, hydrated lime and natural calcium carbonate

Part 4. Methods of test for physical properties of hydrated lime and lime putty

Chaux vive, chaux hydratée et carbonate de calcium naturel
Partie 4. Méthodes d'essai des propriétés physiques de la chaux hydratée et du mastic de chaux

Branntkalk, Löschkalk und natürliches Kalziumkarbonat
Teil 4. Verfahren zur Prüfung der physikalischen Eigenschaften von Kalkhydrat und Kalkteig

British Standards Institution

Foreword

This Part of BS 6463 has been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee in order to bring together standard methods of test for quicklime, hydrated lime and natural calcium carbonate.

This standard incorporates and revises the test methods contained in BS 890 which is also to be revised. Although the standard deals primarily with methods of test for lime products used in the construction industry, methods used in other fields, e.g. water treatment, food, agriculture and the steel and chemical industries, have also been included.

BS 6463 is published in four Parts as follows:

Part 1. Methods of sampling
Part 2. Methods of chemical analysis
Part 3. Methods of test for physical properties of quicklime
Part 4. Methods of test for physical properties of hydrated lime and lime putty

Part 4 describes methods for testing hydrated lime and lime putty as produced and delivered to the customer. These tests include size grading, bulk density, soundness and the presence of coarse particles. The remainder of the tests are to determine the properties of lime putty produced from hydrated lime or quicklime or purchased in that form.

Contents

Methods

Appendix

Table

Figures

Methods

1 Scope

This Part of BS 6463 describes methods for the physical testing of hydrated lime and lime putty.

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

2 Determination of particle size of hydrated lime

2.1 Principle

The particle size distribution is determined by sieve analysis using an air-jet sieving apparatus. This method of sieve analysis determines the particle size of the agglomerates of the very fine particles of hydrated lime in the dry material produced by the manufacturing process.

2.2 Apparatus

2.2.1 *Air-jet sieving apparatus,* of the form shown in figure 1, capable of giving a pressure difference of 1 kPa across the sieves, with 200 mm diameter, 40 µm, 63 µm and 75 µm mesh sieves in accordance with BS 410*.

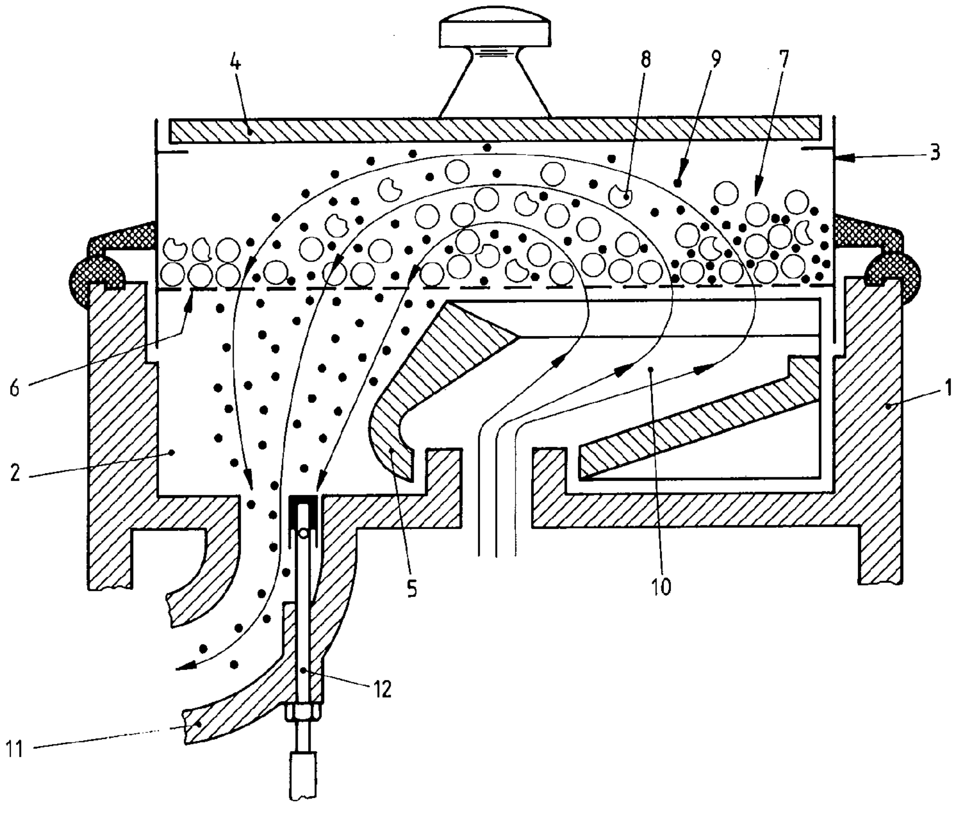
2.2.2 *Balance,* with an accuracy of 0.001 g.

2.2.3 *Soft brush* (a camel hair brush is suitable).

2.2.4 *Weighing bottle.*

2.3 Procedure

Place the 40 µm sieve on the air-jet sieving apparatus (**2.2.1**) after ensuring that the corresponding nozzle is in position and properly located. Do not turn the nozzle by hand.



1. Housing
2. Dish
3. Sieve drum
4. Lid
5. Slit-nozzle
6. Sieve
7. Test sample
8. Oversize material
9. Undersize material
10. Air jet
11. Air discharge
12. Pressure gauge socket, with dust hood

Figure 1. Air-jet sieving apparatus

---

*The Alpine A200 LS is a suitable apparatus.

Weigh approximately 5 g of hydrated lime to an accuracy of 0.001 g using the weighing bottle (**2.2.4**). Switch on the apparatus and pour the sample onto the sieve. Brush out the weighing bottle with the soft brush (**2.2.3**) and switch off the apparatus. When the vacuum has ceased, place on the lid, switch on the apparatus and adjust to give a pressure difference of 1 kPa. If there is any tendency for material to adhere to the lid, gently tap the knob as necessary with a mallet. Do not tap any other part of the lid.

After 15 min switch off the apparatus, carefully remove the sieve and brush the contents on to a clean sheet of paper taking care not to damage the mesh. Pour the material into a tared weighing bottle and reweigh.

Repeat the above procedure on further 5 g portions of the sample using the 63 µm and 75 µm sieves (**2.2.1**).

2.4 Expression of results

The percentage by mass passing the sieve, P, is given by the equation:

$$P = \frac{100\,(m - w)}{m}$$

where

m is the mass of sample (in g);

w is the mass retained on the sieve (in g).

2.5 Test report

The percentage by mass passing each sieve shall be reported to the nearest whole number.

3 Determination of coarse material

3.1 Principle

The amount of coarse material present is determined by wet sieving.

NOTE. The coarse particles present in hydrated lime may sometimes cause unsoundness.

3.2 Apparatus

3.2.1 *Balance,* with an accuracy of 0.01 g.

3.2.2 *500 mL wide-mouthed bottle,* or other suitable vessel which can be sealed with a stopper.

3.2.3 200 mm *diameter* 180 µm *and* 90 µm *mesh BS 410 test sieves.*

3.2.4 *5 mm bore rubber or plastics tubing.*

3.2.5 *Drying oven,* controlled at 105 ± 5 °C.

