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PORTLAND CEMENT
(ORDINARY AND RAPID-HARDENING)

BRITISH STANDARDS INSTITUTION

BRITISH STANDARD SPECIFICATION

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B.S. 12 : 1958

Price 7/6 net

BRITISH STANDARDS INSTITUTION
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THIS BRITISH STANDARD, having been approved by the Cement, Lime and Gypsum Products Industry Standards Committee and endorsed by the chairman of the Building Divisional Council, was published by the authority of the General Council on 10th March, 1958.

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Eighth revision, November, 1947.
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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 3000 indexed and cross-indexed for reference, together with an abstract of each standard will be found in the Institution's Yearbook, price 15s.

This standard makes reference to the following British Standards :

B.S. 350. Conversion factors and tables.
B.S. 410. Test sieves.
B.S. 481. Woven wire and perforated plate sieves and screens for industrial purposes.
B.S. 812. Methods for the sampling and testing of mineral aggregates, sands and fillers.
B.S. 882, 1201. Concrete aggregates from natural sources.
B.S. 1610 : Part I. Methods of load verification; and verification of tensile and compression machines.
B.S. 1881. Methods of testing concrete.

British Standards are revised, when necessary, by the issue either of amendment slips 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.

The following B.S.I. references relate to the work on this standard :—
Committee references CEB/1, CEB/1/1.
Draft for comment CW(CEB) 7821.

CO-OPERATING ORGANIZATIONS

The Cement, Lime and Gypsum Products Industry Standards Committee under whose supervision this British Standard was prepared consists of representatives from the following Government departments and scientific and industrial organizations :

Admiralty
Air Ministry
*Association of Consulting Engineers (Incorporated)
*British Cast Concrete Federation
British Granite and Whinstone Federation
*British Iron and Steel Federation
British Railways, The British Transport Commission
Cast Stone and Concrete Federation
*Cement and Concrete Association
*Cement Makers' Federation
Chalk, Lime and Allied Industries Research Association
Chalk Quarrying Association
*D.S.I.R.—Building Research Station
*Federation of Civil Engineering Contractors
Gypsum Plasterboard Development Association
*Institution of Civil Engineers
*Institution of Municipal Engineers
*Institution of Structural Engineers
Institution of Water Engineers
Limestone Federation
*London County Council
*London Transport Executive, The British Transport Commission
Ministry of Housing and Local Government
*Ministry of Transport and Civil Aviation
*Ministry of Works
*National Federation of Building Trades Employers
*Reinforced Concrete Association
*Royal Institute of British Architects
*Royal Institution of Chartered Surveyors
Sand and Gravel Association of Great Britain
*Society of Chemical Industry
Southern Lime Association

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard :—

British Slag Federation
Colonial Geological Surveys, Mineral Resources Division
Crown Agents for Oversea Governments and Administrations
D.S.I.R.—Road Research Laboratory
Docks Division, The British Transport Division
Institute of Builders
Institution of Mechanical Engineers
Prestressed Concrete Development Group
Royal Institute of Chemistry
Manufacturers of Portland and High Alumina Cements

BRITISH STANDARD SPECIFICATION FOR

PORTLAND CEMENT (ORDINARY AND RAPID HARDENING)

NOTE. The term ' Rapid hardening ' has been adopted in this standard because its use has become accepted in this country. It is synonymous with the designation ' High early strength ' which is used in other countries and should not be confused with ' Quick-setting '.

FOREWORD

This British Standard has been revised under the authority of the Cement, Lime and Gypsum Products Industry Standards Committee, in order to bring it into line with present practice followed in the production and testing of cement.

In this revision the tensile test has been deleted except for rapid hardening Portland cement to be used in the manufacture of pre-cast concrete products and for other similar purposes. For this particular case the tensile test is retained as an optional one-day test pending the development of a more satisfactory one-day strength test.

A new compressive strength test has been introduced as an alternative to the vibrated mortar cube test. This new test is carried out on concrete cubes using any aggregate meeting certain specified requirements. It is considered that the value of the cement is more clearly indicated by the results of this concrete cube test than by those of the tensile test.

The sieve test has been deleted, and the specific surface test is retained as the better method of testing the fineness of the cement. This measures the surface area of the particles per unit weight (known as the ' specific surface '). For the determination of the density of cement in the specific surface test an alternative kerosine fraction has been included, subject to a specified limit for the change in density of the fraction. The time of wet mixing in the preparation of mortar cubes has been increased. The water content required for the determination of both setting time and soundness has been raised to one hundred per cent of the water required to give a paste of standard consistence. The initial setting time has been increased.

The temperature allowed during the performance of the various operations required throughout this British Standard has been raised in order to bring it into closer conformity with international practice.

With the exception of the figure for the 3 day test on rapid-hardening Portland cement, the figures for the average compressive strength of the mortar cubes used in the strength test have been increased.

New limits for total sulphur, expressed as sulphuric anhydride, are related to the amount of tri-calcium aluminate contained in the cement, and the limit for insoluble residue has been raised.

The sampling procedure has been revised.

NOTE. Where metric equivalents have been given the figures in British units are to be regarded as the standard. The metric conversions are approximate. More accurate conversions should be based on the tables in B.S. 350.

SPECIFICATION

SCOPE

1. This British Standard gives requirements for the composition, manufacture, sampling and testing of ordinary and rapid hardening Portland cement.

COMPOSITION AND MANUFACTURE OF PORTLAND CEMENT

2. The cement, whether ordinary or rapid-hardening, shall be manufactured by intimately mixing together calcareous or other lime bearing material with, if required, argillaceous and/or other silica, alumina or iron oxide bearing materials, burning them at a clinkering temperature and grinding the resulting clinker so as to produce a cement capable of complying with this British Standard.

No materials other than gypsum (or its derivatives), or water, or both, shall be added after burning.

TESTS

3. The sample or samples taken as described in Clause 9 shall be tested in the manner specified for :—

a. Fineness.

b. Chemical composition.

c. Strength.

d. Setting time.

e. Soundness.

FINENESS

4. The cement shall be tested for fineness by the method described in Appendix A, and shall have a specific surface of not less than :—

Ordinary Portland cement 2250 sq. cm/g
Rapid-hardening Portland cement 3250 sq. cm/g.

CHEMICAL COMPOSITION

5. The chemical composition of the cement shall comply with the following requirements :

a. **Lime saturation factor.** The lime saturation factor (L.S.F.) shall be not greater than 1·02 and not less than 0·66 when calculated by the formula :—

$$\text{L.S.F.} = \frac{(CaO) - 0{\cdot}7\,(SO_3)}{2{\cdot}8\,(SiO_2) + 1{\cdot}2\,(Al_2O_3) + 0{\cdot}65\,(Fe_2O_3)}$$

where each symbol in brackets refers to the percentage (by weight of total cement) of the oxide, excluding any contained in the insoluble residue referred to below.

b. **Insoluble residue.** The weight of insoluble residue, as determined by the method described in Appendix B, shall not exceed 1·5 per cent.

c. **Magnesia.** The weight of magnesia contained in the cement shall not exceed 4·0 per cent.

d. **Alumina-iron ratio.** The ratio of the percentage of alumina to the percentage of iron oxide shall be not less than 0·66.

e. **Sulphuric anhydride.** The permitted content of total sulphur in the cement, expressed as SO_3 shall not exceed the appropriate figure in the following table :

Tri-calcium aluminate	Maximum total sulphur expressed as SO_3
(Percentage by weight)	(Percentage by weight)
7 or less	2·5
Greater than 7	3·0

The tri-calcium aluminate content (C_3A) is calculated by the formula:—

$$C_3A = 2{\cdot}65\,(Al_2O_3) - 1{\cdot}69\,(Fe_2O_3)$$

where the symbols have the same meaning as in 5*a* above.

f. **Loss on ignition.** The total loss on ignition shall not exceed 3 per cent for cement in temperate climates or 4 per cent for cement in tropical climates.

STRENGTH

6. *a.* **Compressive strength.** The cement shall be tested for compressive strength by one of the following two methods as agreed by the vendor and purchaser at the time of placing the order.

In the event of a dispute, a re-test shall be carried out in the presence of representatives of the two parties concerned. When Method 2 is employed the aggregate to be used in the re-test shall be agreed by both parties. If an aggregate cannot be agreed then Method 1 shall be used.

Method 1. The average compressive strength of three mortar cubes, prepared, stored and tested in the manner described in Appendix C, shall be :—

Ordinary Portland cement

3 days (72 ± 1 hour) not less than 2200 lb/sq. in. (154 kg/sq. cm.)

7 days (168 ± 2 hours) shall show an increase on the compressive strength at 3 days and be not less than 3400 lb/sq. in. (239 kg/sq. cm)

Rapid hardening Portland cement

3 days (72 ± 1 hour)	not less than 3000 lb/sq. in. (210 kg/sq. cm)
7 days (168 ± 2 hours)	shall show an increase on the compressive strength at 3 days and be not less than 4000 lb/sq. in. (281 kg/sq. cm)

Method 2. The average compressive strength of three concrete cubes, prepared, stored and tested in the manner described in Appendix D, shall be :

Ordinary Portland cement

3 days (72 ± 1 hour)	not less than 1200 lb/sq. in. (84 kg/sq. cm)
7 days (168 ± 2 hours)	shall show an increase on the compressive strength at 3 days and be not less than 2000 lb/sq. in. (140 kg/sq. cm)

Rapid hardening Portland cement

3 days (72 ± 1 hour)	not less than 1700 lb/sq. in. (119 kg/sq. cm)
7 days (168 ± 2 hours)	shall show an increase on the compressive strength at 3 days and be not less than 2500 lb/sq. in. (175 kg/sq. cm)

b. Tensile strength. When specially desired the one-day strength test of rapid hardening Portland cement shall be asked for at the time of placing the order. It shall be carried out by the method described in Appendix H and the average tensile strength of six mortar briquettes shall be not less than 300 lb/sq. in. (21 kg/sq. cm).

NOTE. Pending the development of a more satisfactory one-day test, this test is retained for the benefit of those users, such as the manufacturers of pre-cast concrete products, for whom early demoulding is an essential part of the process.

CONSISTENCE OF STANDARD CEMENT PASTE

7. The quantity of water needed to produce a paste of standard consistence shall be ascertained by the method described in Appendix E.

SETTING TIME

8. The setting time of the cement, when tested by the method described in Appendix F, shall be as follows :

Initial setting time	not less than 45 minutes.
Final setting time	not more than 10 hours.

SOUNDNESS

9. The cement, when tested for soundness by the method described in Appendix G, shall not have an expansion of more than 10 mm (0·4 in.).

If the cement fails to comply with this requirement, a further test shall be made in the manner described in Appendix G. For this test another portion of the same sample shall be used after it has been aerated by being spread out to a depth of 3 in. at a relative humidity of 50 to 80 per cent for a total period of 7 days. The expansion of this aerated sub-sample shall not exceed 5 mm (0·2 in.).

SAMPLING

10. If a sample is required for testing it shall be taken by the purchaser or his representative. The sample shall be taken within one week of delivery of the cement, stored in a dry and clean airtight container and tested within four weeks of delivery.

Selection of samples. Each sample for testing shall weigh at least 15 lb (6·80 kg) and shall be truly representative of the consignment, or part of a consignment, sampled. The sample shall consist of a mixture of at least 12 equal sub-samples taken from places evenly spaced throughout the consignment, or part of a consignment, sampled. Sub-samples of bulk cement shall be taken from the bulk container, or containers, during filling or emptying. For cement in bags, drums or other packages, not more than one sub-sample shall be taken from any one bag, drum or other package. Where there are fewer than 12 bags, drums or other packages to be sampled, one sub-sample shall be taken from each.

FACILITIES FOR SAMPLING AND IDENTIFYING

11. When a sample of cement for testing is to be taken on the premises of the vendor*, he shall afford every facility and provide all labour and materials for taking and packing the sample and, as far as possible, for subsequently identifying the cement sampled.

NOTE. It is recognized that there may sometimes be difficulty in satisfying the last requirement since it may not be possible to identify a particular lot of cement after it has been placed with other cement in a silo on the user's site.

TESTS AND MANUFACTURER'S CERTIFICATES

12. The manufacturer shall satisfy himself that the cement at the time of its delivery conforms to the requirements of this British Standard and, if requested, shall forward a certificate to this effect to the purchaser or his representative. Any consignment, or part of a consignment, which, when sampled according to Clause 10, does not satisfy the whole of the test and analytical requirements specified above, shall be deemed not to comply with this British Standard.

* The term 'vendor' in this standard shall mean the seller of the cement, whether he be the manufacturer of the cement or not.

If the purchaser or his representative requires independent tests, the samples shall, at the option of the purchaser or his representative, be taken before or immediately after delivery and the tests shall be carried out in accordance with this British Standard on the written instructions of the purchaser or his representative. If the vendor so desires, he or his representative shall be present at the sampling. The manufacturer shall supply, free of charge, the cement required for testing. Unless otherwise specified in the enquiry and order, the cost of the tests shall be borne as follows :—

a. By the manufacturer if the results show that the cement does not comply with this British Standard.

b. By the purchaser if the results show that the cement complies with this British Standard.

DELIVERY

13. Unless otherwise agreed between the purchaser and the vendor, the cement shall be packed in bags, of which there shall be 20 to the ton (2240 lb), bearing the manufacturer's name or registered mark. The number of bags to the ton or the approximate weight of the cement shall be legibly marked on each bag.

CEMENT IN TROPICAL CLIMATES

14. The temperatures specifically mentioned in Appendixes C, D, E, F, G and H are applicable to temperate climates. Cement intended for use in tropical climates may be tested at temperatures exceeding 68°F (20°C) but not exceeding 95°F (35°C)*. When so tested, cement satisfying the requirements herein specified for temperate climates shall be deemed to comply with this British Standard.

* When cement is tested at temperatures above 68°F (20·0°C) the setting time and strength requirements may be altered by agreement between purchaser and vendor. It should be noted that an increase in the testing temperature reduces the setting time and increases the compressive strength.

APPENDIX A

TEST FOR FINENESS BY DETERMINATION OF SPECIFIC SURFACE

SUMMARY

A.1. This method of test covers the procedure for determining the fineness of cement as indicated by specific surface expressed as total surface area in square centimetres per gramme.

PERMEABILITY CELL

A.2. The permeability cell consists of a metal* cylinder made in two flanged parts which are bolted together, containing a perforated plate on which is supported a No. 40 Whatman or similar filter paper 3·2 cm in diameter. The joint between the flanges is rendered airtight by means of a rubber or other suitable gasket. The permeability cell shall be constructed to the dimensions and tolerances shown in Fig. 1, as shall the plunger by means of which the cement sample is formed, as described below, into a cylindrical bed supported by the filter paper.

MANOMETER STAND

A.3. The permeability cell shall be connected by rubber bungs and tubes to a manometer and flowmeter as shown in Fig. 2. The arms of the manometer should be about 60 cm long and the capillary of the flowmeter shall have a constant C (as defined in the next clause) between $2{\cdot}0 \times 10^{-6}$ and $4{\cdot}0 \times 10^{-6}$ c.g.s. units. In addition the bore of the capillary shall be not less than 0·5 mm. The liquid in both U-tubes shall be kerosine (paraffin oil).

The necessary air flow may be produced by any convenient process, but the air entering the apparatus shall be dried by passing through a tower packed with anhydrous calcium chloride or other suitable desiccant.

CALIBRATION OF THE FLOWMETER

A.4. Dry air shall be passed through the flowmeter at a constant rate for a measured time. The issuing air shall be collected over water and measured. This process shall be repeated for a number of flowmeter readings over the range 25-55 cm. The average value of the constant C shall be calculated from the formula :

$$C = \frac{Q\eta}{h_2\rho_L}$$

where Q is the volume of dry air passed in cubic centimetres per second†

* Stainless steel is recommended.

† If the measured volume of damp air is V cu. cm at atmospheric pressure P, and the vapour pressure of water at the room temperature is p, and the time during which the air collected is t seconds, then :—

$$Q = \frac{V}{t} \cdot \frac{(P-p)}{P}$$

corrected to atmospheric pressure, η is the viscosity, in c.g.s. units, of air at the given temperature, h_2 is the flowmeter reading in centimetres and ρ_L the density of the kerosine in grammes per millilitre.

The flowmeter constant C shall be checked every three months.

The viscosity of air in c.g.s. units at temperatures of 15-20°C is shown below multiplied by 10^4.

Temp. °C	15	16	17	18	19	20	21	22	23	24	25
Viscosity	1·78	1·78	1·79	1·79	1·80	1·80	1·81	1·81	1·82	1·82	1·8 3

ASSEMBLING AND TESTING

A.5. The filter paper shall be changed after every six determinations. In assembling the permeability cell care shall be taken that the two halves are firmly bolted together and from time to time the apparatus shall be tested for leakage. This is best done by disconnecting at the manometer the rubber tube leading from the lower bung of the cell, sealing the tube with a screw clip, applying the air pressure and then sealing off the air inlet. Readings of the manometer should not differ by more than 0·05 cm in a period of one minute.

DETERMINATION OF DENSITY

A.6. The density of the cement shall be determined in the usual manner by displacement of liquid in a density bottle. The liquid used shall be re-distilled kerosine (paraffin oil). The bottle containing the weighed cement shall be half filled with kerosine and evacuated for at least half-an-hour on a water or vacuum pump before the bottle is filled with kerosine and transferred to a thermostat.

The accuracy of determination of the density of the cement shall be $\pm$ 0·02 g/cu. cm. For this purpose the liquid used shall not change in density by more than 0·0005 g/ml when evacuated for a period of 5 hours.

NOTE. A suitable liquid can be prepared in the laboratory by re-distilling kerosine and collecting the fraction condensing at 200—240°C. Alternatively, petroleum fractions with boiling ranges within the range 190—255°C and with sufficiently stable density characteristics are commercially available. If any difficulty is experienced in obtaining commercial supplies, the B.S.I. should be consulted for the names of stockists.