3.2.6 *Two sintered glass filter crucibles,* of porosity equivalent to grade P 100 of BS 1752 with filter flask and adaptor funnel for crucibles.

3.2.7 *Desiccator.*

3.2.8 *Wash bottle.*

3.3 Procedure

Superimpose the 180 µm mesh BS 410 test sieve on the 90 µm mesh BS 410 test sieve (**3.2.3**) and wet the sieves with distilled or potable water. Place 50 ± 0.5 g of hydrated lime or 100 ± 1 g of lime putty in a 500 mL wide-mouthed bottle (**3.2.2**) and add about 250 mL of water. Replace the stopper and shake the bottle for about 30 s. Remove the stopper immediately and pour the contents of the bottle onto the sieves. Wash any residue remaining in the bottle or on the stopper with a jet of water from the 5 mm bore tubing (**3.2.4**) and at a pressure equal to a head of 1.2 m (approximately 10 kN/m^2) on to the sieves. Then use the jet to wash the residue on the 180 µm mesh BS 410 test sieve, for not less than 2 min or more than 5 min. Do not rub the residue through the sieve and take care not to flood the lower sieve during the operation. At the end of this period, wash the residue to one side of the sieve. Detach the 180 µm mesh BS 410 test sieve and, using a wash bottle (**3.2.8**), transfer the residue from the sieve through a glass funnel into one of the tared, sintered glass filter crucibles (**3.2.6**) connected to the suction system. When all the residue has been washed into the filter, and the water extracted, remove the filter containing the residue and dry it at 105 ± 5 °C for 1 h. Cool the dried filter in a desiccator (**3.2.7**) and reweigh.

Wash the residue on the 90 µm mesh BS 410 test sieve for a minimum period of 4 min or a longer period, not exceeding 10 min in all, as may be necessary until the washings are clear.

Transfer the residue to a tared filter crucible, dry, cool and reweigh as described above.

3.4 Expression of results

The percentage by mass retained on each sieve, x, is given by the equation:

$$x = \frac{100w}{m}$$

where

m is the mass of the sample (in g);

w is the mass retained on the sieve (in g).

3.5 Test report

The residue on a 180 µm mesh BS 410 test sieve shall be reported to the nearest 0.05 %. The residue on a 90 µm mesh BS 410 test sieve which passes a 180 µm mesh BS 410 test sieve shall be reported to the nearest 0.05 % and the cumulative residue on a 90 µm mesh BS 410 test sieve shall be reported to the nearest 0.05 %.

NOTE. To enable the residue in the lime putty to be referred to the dry mass of hydrated lime the water content of the lime putty should be determined by the method given in BS 6463 : Part 2.

4 Determination of particle density

4.1 Principle

The particle density of hydrated lime is determined by displacement of a non-reactive liquid in a density bottle. This density is then used in the determination of the specific surface (see clause **5**).

4.2 Material

Displacement liquid, redistilled kerosine (paraffin oil), the density of which shall not change more than 0.0005 g/mL when evacuated for a period of 5 h at a pressure of 0.27 kPa to 2.7 kPa (2.7 mbar to 27 mbar).

NOTE. A suitable liquid can be prepared in the laboratory by redistilling kerosine and collecting the fraction condensing at 200 °C to 240 °C. Alternatively, petroleum fraction with boiling ranges within the range 190 °C to 225 °C and with sufficiently stable density characteristics is commercially available.

4.3 Apparatus

4.3.1 *Density bottle,* of nominal capacity 50 mL, in accordance with BS 733.

4.3.2 *Small funnel,* to fit inside the neck of the density bottle.

4.3.3 *Balance,* capable of weighing up to at least 100 g to an accuracy of ± 0.0005 g.

4.3.4 *Thermostatically controlled water bath,* capable of being maintained to within ± 0.2 °C at a selected operating temperature slightly above room temperature.

NOTE. A convenient operating temperature is 25 °C, but this is left to the discretion of the operator.

4.3.5 *Vacuum desiccator and pump,* capable of reducing the pressure to 0.27 kPa to 2.7 kPa (2.7 mbar to 27 mbar).

NOTE. A glass vacuum desiccator should be enclosed in a suitable protective mesh guard.

4.4 Procedure

4.4.1 *Water bath.* Maintain the water bath at the same selected operating temperature throughout the following tests.

4.4.2 *Determination of density of displacement liquid.* Clean and dry the density bottle and stopper (**4.3.1**) and weigh to ± 0.0005 g.

Fill the bottle with de-aerated distilled or de-aerated de-ionized water at room temperature and, without undue force, insert the stopper with a slight twist, taking care to avoid trapping air bubbles.

Immerse the bottle nearly to the top of its neck in the water bath (**4.3.4**) and leave for at least 30 min.

After ensuring that air bubbles are absent and that the bottle is filled to the top of the capillary bore, remove with dry filter paper any water on the top of the neck of the bottle where stopper and neck meet, and dry the sides and the top of the stopper, taking care not to withdraw any water from the capillary.

Remove the bottle from the water bath and, after allowing it to cool for a few minutes, wipe it free of water with the minimum of handling, and weigh to ± 0.0005 g.

By topping up the bottle with more distilled or de-ionized water, re-immersing it in the water bath and proceeding as before, make two additional weighings of the bottle filled with water.

Calculate the mean of these three weighings, and from the difference between this mean weighing and the first weighing of the bottle and stopper alone, calculate the mass of water to fill the bottle at the selected operating temperature.

Clean and dry the density bottle and stopper used in the above test and reweigh to ± 0.0005 g. Repeat the above procedure but filling the bottle with the displacement liquid instead of water, and determine the average mass of displacement liquid to fill the bottle at the selected operating temperature.

4.4.3 *Determination of particle density of hydrated lime.* Clean and dry the calibrated density bottle and stopper and weigh to 0.0005 g.

Place 4 g to 5 g of hydrated lime in the bottle by means of the small funnel (**4.3.2**), reweigh with stopper to ± 0.0005 g and, from the difference between the first and second weighings, calculate the mass of the sample of hydrated lime in the bottle.

Add sufficient displacement liquid to cover the hydrated lime sample and half fill the bottle, ensuring that the lime is thoroughly wetted by swirling the contents gently, taking care to keep lime particles clear of the neck of the bottle.

Place the bottle, together with a small beaker containing some displacement liquid, in the vacuum desiccator (**4.3.5**) and evacuate at a pressure of 0.27 kPa to 2.7 kPa (2.7 mbar to 27 mbar) for at least 30 min until bubbles of air cease to be evolved.

Remove the bottle from the desiccator and fill with displacement liquid from the beaker.

Using the same procedure as described in **4.4.2**, determine the average mass of the bottle, stopper, hydrated lime sample and displacement liquid to fill the bottle at the selected operating temperature.

4.5 Expression of results

4.5.1 *Density of displacement liquid.* Calculate the density of the displacement liquid, ρ_L, (in g/mL) to the nearest 0.0005 g/mL from the equation:

$$\rho_L = \left(\frac{m_2}{m_1}\right) \rho_W$$

where

ρ_W is the density of pure water at the selected operating temperature (in g/mL) (see table 1);

m_1 is the mass of water to fill the bottle at the selected operating temperature (in g);

m_2 is the mass of displacement liquid to fill the bottle at the selected operating temperature (in g).