TABLE 1. WEIGHT OF CEMENT (GRAMMES) REQUIRED TO FORM A BED 1·0 CM DEEP × 2·54 CM DIAMETER, POROSITY 0·475

Density	0	1	2	3	4	5	6	7	8	9
2·8	7·449	7·475	7·502	7·528	7·555	7·582	7·608	7·635	7·661	7·688
2·9	7·715	7·741	7·768	7·794	7·821	7·848	7·874	7·901	7·927	7·954
3·0	7·981	8·007	8·034	8·060	8·087	8·114	8·140	8·167	8·193	8·220
3·1	8·247	8·273	8·300	8·326	8·353	8·380	8·406	8·433	8·459	8·486
3·2	8·513	8·539	8·566	8·592	8·619	8·646	8·672	8·699	8·725	8·752

DETERMINATION OF SPECIFIC SURFACE

A.7. From Table 1 a weight of cement shall be selected which will give, when compacted, a porosity of 0·475 at the given density of the cement sample. The porosity is defined as the ratio of the volume of pore space to the total volume of the bed. The cement shall be brushed from the weighing bottle into the permeability cell, which shall be gently shaken from side to side to level off the surface. If the cement is lumpy it may first be rubbed gently with a spatula on glazed paper.

The cell shall then be tapped four times by allowing it to fall from a height of about 1 cm on to a wooden bench. The plunger shall next be slowly inserted and pushed home so that the collar of the plunger is in contact with the top of the permeability cell. The plunger shall not be twisted while in contact with the cement surface but shall be slowly withdrawn with a twisting motion.

If, on inspection, the cement bed is seen to be disturbed, it shall be knocked out and the operation repeated. Occasionally a cement is encountered which springs up slightly on the withdrawal of the plunger. The increase in the depth of bed so caused may be up to 0·01 cm. The resulting error in specific surface will be less than 2 per cent but, if desired, the true height of the bed may be measured and the result corrected.

The upper bung shall then be inserted and the air turned on slowly ; the lower bung shall next be inserted slowly in order to avoid forcing air through the cement in the wrong direction. The rate of air flow shall be adjusted until the flowmeter shows a difference in level of 30-50 cm. Readings of the difference in level h_1 of the manometer and of the difference in level h_2 of the flowmeter shall then be made. These observations shall be repeated to ensure that steady conditions have been obtained, as shown by a constant value of h_1/h_2.

NOTE. While the apparatus described above should be regarded as standard, alternative forms of air permeability apparatus may also be used provided they have been calibrated against the standard apparatus.

CALCULATION OF RESULT

A.8. The specific surface S_w is given by the formula :

$$S_w = K\sqrt{h_1/h_2}$$

$$\text{where } K = \frac{14}{\rho(1-\epsilon)}\sqrt{\frac{\epsilon^3 A}{CL}}$$

ϵ is the porosity, i.e. 0·475, A the area (sq. cm) and L the depth (cm) of the cement bed, ρ is the density of the cement expressed in grammes per cubic centimetre, and C the flowmeter constant. Values of K for densities between 2·8 and 3·2 should be tabulated for each apparatus. For apparatus made to the specified dimensions,

$$K = 19{\cdot}65\,\frac{1}{\rho}\sqrt{\frac{1}{C}}$$

ROUTINE CHECKING OF *K* VALUES

A.9. When the apparatus is made to the specified dimensions, the values of A and L, to be used in calculating K, will be 5·066 sq. cm and 1·00 cm respectively. The depth of bed shown in Fig. 1 is 0·001 in. greater than 0·394 in. (1 cm) in order to allow for the filter paper which is compressed where it is held by the walls of the metal cylinder but not in the cell itself.

These dimensions should be checked when the apparatus is received, either by means of a travelling microscope or by using a test piece to simulate the cement bed. This test piece shall be made of hardened steel, 0·99 in. (2·51 cm) in diameter and 0·399 in. (1·01 cm) deep. It shall be placed on the filter paper and the plunger shall be inserted. The gap between the shoulder of the plunger and the top of the permeability cell shall then be checked by means of feeler gauges and should be 0·005 in. (0·1 mm).

The dimensions of the permeability cell shall be checked after every 100 determinations.

APPENDIX B

TEST FOR DETERMINATION OF INSOLUBLE RESIDUE

SUMMARY

B.1. This method of test determines the quantity of cement which is insoluble in hydrochloric acid of specified normality.

METHOD OF DETERMINING INSOLUBLE RESIDUE

B.2. One gramme of cement shall be weighed into a 250-400 ml beaker and stirred with 40 ml of water ; 10 ml concentrated HCl (sp. gr. 1·16) shall be added and the mix stirred again. The mix shall be warmed, any lumps present being broken up, and then boiled gently for 10 minutes, maintaining constant volume by adding water. The contents of the beaker shall then be filtered through a No. 40 Whatman or similar filter paper, the beaker rinsed out five times with hot water and the residue on the filter washed approximately ten times with hot water. The residue shall then be washed from the filter paper back into the same beaker with approximately 30 ml of hot distilled water, and 30 ml of 2N solution of Na_2CO_3 shall be added. The contents of the beaker shall then be boiled for 10 minutes, maintaining constant volume by adding water. The contents of the beaker shall then be filtered again through the same filter paper, taking care to transfer all the residue to the paper, and washed at least five times with hot water, twice with a hot 2N solution of HCl and finally with hot water until free from chlorides. The filter paper with the residue shall be dried, ignited and weighed as ' insoluble residue '.

APPENDIX C

TEST FOR COMPRESSIVE STRENGTH OF CEMENT USING MORTAR CUBES

SUMMARY

C.1. This method of test covers the procedure for determining the strength of cement as represented by compressive strength tests on mortar cubes compacted by means of a standard vibration machine.

DESCRIPTION OF VIBRATION MACHINE

C.2. The vibration machine consists of a frame mounted on coil springs to carry the cube mould, and a revolving shaft provided with an eccentric. By means of a balance weight beneath the base plate attached rigidly to the frame, the centre of gravity of the whole machine, including the cube and mould, is brought either to the centre of the eccentric shaft or within a distance of 1 in. below it. In consequence of this, the revolving eccentric imparts an equal circular motion to all parts of the machine and mould, the motion being equivalent to equal vertical and horizontal simple harmonic vibration 90° out of phase. The minimum running speed of the machine is well above its natural frequency on its supporting springs, so that the amplitude of vibration is independent of the speed. The motor should preferably be of the synchronous type and the drive should be by means of an endless belt running on a crowned pulley on the motor and a crowned pulley on the vibrator.

The machines shall be constructed to comply with the following essential requirements :—

Weight of machine on its supporting springs (excluding weight of solid eccentric, but including weight of mould, mould clamp, hopper and cube)	64 lb (29 kg) approx.
' Out-of-balance ' moment of eccentric shaft	0·14 in. lb
Normal running speed of eccentric shaft	12 000 ± 400 rev/min.

A machine of the type described above is shown in Fig. 3. A set of working drawings and specification of a machine of a suitable type can be obtained on application to the British Standards Institution, 2 Park Street, London, W.1.

PREPARATION OF TEST SPECIMENS

C.3. *a.* **Size of specimens and markings.** The test specimens shall be cubes having a length of side of 2·78 in. (7·06 cm), the area of each face equalling 7·75 sq.in. (50 sq.cm). Each cube shall be suitably marked for identification.

b. **Cube moulds.** Moulds for the 2·78 in. cube specimens shall be of metal not attacked by cement mortar, and there shall be sufficient

material in the sides of the mould to prevent spreading and warping. The moulds shall be rigidly constructed in such a manner as to facilitate the removal of the moulded specimen without damage. The moulds shall be machined so that when assembled ready for use they satisfy the following requirements :

(i) The height of the moulds and the distance between opposite faces shall be 2·78 ± 0·005 in.

(ii) The angle between adjacent interior faces and between interior faces and top and bottom planes of the mould shall be 90 ± 0·5 degrees.

(iii) The interior faces of the moulds shall be plane surfaces with a permissible variation of 0·005 in.

(iv) Each mould shall be made of non-absorbent material, preferably metal which is not attacked by cement mortar, and shall be provided with a base plate having a plane surface machined to a tolerance of ± 0·005 in. The base plate shall be of such dimensions as to support the mould without leakage during the filling.

The weight of the cube mould shall be such that the total weight of the cube mould and machine, as given in Clause C.2 of this Appendix, is approximately 64 lb (29 kg).

In order to protect the moulded specimen from damage the parts of the mould, when assembled, shall be positively held together, both during the filling and on subsequent removal of the filled mould from the vibration machine.

c. **Standard sand.** The standard sand shall be obtained from Leighton Buzzard, shall be of the white variety and shall be thoroughly washed and dried. Its loss of weight on extraction with hot hydrochloric acid shall not be more than 0·25 per cent.*

The sand shall pass through an 18-mesh B.S.† sieve and not more than 10 per cent by weight shall pass a 25-mesh B.S. sieve.

d. **Mix proportions and mixing.** A mixture of cement and sand in the proportions of one part by weight of cement to three parts by weight of the standard sand shall be mixed dry with a trowel on a non-porous plate for one minute and then with water for 4 minutes.

The material for each cube shall be mixed separately and the quantities of cement, standard sand and water shall be as follows :

Cement	185 g
Standard sand	555 g
Water	74 g

* To test, dry the sand at 100°C for 1 hour, weigh out 2 g into a porcelain dish, add 20 ml of hydrochloric acid of specific gravity 1·16 and 20 ml of distilled water. Heat on a water bath for one hour, filter, wash well with hot water, dry and ignite in a covered crucible.

† B.S. 410, ' Test sieves '.

Clean appliances shall be used for mixing, and the temperature of the materials and that of the test room during mixing shall conform to the requirements given in Clause D3 of Appendix D.

e. **Moulding specimens.** In assembling the moulds ready for use, the joints between the halves of the moulds shall be covered with a thin film of petroleum jelly and a similar coating of petroleum jelly shall be applied between the contact surfaces of the bottom of the mould and its base plate in order to ensure that no water escapes during the vibration. The interior faces of the assembled mould shall be treated with a thin coating of mould oil.

The assembled mould shall then be placed on the table of the vibration machine and firmly held in position by means of a suitable clamp. A hopper of suitable size and shape shall be securely attached to the top of the mould to facilitate filling and this hopper shall not be removed until completion of the vibrating period.

Immediately after mixing in accordance with sub-clause *d* of this clause, the whole of the mortar shall be placed in the hopper of the cube mould and shall then be compacted by vibration for 2 minutes at 12 000 ± 400 vibrations per minute.

f. **Curing of specimens.** Immediately after vibration the cubes shall be placed in an atmosphere of at least 90 per cent relative humidity at a temperature of 66 ± 2°F (18·9 ± 1·1°C) for 24 ± ½ hours. In order to reduce evaporation, the exposed top of the cubes shall be covered with a flat impervious sheet (e.g. thin rubber, polythene or steel) making contact with the upper edge of the mould. After 24 ± ½ hours the cubes shall be marked for identification, removed from the moulds, immediately submerged in water and kept there until taken out just prior to breaking. The water in which they are submerged shall have been initially clean and fresh and shall be renewed every seven days with clean fresh water and maintained at a temperature of 66 ± 2°F (18·9 ± 1·1°C).

TESTING

C.4. The cubes shall be tested immediately upon removal from the water and while they are still wet. Surface water and grit shall be wiped off the cube and any projecting fins removed. Three cubes shall be tested for compressive strength at 3 days and three at 7 days, the ages being reckoned from the completion of vibration, and the compressive strength shall be the average compressive strength of the three cubes for each period respectively.

The compression test shall be made on a compression testing machine complying with Clause 58 of B.S. 1881, ' Methods of testing concrete ' including the requirements for accuracy given for Grades A and B in B.S. 1610, Part 1, ' Verification of testing machines '.

The cubes shall be tested on their sides without any packing other than hardened steel plates between the cube and the steel platens of the testing machine. One of the platens shall be carried on a ball seating and shall be self-adjusting. The load shall be steadily and uniformly applied, starting from zero, at a rate of 5000 lb/sq.in min (351·5 kg/sq.cm min).

CALCULATIONS

C.5. The compressive strength shall be calculated from the crushing load and the area over which the load is applied and shall be expressed in pounds per square inch to the nearest 50.

APPENDIX D

TEST FOR COMPRESSIVE STRENGTH OF CEMENT USING CONCRETE CUBES

SUMMARY

D.1. This method of test covers the procedure for determining the strength of cement as indicated by compressive strength tests on concrete cubes compacted by hand and made with an aggregate complying with specified requirements.

PRINCIPAL APPARATUS

D.2. *a.* **Compression testing machine.** The compression tests shall be made on a compression testing machine complying with Clause 58 of B.S. 1881, ' Methods of testing concrete ' including the requirements for accuracy given for Grades A and B in B.S. 1610, Part 1, ' Verification of testing machines '.

b. **Cube moulds.** The moulds shall be 4 in. (10·16 cm) cubes and shall conform to the requirements of B.S. 1881 (Clause 44*a*).

c. **Tamping bar.** The tamping bar shall be as specified in B.S. 1881* (Clause 44*b*).

TEMPERATURES

D3. The temperatures shall be kept within the ranges stated below :

a. Air in the mixing room between 64°F and 74°F (17·7°C and 23·3°C).

b. Temperature of air in the immediate vicinity of specimens during the first 24 hours of storage : 66 ± 2°F (18·9 ± 1·1°C).

c. Temperature of curing water 60 ± 2°F.

*B.S. 1881. ' Methods of testing concrete '.

All the materials, moulds and other appliances shall be at the same temperature as the air in the mixing room. This condition shall be achieved by storing them in the room for a sufficient time.

A record of the actual temperatures of the air in the mixing room shall be kept for reference purposes, and in addition the maximum and minimum temperatures of the air in the immediate vicinity of the specimens and of the curing water shall be recorded daily throughout the period of curing by means of a maximum and minimum thermometer.

NOTE. Variation in the temperature of storage during the first 24 hours, even within the range permitted, can influence the test results, and particular attention should be given to satisfying the requirements of sub-clause *b* of this clause.

MATERIALS

D.4. *a.* **Coarse aggregate.**

(i) *Type.* The coarse aggregate shall belong to one or more of the following five groups as specified in B.S. 812*, Clause 9 :—

Flint, granite, limestone, porphyry or quartzite.

If granite is used the felspar contained in it shall be fresh and shall show no decomposition or kaolinization. Dolerite may be used provided that it gives substantially the same results as the specified aggregates, but it is not specified because some dolerites have been found unsuitable for this test.

The aggregate shall comply with B.S. 882†, Clause 3, except for the quantity of the fine material which is referred to in (ii) below.

(ii) *Grading.* The aggregates shall all pass a ¾ in.-mesh B.S.‡ sieve and be substantially retained on a 3/16 in.-mesh B.S. sieve. The amount passing a 200-mesh B.S. sieve shall not exceed ½ per cent when tested in accordance with B.S. 812* (Clause 13).

b. **Fine aggregate.**

(i) *Type.* The fine aggregate shall be a siliceous sand complying with B.S. 882†, Clause 3, except in respect of the organic impurities referred to in (ii) below and in respect of clay and silt etc., referred to in (iii) below, and containing not more than 5 per cent of carbonates. The carbonate content of the sand shall be determined by the method described in Clause D.8 of this Appendix

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ERRATUM

Clause D3 *c.* In place of ' 60 ± 2 °F.' read ' 66 ± 2 °F (18·9 ± 1·1 °C).'

(iii) *Grading*. Substantially all fine aggregate shall pass a $\frac{3}{16}$ in.-mesh B.S.† sieve and the proportion by weight of the fine aggregate passing a 100-mesh B.S. sieve, when tested in accordance with B.S. 812* (Clause 11), shall not be more than 10 per cent. The amount of aggregate passing a 200-mesh B.S. sieve shall not exceed 2 per cent when tested in accordance with B.S. 812* (Clause 13).

c. **Absorption.** When combined in the required proportions the coarse and fine aggregates shall not have an absorption of water greater than 2½ per cent by weight when tested by the method described in Clause D.9 of this Appendix.

PREPARATION OF SPECIMENS

D.5. *a.* **Number of cubes.** Three cubes shall be tested at each of the specified ages.

b. **Aggregate.**

(i) *Quantity*. The total quantity of dry aggregate for each cube to be mixed with the amounts of cement and water specified below shall be determined by trial and shall be such that the finished surface of the fully-compacted concrete is level with the upper plane of the mould. The weight of this dry aggregate will depend on its specific gravity but will be approximately 1950 g for siliceous materials.

(ii) *Drying*. The aggregate shall be dried either by the use of a hotplate or by other means at a temperature not exceeding 250°F (121·1°C), until no moisture is deposited on a cold glass plate held over the hot aggregate. The aggregate shall then be stored in a closed container.

c. **Proportioning.**

(i) *Mix*. The total quantity of dry aggregate, as defined above, shall consist of coarse and fine aggregate in proportions which shall be determined by trial and shall satisfy the requirements for slump and workability specified below.

The amounts of cement and water used in each 4 in. (10·16 cm) cube shall be :

Cement	325 ± 1 g
Water	195 ± 1 g

NOTE. The specified quantities give a concrete with an aggregate/cement ratio of approximately 6 and a water/cement ratio of 0·60.

(ii) *Slump and workability*. The grading of the aggregates and the relative proportions of coarse and fine aggregates shall be adjusted by

*B.S. 812 'Methods of sampling and testing of mineral aggregates, sands and fillers'.
†B.S. 410 'Test sieves' and B.S. 481 'Woven wire and perforated plate sieves and screens for industrial purposes'.

trial until a true slump* of between ½ in. (1·3 cm) and 2 in. (5·1 cm) is obtained. In addition the concrete obtained shall be reasonably workable in the opinion of an experienced tester. The slump test shall be carried out in accordance with the method described in B.S. 1881, Part 2, the cone being lifted 6 minutes after the water is added to the dry mixed materials. The trial mixes for slump will require larger quantities than those for the cubes but the quantities shall be mixed by hand in the same way. The period of dry mixing given below shall be increased if necessary in order to mix completely this larger quantity.