Table 1. Density of pure water ρ_W

Temperature	Density, ρ_W	Temperature	Density, ρ_W
°C	mL	°C	mL
18	0.9986	24	0.9973
19	0.9984	25	0.9971
20	0.9982	26	0.9968
21	0.9980	27	0.9965
22	0.9978	28	0.9963
23	0.9976		

4.5.2 *Density of sample.* Calculate the particle density of the hydrated lime sample, ρ, (in kg/m^3) to the nearest 1 kg/m^3 from the following equation:

$$\rho = \left(\frac{m_4\ \rho_L}{m_3 + m_4 - m_5}\right) \times 1000$$

where

ρ_L is the density of the displacement liquid at the selected operating temperature (in g/mL);

m_3 is the mass of the bottle, stopper and displacement liquid to fill the bottle at the selected operating temperature (in g);

m_4 is the mass of the hydrated lime sample (in g);

m_5 is the mass of bottle, stopper, hydrated lime sample and displacement liquid to fill the bottle at the selected operating temperature (in g).

Make two separate determinations on different portions of the sample (if desired, two calibrated density bottles may be used). If the two results differ by more than 30 kg/m^3, discard the results and make two fresh determinations.

4.6 Test report

The densities of the individual samples shall be reported to the nearest 1 kg/m^3, and the average density to the nearest 10 kg/m^3.

5 Determination of surface area

5.1 Principle

The fineness of hydrated lime is determined by measuring the surface area expressed as specific surface in square metres per kilogram. The method uses the Rigden constant volume air permeability apparatus fitted with a Lea and Nurse permeability cell.

NOTE. The Lea and Nurse constant flow rate apparatus may be used as an alternative to the Rigden apparatus.

5.2 Apparatus

5.2.1 *Rigden constant volume air permeability apparatus,* as described in BS 4359 : Part 2.

5.2.2 *Permeability cell,* as described in BS 4550 : Part 3 : Section 3.3.

5.2.3 *Balance,* with an accuracy of 0.0001 g.

5.2.4 *Medium filter papers,* 32 mm in diameter*.

5.2.5 *Vernier gauge,* calibrated in millimetres.

5.2.6 *Desiccator.*

5.3 Procedure

Place a new 32 mm diameter filter paper (**5.2.4**) on the perforated steel disc at the bottom of the permeability cell (**5.2.2**). Re-assemble the cell ensuring that the two parts are firmly bolted together and test the cell and its connections for leakage.

Measure the depth of the permeability cell with its plunger in place using a vernier gauge (**5.2.5**) to obtain a zero reading.

Dry about 30 g of the hydrated lime at 105 ± 5 °C for 2 h and cool in a desiccator (**5.2.6**).

Weigh 8.0 g of the sample to an accuracy of 0.0005 g. Brush the sample into the permeability cell with gentle tapping from side to side to level off the surface. Gently insert the plunger and apply pressure until the top surface of the bed is slightly compacted in order to make a level surface. Remove the plunger and place a filter paper on the top of the plug. This will prevent the fine lime passing up the upper tube and contaminating the apparatus. Replace the plunger, press it down with the thumb on the cap and compact by striking the cell on a steel plate four times from a height of 10 mm.

Remeasure the depth of the permeability cell with its plunger in place with a vernier gauge to obtain the thickness of the sample bed. Remove the plunger slowly with a gentle twisting motion. Inspect the top surface of the bed and if it is disturbed or cracked, reject and remake the bed.

Connect the cell to the permeability apparatus so that there are no leaks, taking care to avoid disturbing the powder bed. Apply pressure or suction as appropriate to raise the manometer liquid level to above the upper timing mark ensuring that no air flows through the powder bed in the reverse direction. Turn the appropriate stopcock, so that as the manometer liquid level falls to its equilibrium position it draws air through the powder bed, and measure the time taken for the level to pass between the upper and lower marks.

NOTE. More detailed procedures for specific apparatus are given in BS 4359 : Part 2.

---

*Whatman No. 40 or similar filter paper is suitable.

5.4 Expression of results

Calculate the porosity of the bed, ϵ, from the following equation:

$$\epsilon = 1 - \frac{10^{-3} W}{L A \rho}$$

where

W is the mass of hydrated lime sample (in g);

A is the cross-sectional area of the permeability cell (in m^2);

ρ is the density of the hydrated lime sample as determined by the method of clause 4 (in kg/m^3);

L is the thickness of the bed (in m).

Calculate the mass specific surface in m^2/kg as described in BS 4359 : Part 2 (see equations 5 and 11 of BS 4359 : Part 2 : 1982).

6 Determination of general expansion

6.1 Principle

Any fine particles of unhydrated quicklime present are slaked by steam and the resulting expansion measured.

6.2 Apparatus

6.2.1 *Three Le Chatelier moulds,* as shown in figure 2. The mould consists of a small split cylinder of unplated spring brass or other suitable metal of 0.5 mm thickness forming a mould of 30 mm internal diameter and 30 mm high. On either side of the split are attached two indicators with pointed ends (A-A), the distance from these ends to the centre of the cylinder being 165 mm. The moulds shall be kept in good condition and with the jaws not more than 0.5 mm apart.

6.2.2 *Six non-porous plates,* each of mass 10 g.

6.2.3 *Three strips of paper,* 160 mm long and 40 mm wide.

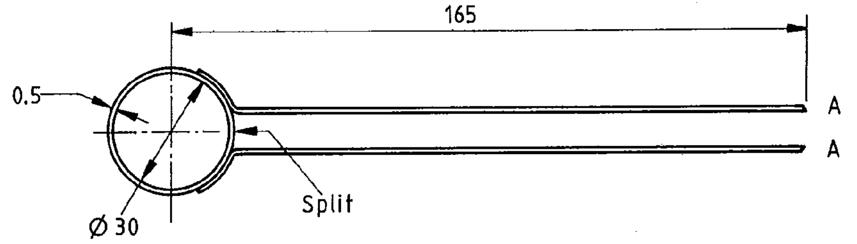
6.2.4 *Three small elastic bands.*

6.2.5 *One weight,* of 100 ± 1 g.

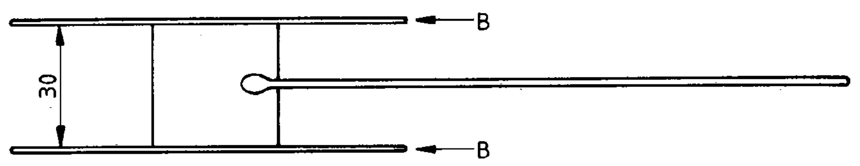
6.2.6 *Metal rod,* of mass about 70 g and having an end diameter of about 17 mm.

6.2.7 *Pair of thin rubber gloves.*

6.2.8 *Boiler,* in which soundness specimens can be submitted to the action of steam at atmospheric pressure. The lid shall contain an integral drip sheet to prevent condensed water from dripping on to the specimens.



(a) Plan view



(b) Elevation showing non-porous plates B-B in position

All dimensions are in millimetres.

Figure 2. Le Chatelier mould

6.3 Procedure

6.3.1 *Extensibility of moulds.* Check the extensibility of each Le Chatelier mould (**6.2.1**) regularly as follows.

Rigidly secure the mould by means of the clamp (C) as shown in figure 3. Slip a small metal sleeve having a hook (E) at the end over the unclamped pointer and secure it by means of the set screw (D) so that the distance between the hook and the cylindrical surface of the mould is 50 ± 2 mm and the distance between the ends of the pointers does not exceed 5 mm. Suspend a weight of 100 ± 1 g (**6.2.5**) from the hook as shown and measure the distance between the ends of the pointers in millimetres.

Remove the weight and again measure the distance between the ends of the pointers in millimetres. Take the difference between the readings when loaded with the 100 g weight and after unloading.

NOTE. This is termed the extensibility of the moulds.

Moulds shall be considered as satisfactory for use in the general expansion test if the extensibility is between 20 and 30. Moulds with extensibilities outside these limits shall not be used.

6.3.2 *Expansion test.* Grease the internal surface of each of the three moulds with petroleum jelly and place on similarly greased plates (**6.2.2**).

Hand mix 75 g of the dry hydrated lime sample with 25 mL of water.

NOTE. This may be achieved by crumbling the mixture between fingers protected by thin rubber gloves (**6.2.7**) until no lumps remain.

Immediately fill each mould completely but loosely with the material and, using the rod (**6.2.6**), lightly tamp the sample to avoid the inclusion of air, then fill and retamp level with the top of the mould taking care to keep the split of the mould just visibly open when this operation is completed. Cover each mould with a greased plate, bind with a strip of paper (**6.2.3**) and secure with an elastic band (**6.2.4**).

Measure the distance in millimetres separating the ends of the indicator points. Transfer the moulds immediately to the boiler (**6.2.8**) which shall be boiling vigorously as indicated by a constant egress of steam.

Subject the moulds to the continuous action of steam at atmospheric pressure for a period of 3 h ± 10 min. At the end of this time remove the moulds, allow to cool to room temperature and measure the distance separating the indicator points.

6.4 Expression of results

The difference between the two measurements in millimetres represents the expansion of the sample. If individual results differ by more than 2 mm then the test shall be repeated.

6.5 Test report

The mean of the three results shall be reported to the nearest millimetre.

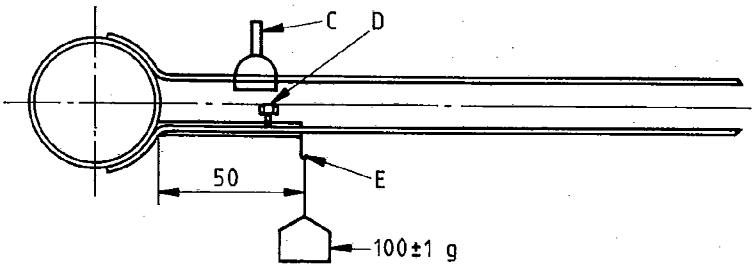
7 Determination of soundness for plastering

7.1 Principle

Large particles of overburnt quicklime can cause popping and pitting when used for plastering. In this test hydrated lime is added to a non-retarded pure plaster of Paris and, after the plaster has set, it is subjected to the action of steam. The steam hydrates any unhydrated calcium oxide present causing expansion and thus eruption of the plaster surface.

7.2 Material

7.2.1 *Plaster of Paris,* complying with BS 1191 : Part 1, except that it shall contain not less than 90 % by mass of calcium sulphate ($CaSO_4$) and it shall all pass a 180 µm BS 410 test sieve.



C = Clamp
D = Set screw
E = Hook
All dimensions are in millimetres.

Figure 3. Apparatus for measuring extensibility of Le Chatelier moulds

In addition when gauged with 50 % of its own mass of water at a temperature of 20 ± 5 °C, it shall show an initial setting time, by the Vicat needle test specified in BS 12, of not less than 4 min and not greater than 15 min.

7.3 Apparatus

7.3.1 *Large sheet of non-absorptive material* for mixing (a glass plate 500 mm × 750 mm has been found to be suitable).

7.3.2 *Three brass ring moulds,* 100 mm internal diameter, 5 mm deep of an annular thickness of at least 5 mm, and having an internal taper of about 5 °, each with a non-porous base plate about 120 mm square.

7.3.3 *Two broad palette knives.*

7.3.4 *Ventilated drying oven,* controlled at 40 ± 5 °C.

7.3.5 *Boiler,* in which soundness specimens can be submitted to the action of steam at atmospheric pressure. The lid shall contain an integral drip sheet to prevent condensed water from dripping onto the specimens.

7.4 Procedure

Weigh approximately 250 g of the sample to an accuracy of 1 g and mix in 250 mL of water using the two palette knives (**7.3.3**), at a temperature of 20 ± 5 °C, on the large non-absorptive sheet (**7.3.1**). Gather the mix into a compact mass, cover it to avoid loss of water and allow to stand for 2 h ± 10 min.

Grease the ring moulds (**7.3.2**) and base plates with petroleum jelly.

When 2 h have elapsed, mix the lime putty using the palette knives (**7.3.3**), until a stiff plastic mass is obtained. If it is essential, a little more water may be added. Spread out the putty, then sprinkle 35 g of the plaster of Paris evenly over the surface of the putty and mix rapidly with the palette knives for 2 min ± 5 s.

Using a palette knife, form a flat pat by pressing the gauged material, in small quantities, into a ring mould (**7.3.2**) resting with its wider diameter downwards on a non-porous base plate (**7.3.2**). Ensure that no air is entrapped. Using the palette knife with its blade nearly vertical, cut off the excess putty and then with the blade nearly horizontal, smooth off level with the top of the mould using not more than 12 strokes. Do not exceed 5 min total time, from the addition of the plaster of Paris, for the completion of the pats.

Leave the three pats to set for 1 h. Place the pats on their base plates with or without the ring moulds, in the drying oven (**7.3.4**) at a temperature of 40 ± 5 °C for not less than 12 h. (It is usually convenient to dry the pats overnight.) If any pat shows shrinkage cracks, discard it and make a new pat. Place the pats, still on their base plate, horizontally in the boiler (**7.3.5**), in which the water shall be boiling vigorously as indicated by a constant egress of steam from the vent in the lid. Subject the three pats to continuous action of saturated steam at atmospheric pressure for 3 h ± 10 min, taking precautions to prevent condensed water dripping on the pats.

Remove the pats from the boiler, allow them to cool and examine them in good light for disintegration, popping or pitting.

NOTE. Drips of water can cause 'water blistering' which should not be confused with popping or pitting.

7.5 Test report

Report as either free from, or as showing, disintegration, popping or pitting.

8 Method of preparing lime putty at standard consistence

8.1 Principle

Lime putty is prepared and the water content is adjusted to give standard consistence measured by the flow table method.

8.2 Apparatus

8.2.1 *Mixer,* with a blade rotating axially at 120 ± 25 r/min and in a planetary motion at 60 ± 15 r/min with a bowl and blade of the general form shown in figure 4 and a capacity of between 5 L and 20 L, according to the amount of lime to be tested.