If it is found that these conditions for slump and workability cannot be fulfilled then the aggregates chosen shall be rejected and other aggregates shall be selected.

d. **Mixing.** The concrete for each cube shall be mixed separately. The mixing shall be performed on a non-porous surface which has been wiped over with a damp cloth. The cement and sand shall be mixed dry, for one minute, by means of two trowels of which a suitable type is shown in Fig. 4. The coarse aggregate shall then be added and mixed dry with the cement and sand until the mixture is uniform. The water shall then be added and the whole mixed for three† minutes with two trowels. The concrete shall be transferred to the mould in two approximately equal layers, each of which shall be given at least 35 strokes of the standard tamping bar distributed in a uniform manner over the cross section of the mould. After each layer has been compacted the sides of the cube shall be trowelled by passing the blade of the trowel between the concrete and the mould wall to remove air bubbles.

The whole of the concrete shall be transferred to the mould by scraping the slab and tamping bar with the trowels and the trowels with each other. Finally, the top of the concrete shall be smoothed with a trowel.

STORAGE OF SPECIMENS

D.6. Immediately after making, the cubes shall be placed in an atmosphere of at least 90 per cent relative humidity at a temperature of 66 ± 2°F (18·9 ± 1·1°C) for 24 ± ½ hours. In order to reduce evaporation the exposed top of the cubes shall be covered with a flat impervious sheet (e.g. thin rubber, polythene or steel) making contact with the upper edge of the mould. After 24 hours the cubes shall be marked for identification, removed from the moulds‡, immediately submerged in water and kept there until taken out just prior to breaking. The water in which they are

* A true slump is one in which the concrete remains substantially intact and retains a symmetrical shape.
† This period of mixing, after adding the water, has been found to be adequate for experienced testers and ensures that there is no substantial evaporation of water.
‡ It is recommended that the cubes should be weighed at this stage in order to ensure that there has been no error in the procedure. This may detect errors at an early stage

submerged shall have been initially clean and fresh and shall be renewed every seven days with clean fresh water and maintained at a temperature of 66 ± 2°F (18·9 ± 1·1°C).

TESTING

D.7. The procedure for determining the compressive strength of the concrete test cubes shall be that specified in Clauses 58, 59, 60 and 61 of B.S. 1881 : 1952*.

DETERMINATION OF CALCIUM CARBONATE IN SILICA SAND

D.8. Reagents required.

N/2 hydrochloric acid solution.
Approx. N/4 caustic soda solution.

b. **Test procedure.** 20 ml of N/2 hydrochloric acid shall be titrated against the caustic soda solution. Let the number of millilitres of the caustic soda solution required be denoted by A.

A representative quantity of 100 g of dry fine aggregate shall be ground to pass a 25-mesh B.S. sieve. By suitable methods of sample division, such as riffling or quartering, from this 100 g a representative 1 g sample shall be obtained and ground further to pass a 100-mesh B.S. sieve. This 1 g sample shall be placed in a conical flask and 20 ml of N/2 hydrochloric acid and approximately 50 ml of boiled distilled water shall be added.

The solution shall be boiled gently for 2 minutes. Six drops of 1 per cent solution of phenolphthalein in alcohol shall be added and caustic soda solution shall be titrated until a distinct pink colour appears. Let the number of millilitres of caustic soda required be *B*.

In order that the carbonate, calculated as calcium carbonate, shall not exceed 5 per cent,

B shall be not less than $0{\cdot}9\ A$.

DETERMINATION OF THE ABSORPTION OF COMBINED AGGREGATES

D.9. *a.* **Determination of the absorption of coarse aggregate.** A sample of about 3 kg of the aggregate shall be dried in a well ventilated oven at a temperature of 100-110°C for 24 hours, cooled in an airtight container and weighed (Weight *A*).

The dried sample shall then be placed in a suitable vessel and covered with distilled water or clean tap water at a temperature of 15-25°C and shall remain immersed for 24 hours. Air bubbles on the surface of the aggregate shall be removed, as they appear, by gentle agitation with a rod. The sample shall then be taken from the water and any water visible on

* B.S. 1881, ' Methods of testing concrete '.

the surface shall be rapidly removed by means of a damp cloth. The surface-dried sample shall immediately be weighed (Weight *B*).

$$\text{Percentage absorption} = \frac{B - A}{A} \times 100$$

b. **Determination of the absorption of fine aggregate.** A sample of about 1 kg of the fine aggregate shall be dried in a well ventilated oven at a temperature of 100-110°C for 24 hours, cooled in a clean and dry airtight container and weighed (Weight *C*). The dried sample shall then be placed in a suitable vessel and covered with distilled water or clean tap water at a temperature of 15-25°C and shall remain immersed for 24 hours. Entrapped air or bubbles on the surface of the aggregate shall be removed by gentle agitation with a rod.

The water shall then be carefully drained from the sample, by decantation through a filter paper to avoid loss of solid matter. The aggregate shall then be exposed to a current of warm air* to evaporate surface moisture. It shall be stirred at frequent intervals to ensure uniform drying, until no free surface moisture can be seen and the material just attains a ' free running ' condition, e.g. when material just fails to adhere to a glass rod dipped in the aggregate and withdrawn ; care shall be taken to ensure that this stage is not passed. This saturated and surface-dry sample shall then be weighed (Weight *D*).

$$\text{Percentage absorption} = \frac{D - C}{C} \times 100$$

c. **Calculation of absorption of combined aggregate.**

Let A_C = percentage absorption of coarse aggregate.
A_F = percentage absorption of fine aggregate.
W_C = weight of coarse aggregate in a cube.
W_F = weight of fine aggregate in a cube.

Then $\dfrac{A_C W_C + A_F W_F}{W_C + W_C}$ shall not exceed 2½.

* A hair drier is useful for this purpose, but it should not be held close enough to the sand to raise its temperature appreciably.

APPENDIX E

DETERMINATION OF CONSISTENCE OF STANDARD CEMENT PASTE

SUMMARY

E.1. This method of test covers the procedure for determining the quantity of water required to produce a cement paste of standard consistence. This quantity is used to determine the water content of the pastes for setting time test (Appendix F) and for soundness test (Appendix G).

APPARATUS

E.2. The Vicat apparatus, shown in Fig. 5, shall be used, the plunger (G) 10 mm in diameter, being substituted for the needle there shown in position.

PROCEDURE

E.3. The quantity of water required to produce a paste of standard consistence shall be that required to give a paste which will permit of the settlement of the Vicat plunger to a point 5 mm to 7 mm from the bottom of the Vicat mould when the cement paste is tested as described below.

The time for gauging, that is the time elapsing from the moment of adding the water to the dry cement until commencing to fill the mould, shall be 4 ± ¼ minutes and the gauging shall be completed before any signs of setting occur.

The Vicat mould (E) Fig. 5, resting on a non-porous plate, shall be filled with the cement paste, the mould shall be completely filled in one layer and the surface of the paste shall be smoothed off level with the top of the mould as quickly as possible.

In filling the mould only the operator's hands and the blade of the ordinary gauging trowel shall be used. The trowel shall weigh approximately 7½ oz (213 g).

Clean appliances shall be used for gauging, and the temperature of the cement and water and that of the test room during gauging and filling the mould shall be 64—74°F (17·7—23·3°C) subject to the provisions of Clause 13.

The test block confined in the mould and resting on the plate shall be placed under the rod bearing the plunger, the latter shall then be lowered gently into contact with the surface of the test block and quickly released and allowed to sink in. This operation should be carried out immediately after filling the mould.

Trial pastes shall be made up of varying percentages of water until the amount necessary for determining the standard consistence, as defined above, is found. The amount of water used shall be recorded and expressed as a percentage by weight of the dry cement.

APPENDIX F

DETERMINATION OF INITIAL AND FINAL SETTING TIMES

SUMMARY

F.1. This method of test covers the procedure for determining the initial and final setting times of cement.

VICAT APPARATUS

F.2. The Vicat apparatus shown in Fig. 5 shall be employed.

PROCEDURE

F.3. *a.* **Preparation of test block.** For the purpose of carrying out the tests, a test block shall be made as follows :

Neat cement paste shall be formed by gauging cement with the quantity of water required to give a paste of standard consistence. The paste shall be gauged in the manner and under the conditions prescribed in Appendix E. The test block shall be made by filling the paste, gauged as above, into the Vicat mould (E) Fig. 5, the mould resting upon a non-porous plate. The mould shall be completely filled, and the surface of the paste shall then be smoothed off level with the top of the mould.

Clean appliances shall be used for gauging, and the temperature of the materials and that of the test room, at the time when the above operations are being performed, shall be 64—74°F (17·7—23·3°C), subject to the provisions of Clause 13.

The test block shall be kept, during the whole time of the test, at a temperature of 66 ± 2°F (18·9 ± 1·1°C), in an atmosphere of at least 90 per cent relative humidity and away from draughts.

b. **Determination of initial setting time.** For the determination of the initial setting time the test block, confined in the mould and resting on the plate, shall be placed under the rod bearing the needle (C) ; the latter shall then be lowered gently into contact with the surface of the test block and quickly released and allowed to sink in. This process shall be repeated until the needle, when brought into contact with the test block and released as above described, does not penetrate beyond a point approximately 5 mm from the bottom of the mould. The period elapsing between the time when the water is added to the cement and the time at which the needle ceases to pierce the test block, as described above, shall be the initial setting time above referred to.

c. **Determination of final setting time.** For the determination of the final setting time the needle (C) of the Vicat apparatus shall be replaced by the needle with an annular attachment (F), shown separately in Fig. 5. The cement shall be considered as finally set when, upon applying the

needle gently to the surface of the test block, only the needle makes an impression, while the attachment fails to do so. If a scum forms on the surface of the test block, the underside of the test block may be used for determining the final set.

APPENDIX G

DETERMINATION OF SOUNDNESS

SUMMARY

G.1. This method of test covers the procedure for determining the soundness of the cement by the ' Le Chatelier ' method of measuring its expansion.

APPARATUS

G.2. The apparatus for conducting the ' Le Chatelier ' test is shown in Fig. 6. The mould shall be kept in good condition, having the split not more than 0·5 mm wide.

PROCEDURE

G.3. In conducting the test the mould shall be placed upon glass and filled with cement paste formed by gauging cement with the quantity of water required to give a paste of standard consistence. The paste shall be gauged in the manner and under the conditions prescribed in Appendix E, care being taken to keep the split of the mould gently closed whilst this operation is being performed. The mould shall then be covered with another piece of glass, upon which a small weight shall be placed, and the whole shall then be submerged immediately in water at a temperature of 66 ± 2°F (18·9 ± 1·1°C), subject to the provisions of Clause 13, and left there for 24 hours.

The distance separating the indicator points (AA, Fig. 6), shall then be measured and the mould again submerged in water at the temperature prescribed above, which shall be brought to boiling point in 25 to 30 minutes, and kept boiling for one hour. The mould shall then be removed from the water and allowed to cool and the distance between the points again measured ; the difference between the two measurements represents the expansion of the cement.

APPENDIX H

OPTIONAL TEST FOR ONE-DAY TENSILE STRENGTH OF RAPID HARDENING PORTLAND CEMENT

SUMMARY

H.1. This method of test covers the procedure for the determination of the one-day strength of cement as represented by a tensile strength test on mortar briquettes of specified shape.

PREPARATION OF BRIQUETTES

H.2. A mixture of one part by weight of cement and three parts by weight of the standard sand specified in Clause 3*c* of Appendix C shall be mixed dry with a trowel or trowels on a non-porous plate for one minute and then with water for four minutes. The quantity of water shall be eight per cent by weight of the weight of cement and sand.

The mixture, gauged as above, shall be evenly distributed in moulds of the form required to produce briquettes of the shape shown in Fig. 7, each mould resting upon a non-porous plate. After filling a mould a small heap of the mixture shall be placed upon that in the mould and beaten down with the standard spatula shown in Fig. 8 until the mixture is level with the top of the mould. This last operation shall be repeated on the other side and the mixture beaten down until water appears on the surface ; the flat only of the standard spatula shall be used, and no other instrument or apparatus is to be employed for this operation. The briquettes shall be finished off in the moulds by smoothing the surface with the blade of a trowel.

Clean appliances shall be used for gauging, and the temperature of the materials and that of the test room during these operations shall be 64—74°F (17·7—23·3°C).

The briquettes shall be kept at a temperature of 66 ± 2°F (18·9 ± 1·1°C) in an atmosphere of at least 90 per cent relative humidity, for 24 ± ½ hours after gauging, when they shall be removed from the moulds for breaking.

BREAKING

H.3. The six briquettes shall be tested and the tensile strength shall be the average tensile strength of the six briquettes. The briquettes to be tested shall be held in strong metal jaws of the shape shown in Figs. 9 and 10, and the load on each briquette shall be steadily and uniformly applied, starting from zero, and increased at the rate of 100 lb (45·4 kg) in 12 seconds.