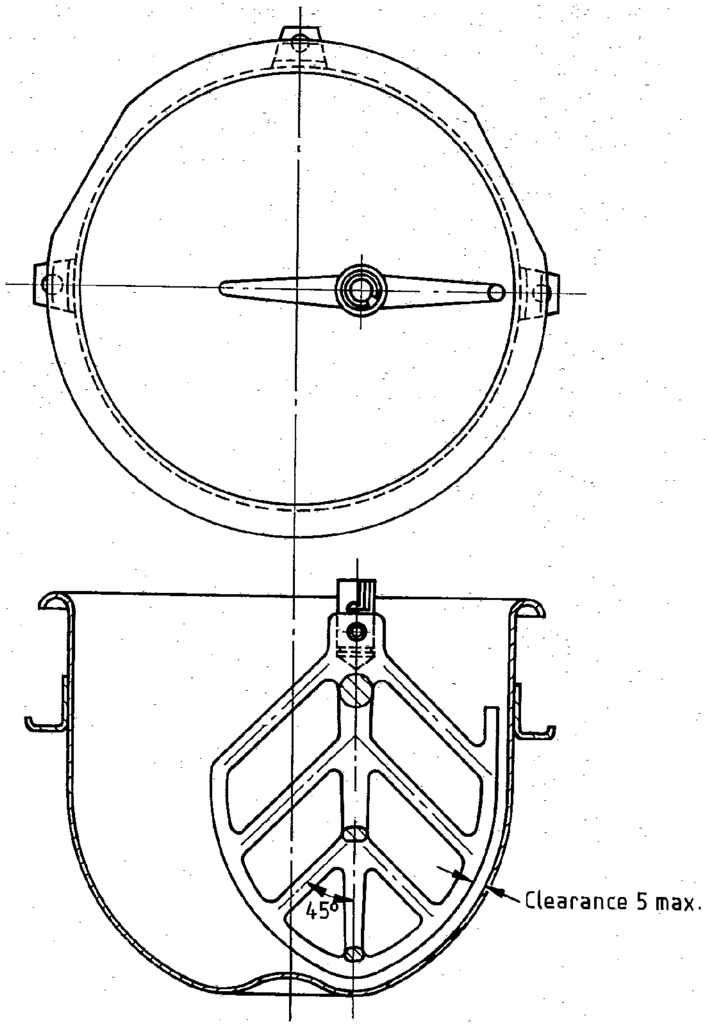
8.2.2 *Standard flow table and mould,* as described in appendix A.

8.3 Procedure

When testing dry hydrated lime, place 1 L of water at 20 ± 5 °C into the mixing bowl (**8.2.1**), start the stirrer at the slowest speed and add over a period of 2 min, 1.0 kg of the sample. When testing lime putty, take an equivalent mass of the putty. Allow the stirring to continue for a further 3 min, remove the bowl from the mixer, cover with a plastics sheet to prevent loss of water and allow to stand for 24 h.

Use the flow table (**8.2.2**) for the determination of consistence of the putty as follows.

Wipe the internal surface of the mould with a clean damp cloth. Place the mould in the centre of the table and hold it in position while filling it in such a manner as to avoid the inclusion of voids. Strike off the top with a palette knife and carefully withdraw the mould vertically giving it a light tap with the handle of the palette knife as it is lifted. Inspect the mould to ensure that there is no appreciable amount of putty adhering to its internal surface. If there is, repeat the procedure. Turn the handle of the flow table one revolution steadily without jerking or lingering at any point. Determine the spread by measuring along three diameters at approximately 60 ° apart and taking the average. The standard consistence is indicated by an average spread of the lower part of the putty cone on the flow table of 110 ± 1 mm.



Linear dimension is in millimetres.

Figure 4. Typical mixer

If when first tested, the consistence is too stiff, discard the test sample and add a further increment of 50 mL of water to the putty in the bowl. With experience this amount may be increased. Mix for 1 min and repeat the consistence measurement. Repeat this process using 50 mL increments of water until a measured standard consistence of 110 ± 1 mm is attained.

If the total time of working the putty exceeds 10 min, discard the putty and repeat the procedure on a fresh sample but using more water or less hydrated lime sample.

When testing certain low surface area hydrated limes, the putty may be too wet when first tested. In this case withdraw a small amount of the water present by removing the putty from the bowl and placing a part, or all of it, for a short period on a clean absorbent surface, or on a filter paper in a Buchner funnel which is being subjected to suction. Return the sample to the mixer bowl and mix for 1 min. Repeat the test.

If necessary further water may be removed but if the total time of working the putty exceeds 10 min, discard the putty and repeat the procedure on a fresh sample but using less water or more hydrated lime sample.

9 Determination of workability of putty

9.1 Principle

The workability of a lime putty, which has been adjusted to standard consistence as described in clause **8**, is determined by the number of drops on the standard flow table required to attain an average spread of 190 ± 1 mm.

9.2 Apparatus

9.2.1 *Standard flow table and mould,* as described in appendix A.

9.3 Procedure

Ensure that the temperature of the material under test, the flow table (**9.2.1**) and the immediate surroundings is 20 ± 5 °C during the test. Take care to avoid any undue exposure of the putty.

Prepare the putty specimen as described in clause **8**. With the cone of putty on the flow table, turn the flow table handle at a steady and even rate of approximately one turn per second, without jerking or lingering at any point in a revolution. Determine the spread by measuring along three diameters at approximately 60 ° apart and taking the average. Record the number of drops required to reach 190 mm spread. Repeat the test on two further specimens.

9.4 Expression of results

Record the average number of drops to the nearest whole number as the workability.

10 Determination of density of putty and volume yield

10.1 Principle

A known volume of a lime putty which is at standard consistence is weighed and the density calculated.

NOTE 1. The density can be used to calculate the volume of putty produced from a given mass of hydrated lime.

NOTE 2. When lime putty is sold it is tested in the 'as received' state.

10.2 Apparatus

10.2.1 *Accurate density vessel,* of capacity of not less than 250 mL. A typical density vessel is shown in figure 5.

10.2.2 *Balance,* with an accuracy of 0.1 g.

10.3 Procedure

Thoroughly dry the density vessel (**10.2.1**) and weigh to the nearest 0.1 g and then fill with distilled water at room temperature. Dry the outside of the vessel and weigh it full of water. Repeat the procedure three times and record the average mass of water. From the mass and temperature of the water, calculate the capacity of the vessel using standard tables.

Fill the vessel with putty at standard consistence (see clause 8) in two approximately equal increments to within 5 mm of the top. Tap the vessel on a protective pad on the bench after each increment, until no visible expulsion of air takes place during a succession of six taps. Slightly overfill the vessel and strike off the excess putty using a palette knife held towards the direction in which it is moved. Wipe the vessel clean on the outside and weigh it to the nearest 0.1 g. Tap the vessel on the bench as previously described, add a small excess of putty and strike off as before; reweigh. Repeat until there is no increase in mass.

10.4 Expression of results

The density of the putty, d (in kg/m^3), is given by the equation:

$$d = \frac{m\,10^3}{v}$$

where

m is the maximum mass of putty in the vessel (in g);

v is the capacity of the vessel (in mL).

Calculate the volume yield, y (in m^3/t), if required, as follows:

$$y = \frac{750}{d - 1000}$$

where

d is the density of the putty (in kg/m^3).

10.5 Test report

The density of the putty shall be reported to the nearest 10 kg/m^3.

11 Test for separation of water from lime putty on standing

11.1 Principle

The amount of water separating from a lime putty at standard consistence, or when sold as lime putty in the 'as received' state, is measured to indicate the water retentivity of the lime.

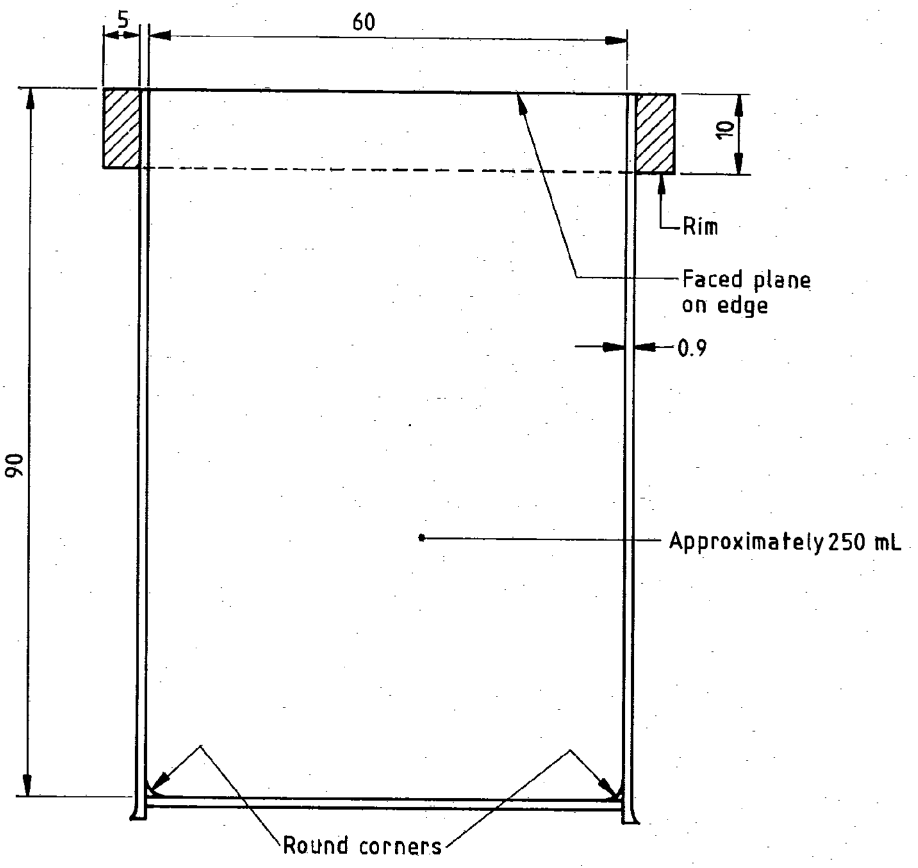
11.2 Apparatus

11.2.1 *Cylindrical glass or metal container,* approximately 150 mm in diameter and with a capacity of at least 1200 mL.

11.2.2 *Measuring cylinder,* with a capacity of 50 mL.

11.3 Procedure

Mix the lime putty at standard consistence (see clause **8**), or in the 'as received' condition at room temperature for 1 min. Weigh 1500 ± 1 g of lime putty into the container (**11.2.1**), cover and allow to stand for 24 ± 4 h at 20 ± 5 °C.



Non-corrodible metal cylindrical pot, 60 mm diameter by 90 mm deep, with soldered joints and with reinforced rim of brass, the upper edge made plain.

All linear dimensions are in millimetres.

Figure 5. Typical density vessel

Pour the supernatant water and suspension of lime into a 50 mL measuring cylinder (**11.2.2**) and allow to settle for 30 min. Measure and record the volume of the supernatant water.

11.4 Test report

The volume of water separated on standing shall be reported to the nearest millilitre.

12 Determination of hydraulic strength

12.1 Principle

Some types of lime contain cementiteous materials which have hydraulic properties and are capable of developing strength. These limes are known as hydraulic or semi-hydraulic.

A mortar is prepared using standard sand and adjusted to standard consistence. The moduli of rupture and compressive strength of the mortar are determined by the methods described in BS 4551.

12.2 Materials

12.2.1 Sand containing the following proportions of the standard sand fractions as specified in BS 4550 : Part 5.

Fraction A	400 g
Fraction B	400 g
Fraction C	500 g
Fraction D	400 g
Fraction E	300 g
Total mass	2000 g

12.3 Apparatus

12.3.1 *Balance,* with an accuracy of 0.1 g.

12.3.2 *Mixer,* with a blade rotating axially at 120 ± 25 r/min and in a planetary motion at 60 ± 15 r/min with a bowl and blade of the general form shown in figure 4 and a capacity of between 5 L and 20 L.

12.3.3 *Dropping ball equipment,* as described in BS 4551.

12.3.4 *Moulds and test equipment,* for flexural strength and compressive strength tests as described in BS 4551.

12.4 Procedure

Bring the standard sand (**12.2.1**) and dry hydrated lime or lime putty at standard consistence (see clause **8**) to a temperature of 20 ± 2 °C before commencing the mixing of the mortar. Carry out the mixing in a room having a temperature of 20 ± 5 °C.

Place the 2000 g of standard sand in the mixing bowl (**12.3.2**) and mix for 30 s. Add either 500 g of dry hydrated lime and 500 mL of water or the equivalent amount of lime putty and mix for 120 s.

Stop the mixer and clean any adhering material from the paddles and the sides in about 15 s with a scraper. Take particular care to ensure no unmixed material remains at the bottom of the bowl. Cover the bowl with a damp cloth and allow the mortar to stand for a total of 10 min.

Restart the mixer and mix the mortar for a further 60 s.

Check the consistence of the mortar by means of the dropping ball test described in BS 4551. The required standard consistence is indicated by a penetration of 10 ± 0.5 mm. If the penetration is too low, add 10 mL of water and remix for 10 s. Repeat until standard consistence is attained. If it is too high, discard the mortar and repeat the mixing procedure with a new sample.

Prepare six 100 mm x 25 mm x 25 mm test specimens from this mortar as described in **15.2.6** of BS 4551 : 1980 and then cure in moist air as described in **15.2.7** of BS 4551 : 1980 for 28 days. If the flexural strength test is not required, test specimens 160 mm x 40 mm x 40 mm may be used.

After this period of storage, keep the specimens in water at 20 ± 2 °C for 4 h to 6 h and then test for flexural strength, and test the ends of the prisms for compressive strength, by the methods described in BS 4551.

12.5 Test report

The modulus of rupture shall be reported in newtons per square millimetre to the nearest 0.01 N/mm^2 or 1 %, whichever is the greater. Report the mean compressive strength in newtons per square millimetre to the nearest 0.05 N/mm^2 and the standard deviation for the 12 determinations.

Appendix

Appendix A. Details of the flow table

NOTE. The flow table is based on the American Society for Testing and Materials tentative specification C230-68T, with acknowledgements, in which working drawings may be found. The intention is that the table top and mould specified in this standard and the ASTM table top and mould specified in BS 4551, which are different, should be interchangeable in a similar frame by use of the same shaft. Manual operation is permitted in this standard.