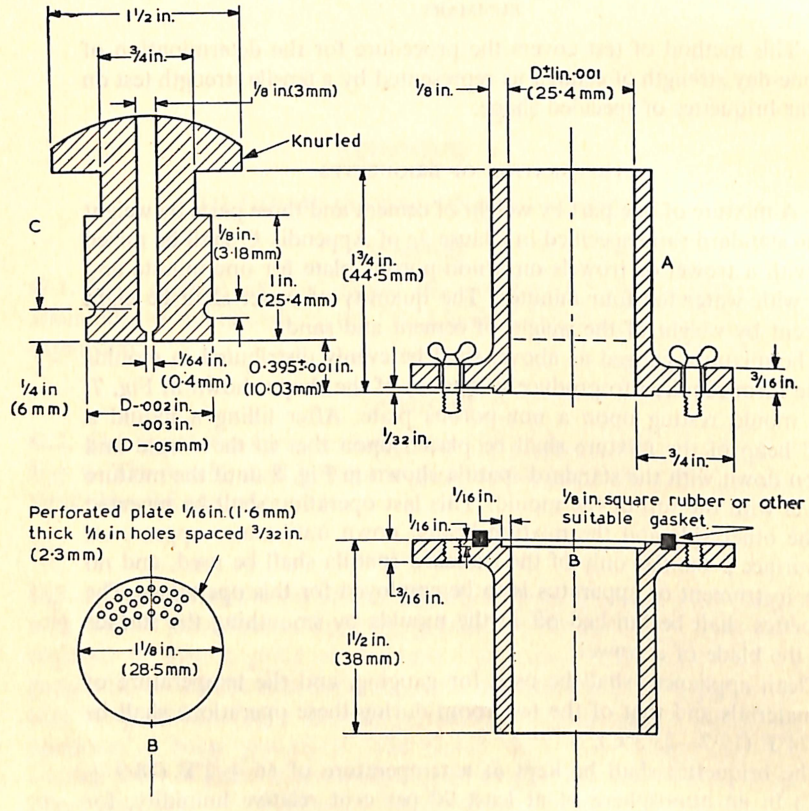


Fig. 1. Details of permeability cell

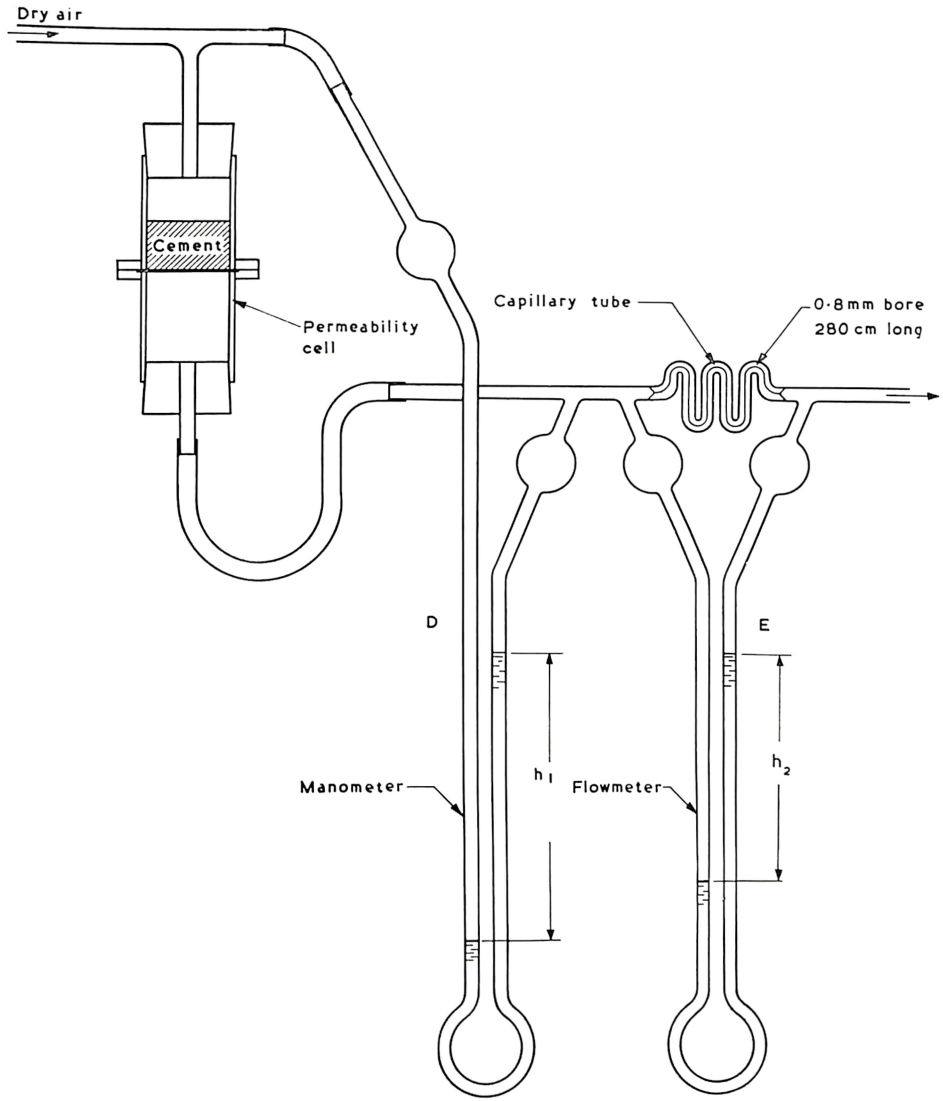


Fig. 2. Permeability apparatus with manometer and flowmeter

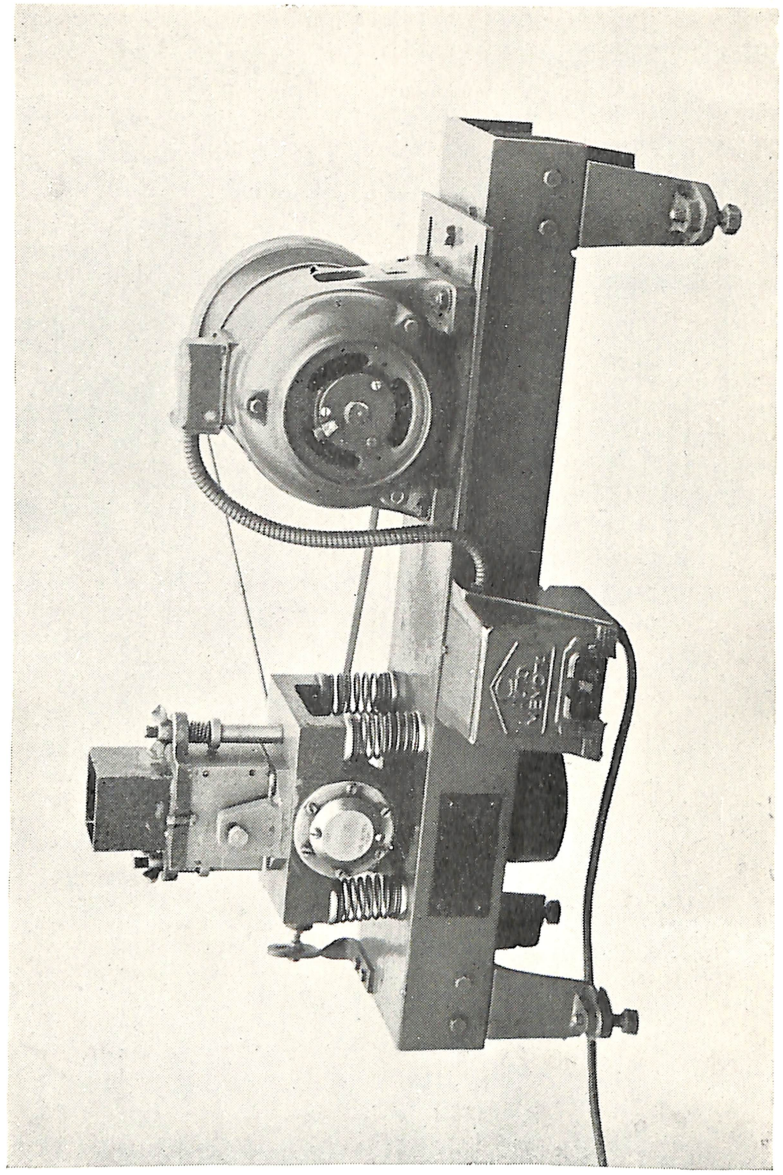
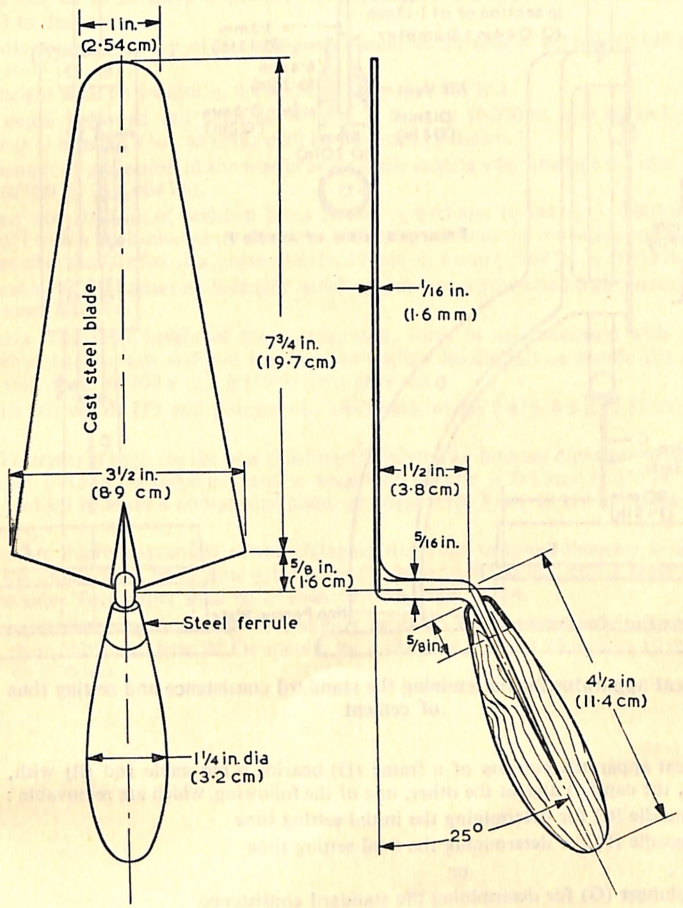


Fig. 3. Typical vibration machine for compacting mortar cubes for the compressive strength test



Trowel to weigh 7½ oz (210 gm) approx.

Fig. 4. Typical trowel

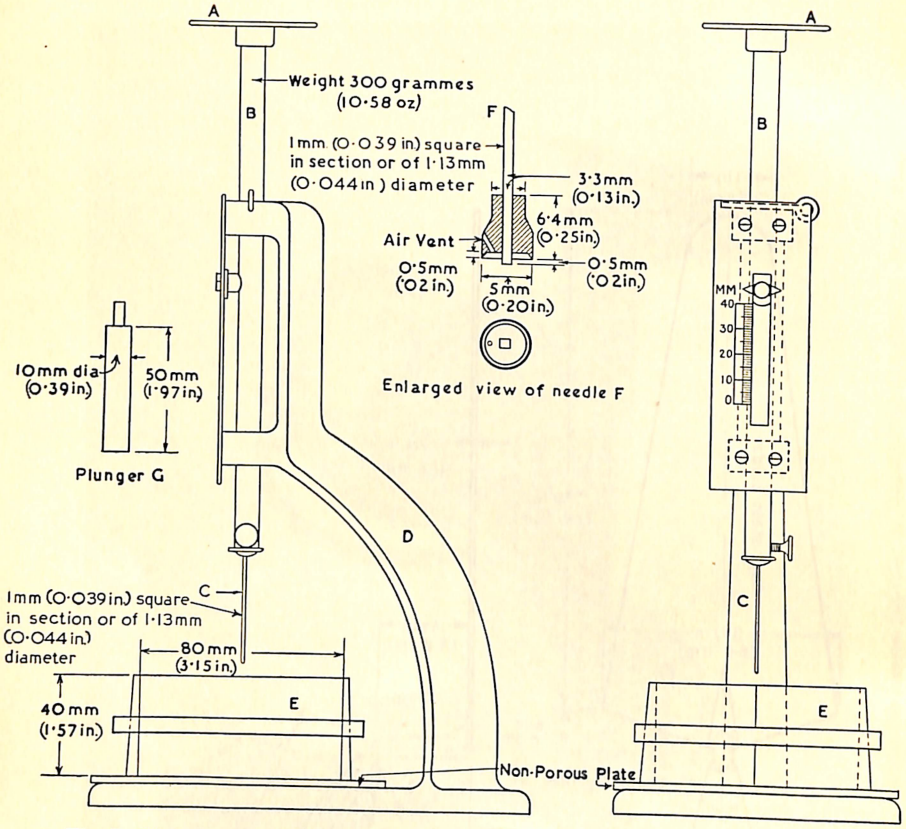


Fig. 5. Vicat apparatus for determining the standard consistence and setting time of cement

The Vicat apparatus consists of a frame (D) bearing a moveable rod (B) with, at one end, the cap (A) and, at the other, one of the following, which are removable :

a. the needle (C) for determining the initial setting time

b. the needle (F) for determining the final setting time

or

c. the plunger (G) for determining the standard consistence.

'*Construction of needles*'. The needles (C) and (F) shall be of hardened and tempered steel.

There should be about 6 mm (0·236 in.) clearance between the bottom end of the needle, when it is raised, and the top edge of the ring mould, to enable the mould to be located in position without damage to the needle.

Dimensions of needles. Needle (C) shall be either square, with sides of 1 mm ± 0·05 mm (0·039 in. ± 0·002 in.) or round, of a diameter of 1·13 mm ± 0·05 mm (0·044 in. ± 0·002 in.). The needle shall have a flat end. The effective length, excluding the hilt (fitting end), shall be 50 mm ± 1 mm (1·968 in. ± 0·039 in.).