A.1 General

The standard flow table (see figures 6 and 7) consists essentially of a horizontal smooth table top (made of mild steel and ground and polished on the surface) 305 mm in diameter and finished 3.2 ± 0.05 mm thick, mounted on a vertical shaft 15.82 ± 0.03 mm in diameter, which may be raised and then allowed to drop freely by a cam, the drop being 12.72 ± 0.13 mm for new tables and 12.72 ± 0.38 mm for tables in use.

The table top is loaded uniformly under the edge by an annular rim of cast iron 25.4 mm square in cross section and of the same external diameter, securely fixed by six rivets symmetrically disposed.

On the underside of the table top is a central bush securely fixed by six rivets symmetrically disposed around its upper flange, which has a diameter of 76.2 ± 0.13 mm, the diameter of the lower flange being 44.5 ± 0.13 mm. The thickness of the upper flange should be not less than 6.4 mm, but may be adjusted to obtain the mass specified. The bush is in turn attached co-axially to the shaft by means of a screw thread. The internal bore of the bush is threaded 1/2-20 UNF-2B, complying with BS 1580 : Parts 1 and 2. The upper end of the shaft is threaded 1/2-20 UNF-2A, complying with BS 1580 : Parts 1 and 2.

Three circles having the diameters of 80 mm, 110 mm and 190 mm, respectively, are engraved not more than 0.2 mm deep on the upper surface of the table top and concentric with it. The engraved lines are filled in with wax polish flush with the surface of the metal.

The length of the drop is defined by a hexagonal shoulder, 31.8 mm across the flats, integral with the shaft and having its upper and lower extremities reduced to 31.8 mm diameter, coming into contact with the top of the cast iron supporting frame of the instrument, the contact being therefore metal on metal. The shaft extends approximately 105 mm below the lowest extremity of the shoulder.

The total mass of the moving part (consisting of the table top, loading rim, shaft, etc.) which is free to drop is 6.58 ± 0.11 kg, the mass being symmetrical around the centre of the shaft.

The supporting frame of the flow table is integrally cast of fine-grained, high-grade cast iron. The frame casting has three integral stiffening ribs extending the full height of the frame and located at 120 ° centres. The top of the frame is chilled to a depth of approximately 6.4 mm and the face ground and lapped square with the bore to give a 360 ° contact with the shaft shoulder. The underside of the base of the frame is ground to secure a complete contact with the steel plate beneath.

The cam and vertical shaft are of medium carbon machinery steel, hardened where indicated in figure 6. The part of the shaft below the hexagonal shoulder consists of two hardened bearing surfaces each 25.4 mm in length and 15.82 ± 0.03 mm in diameter, separated by a central portion where the diameter is reduced to facilitate lubrication. The overall length of the shaft below the shoulder is approximately 105 mm but adjusted to give the drop specified above.

The shaft is straight and the difference between the diameter of the shaft and the diameter of the bore of the frame, other than in the central portion where the diameter of the shaft is reduced to facilitate lubrication, is not less than 0.05 mm and not more than 0.08 mm for new tables and is maintained at from 0.05 mm to 0.25 mm for tables in use. The end of the shaft does not fall upon the cam at the end of the drop, but makes contact with the cam not less than 120 ° from the point of drop. The face of the cam is a smooth spiralled curve of uniformly increasing radius from 12.7 mm at B to 31.8 mm at A in 360 ° so that there is no appreciable jar as the shaft comes into contact with the cam. The cam is so located and the contact faces of the cam and shaft are such that the table does not rotate more than one revolution in 25 drops. The surfaces of the frame and the shoulder which come into contact at the end of the drop are maintained smooth, plane and horizontal, and parallel with the upper surface of the table so that they make continuous contact over a full 360 °.

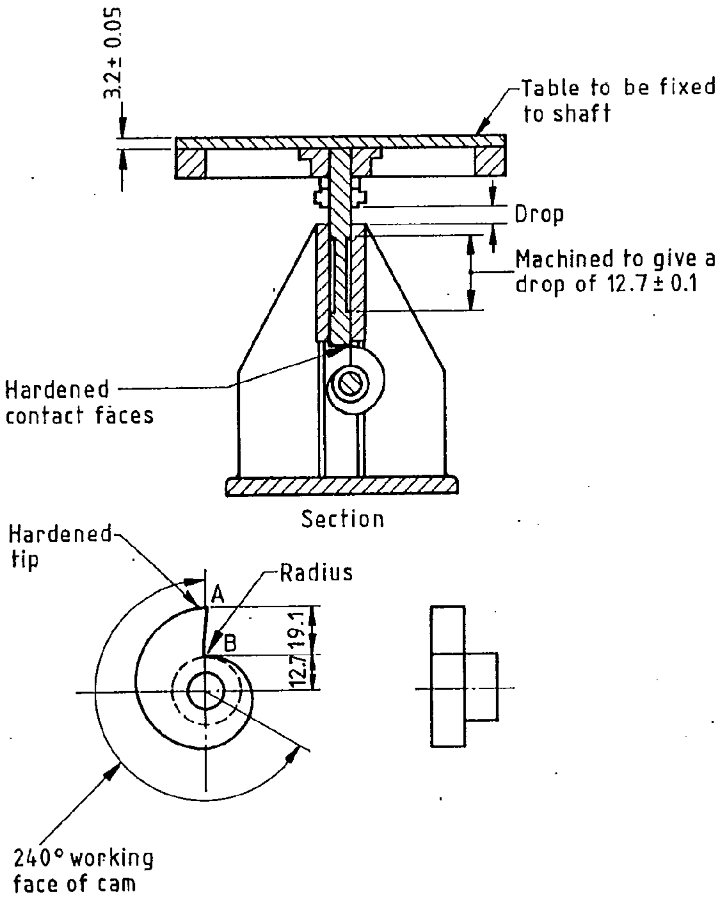
The flow table is actuated by means of a handle attached to the cam shaft having an arm of 101.6 mm radius, or through a flexible drive by an independently mounted motor.

A.2 Flow table mounting

The flow table frame is tightly bolted to a cast iron or steel plate at least 25 mm thick and 250 mm square. The top surface of this plate is machined to a smooth plane surface. The plate is anchored to the top of a concrete pedestal by four 12 mm bolts that pass through the plate and are embedded at least 150 mm in the pedestal. The pedestal is cast inverted on the base plate. There is a positive contact between the base plate and the pedestal at all points. No nuts or other levelling devices are used between the plate and the pedestal. Levelling is effected by suitable means under the base of the pedestal.

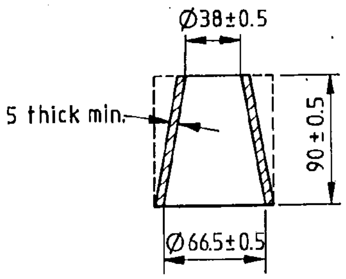
The pedestal is 250 mm to 280 mm square at the top and 380 mm to 410 mm square at the bottom, 630 mm to 760 mm in height, and is of monolithic construction, cast in concrete weighing at least 2240 kg/m^3. A stable gasket cork pad, 12 mm thick and approximately 100 mm square, is inserted under each corner of the pedestal. Check the flow table frequently for levelness of the table top, stability of pedestal, and tightness of bolts and nuts in the table base and pedestal plate. A torque of 30 N·m is recommended when tightening these fastenings.

Ensure that the table top, after the frame has been mounted in its pedestal, is level along two diameters at right angles to each other, in both the raised and lowered positions.



NOTE. Curve from B to A is a smooth spiral of uniformly increasing radius from 12.7 to 31.8 in 360 °.

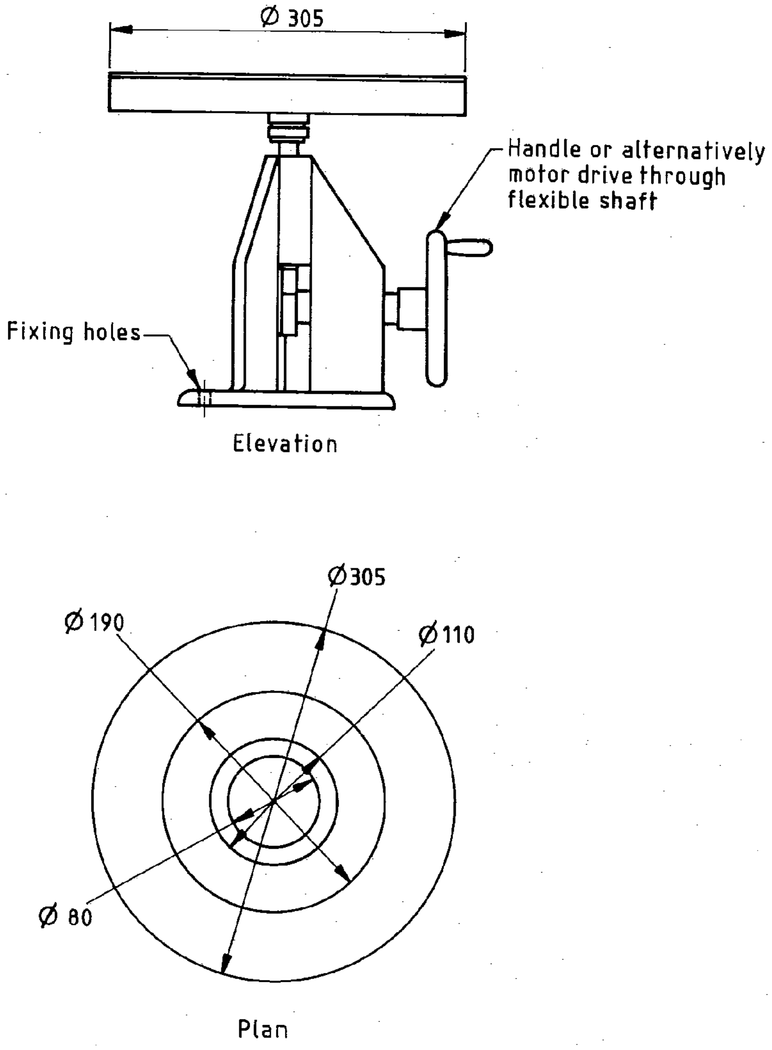
(a) Cam



(b) Conical mould

All dimensions are in millimetres.

Figure 6. Flow table, cam and conical mould



All dimensions are in millimetres.

Figure 7. Flow table

A.3 Flow table lubrication

Keep the vertical shaft of the table clean and lightly lubricated with a light oil (SAE 10). Ensure that no oil is present between the contact faces of the table top and the supporting frame. Oil on the cam face will lessen wear and promote smoothness of operation. The table should be raised and permitted to drop ten or more times just prior to use if it has not been operated for some time.

A.4 Mould

A truncated conical metal mould having walls not less than 5 mm thick, smooth inside, 90 ± 0.5 mm in height, with the narrower end 38 ± 0.5 mm and the wider end 66.5 ± 0.5 mm internal diameter. The ends of the mould, at right angles to its axis, shall be smooth (see figure 6).

NOTE. It is satisfactory to manufacture the mould out of 75 mm external diameter material resulting in a slight chamfer at the wider end.

Publications referred to

BS 12	Specification for ordinary and rapid-hardening Portland cement
BS 410	Specification for test sieves
BS 733	Pyknometers
BS 890*	Building limes
BS 1191	Gypsum building plasters Part 1 Excluding premixed lightweight plasters
BS 1580	Unified screw threads Parts 1 and 2 Diameters ¼ in and larger
BS 1752	Laboratory sintered or fritted filters including porosity grading
BS 4359	Methods for determination of specific surface of powders Part 2 Recommended air permeability methods
BS 4550	Methods of testing cement Part 3 Physical tests Part 5 Standard sand for concrete cubes
BS 4551	Methods of testing mortars, screeds and plasters
BS 6463	Quicklime, hydrated lime and natural calcium carbonate Part 2 Methods of chemical analysis

---

*Referred to in the foreword only.

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 Board of BSI and comes into effect on 30 October 1987.

ISBN 0 580 15262 6

The following BSI references relate to the work on this standard:
Committee reference CAB/5 Draft for comment 85/10001 DC

British Standards Institution. Incorporated by Royal Charter, BSI is the independent national body for the preparation of British Standards. It is the UK member of the International Organization for Standardization and UK sponsor of the British National Committee of the International Electrotechnical Commission.

In addition to the preparation and promulgation of standards, BSI offers specialist services including the provision of information through the BSI Library and Standardline Database; Technical Help to Exporters; and other services. Advice can be obtained from the Enquiry Section, BSI, Milton Keynes MK14 6LE, telephone 0908 221166, telex 825777.

Contract requirements. 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.

Revision of British Standards. British Standards are revised, when necessary, by the issue either of amendments or of revised editions. **It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.**

Automatic updating service. BSI provides an economic, individual and automatic standards updating service called **PLUS**. Details are available from BSI Enquiry Section at Milton Keynes, telephone 0908 221166, telex 825777.

Information on all BSI publications is in the *BSI Catalogue*, supplemented each month by *BSI News* which is available to subscribing members of BSI and gives details of new publications, revisions, amendments and withdrawn standards. Any person who, when making use of a British Standard, encounters an inaccuracy or ambiguity, is requested to notify BSI without delay in order that the matter may be investigated and appropriate action taken.

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cement, Gypsum, Aggregates & Quarry Products Standards Committee (CAB/-) to Technical Committee CAB/5, upon which the following bodies were represented:

British Aggregate Construction Materials Industries
Building Employers' Confederation
Cement Makers' Federation
Department of the Environment (Building Research Establishment)
Department of the Environment (Property Services Agency)
Dry Lining and Partition Association Limited
Gypsum Products Development Association
Institution of Structural Engineers
National Federation of Plastering Contractors
Plasterers' Craft Guild
Royal Institute of British Architects
Scottish Master Plasterers' Association
Society of Chemical Industry

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

Chemical Industries Association
Mortar Producers' Association Ltd
Water Authorities

Amendments issued since publication

Amd. No.	Date of issue	Text affected

British Standards Institution · 2 Park Street London W1A 2BS · Telephone 01-629 9000 · Telex 266933

8710–7–1.5k–B

CAB/5