Needle (F) shall be of the same shape and section as the needle (C), but shall be 30 mm ± 2 mm (1·181 in. ± 0·079 in.) in length, and fitted with a metal attachment hollowed out so as to leave a circular cutting edge 5 mm ± 0·1 mm (0·196 in. ± 0·004 in.) in diameter.

The diameter at the top of the attachment shall be 3·3 mm ± 0·2 mm (0·130 in. ± 0·008 in.).

The height shall be 6·4 mm ± 0·2 mm (0·252 in. ± 0·008 in.).

The depth hollowed out shall be 0·5 mm ± 0·1 mm (0·020 in. ± 0·044 in.). A vent hole 0·75 mm dia. (No. 68 drill) shall be provided as shown.

The length of projection of the needle beyond the cutting edge shall be 0·5 mm ± 0·1 mm (0·020 in. ± 0·004 in.).

Plunger (G) shall be of polished brass 10 mm ± 0·05 mm (0·394 in. ± 0·002 in.) in diameter with a projection at the fitting end for insertion into the moveable rod (B). The lower edge shall be flat. Its length shall be 50 mm ± 1 mm (1·968 in. ± 0·039 in.).

Moveable rod (B) carries an indicator which moves over a graduated scale attached to the frame (D).

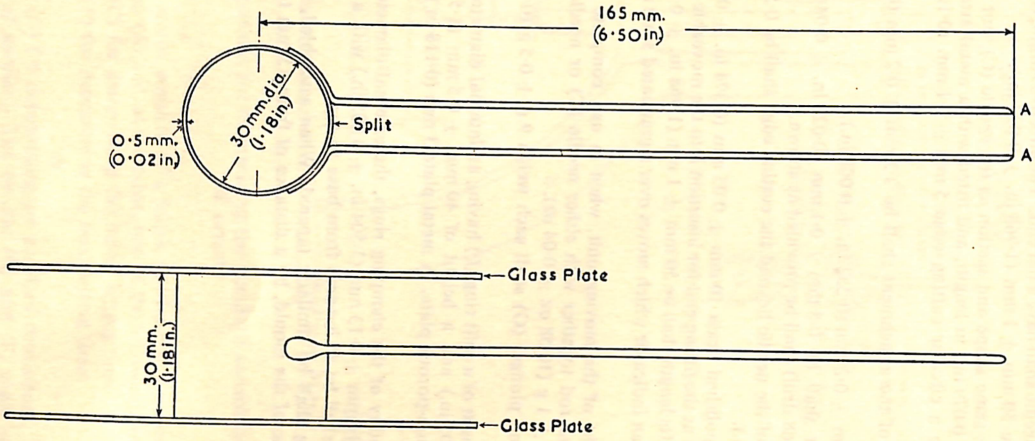
Weights. The total weight of the moving unit, when in use, complete with all attachments, i.e. the cap and rod together with either needle (C) or needle (F) or plunger (G), shall be 300 g ± 1 g (10·58 oz ± 0·04 oz).

Needle (C) needle (F) and plunger (G) shall each weigh 9 g ± 0·5 g (0·32 oz ± 0·02 oz).

The Vicat mould shall consist of a split ring (E) having an internal diameter 80 mm ± 0·13 mm (3·15 in. ± 0·005 in.) and a height of 40 mm ± 0·5 mm (1·575 in. ± 0·020 in.) which rests on a non-porous plate. A metal plate 3 mm (0·118 in.) thick is suitable.

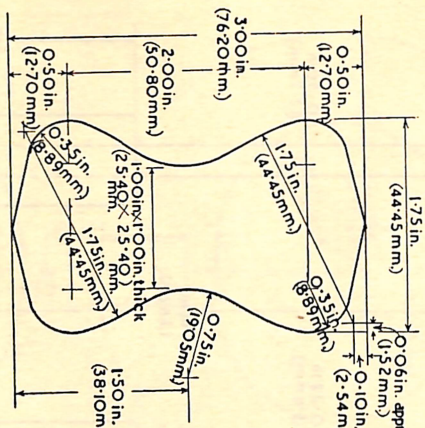
To ensure interchangeability of the clamping rings, the external diameter at the base of the mould shall be 89 mm ± 0·13 mm (3·504 in. ± 0·005 in.) with a taper of 2° on the side. Total taper shall be 4° inwards from base to top.

The outer clamping ring shall be similarly tapered. When assembled, this ring shall be clear above the base of the mould, by a distance of from 15 mm to 18 mm (0·59 in. to 0·70 in.).



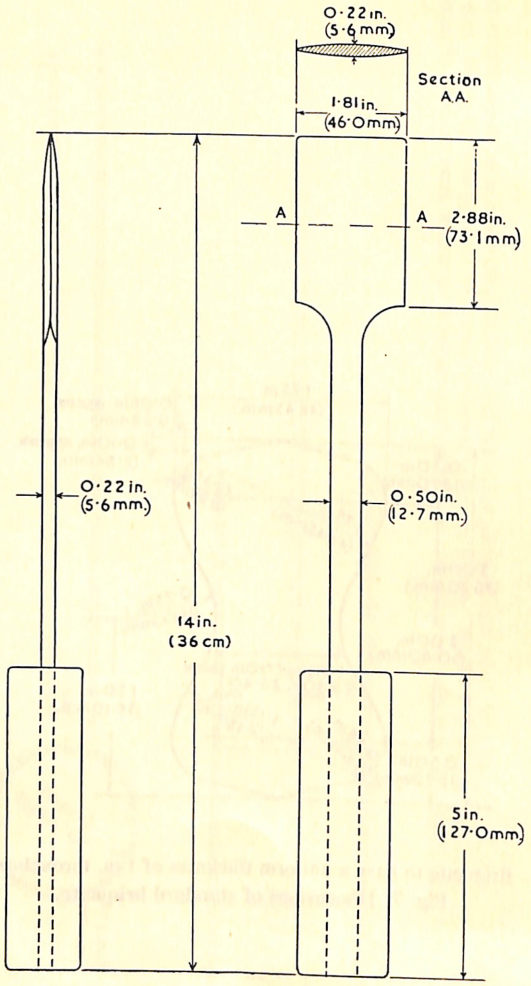
The apparatus for conducting the ' Le Chatelier ' test consists of a small split cylinder of spring brass or other suitable metal of 0·5 mm (0·02 in.) thickness, forming a mould 30 mm (1·18 in.) internal diameter and 30 mm (1·18 in.) high. On either side of the split are attached two indicators with pointed ends AA, the distance from these ends to the centre of the cylinder being 165 mm (6·50 in.).

Fig. 6. Apparatus for conducting the ' Le Chatelier ' test



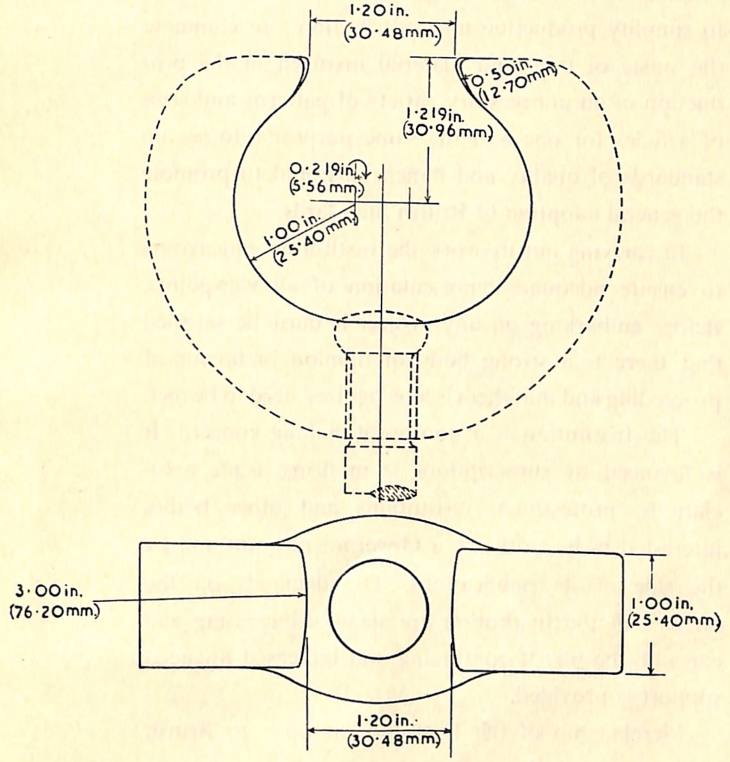
Briquette to have a uniform thickness of 1 in. throughout

Fig. 7. Dimensions of standard briquette.



The standard spatula shown above is of steel to which a wooden handle is securely attached. The total weight shall not exceed 12 oz (340 g), and the centre of gravity shall fall within 0·25 in. (6·35 mm) of the centre of the length of the spatula.

Fig. 8. Standard spatula



Figs. 9 and 10. Elevation and plan of jaws for holding briquette

BRITISH STANDARDS INSTITUTION

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