INTERNATIONAL STANDARD

ISO 679

Second edition
2009-05-01

Cement — Test methods — Determination of strength

Ciments — Méthodes d'essai — Détermination de la résistance mécanique

Reference number
ISO 679:2009(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 679 was prepared by Technical Committee ISO/TC 74, *Cement and lime*.

This second edition cancels and replaces the first edition (ISO 679:1989), which has been technically revised as follows, based on comments received by the Secretariat.

a) The testing procedure has been revised with respect to hardness and surface texture of moulds (4.6.3) and compression strength testing machine platens (4.6.6) as supplied; suitability of mould oil (4.6.3); frequency of operation of jolting apparatus (4.6.4); and the inclusion and accuracy of a balance (4.6.8); deionized water (5.3) is now permitted; procedures for mixing mortar (6.2) and the moulding (Clause 7) and conditioning (Clause 8) of test specimens have been revised to reflect current best practice.

b) Test results (Clause 10) are now reported in megapascals, replacing newtons per square millimetre. (One megapascal is equivalent to one newton per square millimetre.)

c) The use of a flexural strength testing machine (4.6.5) is now optional.

d) Estimates of the precision for compressive strength testing (10.2.3) have been revised to include both short- and long-term repeatability together with reproducibility data for laboratories of “normal” performance and an indication of precision data for “expert” laboratories.

e) The procedure for validation testing of ISO standard sand (11.2) includes initial qualification testing, validation criteria, verification testing and annual confirmation testing.

f) The procedure for validation testing of alternative compaction equipment (11.3) has been revised and a normative annex (Annex A) has been introduced detailing two alternative vibration compaction equipments which have been validated.

Cement — Test methods — Determination of strength

1 Scope

This International Standard specifies a method of determining the compressive and, optionally, the flexural strength of cement mortar containing one part by mass of cement, three parts by mass of ISO standard sand and one half part of water. The method applies to common cements and to other cements and materials, the standards for which call up this method. It might not apply to other cement types that have, for example, a very short initial setting time.

This International Standard describes the reference equipment and procedure, and specifies the method used for validation testing of ISO standard sands and of alternative equipment and procedures.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1101, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

ISO 1302, *Geometrical Product Specifications (GPS) — Indication of surface texture in technical product documentation*

ISO 3310-1, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

3 Principle

The method is comprised of a determination of the compressive, and optionally the flexural, strength of a prismatic test specimen 40 mm × 40 mm × 160 mm in size.

These specimens are cast from a batch of plastic mortar containing one part by mass of cement, three parts by mass of ISO standard sand and one half part of water (water/cement ratio of 0,50). ISO standard sands from various sources and countries may be used, provided that they have been shown to give cement strength results that do not differ significantly from those obtained using the ISO reference sand (see Clause 11).

In the reference procedure, the mortar is prepared by mechanical mixing and is compacted in a mould using a jolting apparatus. Alternative compaction equipment and procedures may be used provided that they have been shown to give cement strength results that do not differ significantly from those obtained using the reference jolting apparatus and procedure (see Clause 11 and Annex A). In the event of a dispute, only the reference equipment and procedure shall be used.

The specimens are stored in the mould in a moist atmosphere for 24 h and, after demoulding, specimens are stored under water until strength testing.

At the required age, the specimens are taken from their wet storage, broken in flexure, determining the flexural strength where required, or broken using other suitable means that do not subject the prism halves to harmful stresses, and each half is tested for strength in compression.

4 Apparatus

4.1 Laboratory, for the preparation of specimens, maintained at a temperature of (20 ± 2) °C and a relative humidity of not less than 50 %.

A laboratory temperature of (25 ± 2) °C or (27 ± 2) °C may be maintained in warm countries, provided the temperature is stated in the test report.

The temperature and relative humidity of the air in the laboratory shall be recorded at least once a day during working hours.

Laboratories testing in accordance with this International Standard should consider the enhanced confidence for test results engendered by conformity to the requirements of ISO/IEC 17025.

4.2 Moist-air room or **large cabinet**, for storage of the specimens in the mould, maintained at a temperature of (20,0 ± 1,0) °C and a relative humidity of not less than 90 %.

The temperature of the moist-air room or the large cabinet for storage may be maintained at (25 ± 1) °C or (27 ± 1) °C in warm countries, provided the temperature is stated in the test report.

The temperature and relative humidity of the moist-air room or cabinet shall be recorded at least every 4 h.

4.3 Storage containers, for curing the specimens in water, with fitted grates, of material that does not react with cement.

The temperature of the water shall be maintained at (20,0 ± 1,0) °C.

The temperature of the water in the storage containers may be maintained at (25 ± 1) °C or (27 ± 1) °C in warm countries, provided the temperature is stated in the test report.

The temperature of the water in the storage containers shall be recorded at least once a day during working hours.

4.4 Cement, **ISO standard sand** (see 5.1.3), and **water**, used to make test specimens, at the laboratory temperature.

4.5 Test sieves, wire cloth, in accordance with ISO 3310-1, of the sizes in accordance with Table 1.

Table 1 — Aperture of test sieves

Square mesh size [a] mm					
2,00	1,60	1,00	0,50	0,16	0,08
[a] Taken from ISO 565:1990, series R 20.					

4.6 Equipment

4.6.1 General requirements

Apparatus used to make and test the specimens shall be at the laboratory temperature. Where temperature ranges are given, the target temperature at which the controls are set shall be the middle value of the range.

The tolerances shown in Figures 1 to 5 are important for correct operation of the equipment in the testing procedure. When regular control measurements show that the tolerances are not met, the equipment shall be rejected, adjusted or repaired. Records of control measurements shall be kept.

Acceptance measurements on new equipment shall cover mass, volume and dimensions to the extent that these are indicated in this International Standard, paying particular attention to those critical dimensions for which tolerances are specified.

In those cases where the material of the equipment can influence the results, the material is specified and shall be used.

The approximate dimensions shown in the figures are provided as guidance to equipment manufacturers or operators. Dimensions that include tolerances are obligatory.

4.6.2 Mixer, consisting essentially of the following:

a) stainless steel bowl, with a capacity of about 5 l, of the typical shape and size shown in Figure 1, provided with a means by which it can be fixed securely to the mixer frame during mixing and by which the height of the bowl in relation to the blade and, to some extent, the gap between blade and bowl can be finely adjusted and fixed;

b) stainless steel blade, of the typical shape, size and tolerances shown in Figure 1, revolving about its own axis as it is driven in a planetary movement around the axis of the bowl at controlled speeds by an electric motor. The two directions of rotation shall be opposite and the ratio between the two speeds shall not be a whole number.

Blades and bowls shall form sets which shall always be used together.

The gap between blade and bowl shown in Figure 1 shall be checked regularly. The gap of (3 ± 1) mm refers to the situation when the blade in the empty bowl is brought as close as possible to the wall. Simple tolerance gauges (“feeler gauges”) are useful where direct measurement is difficult.

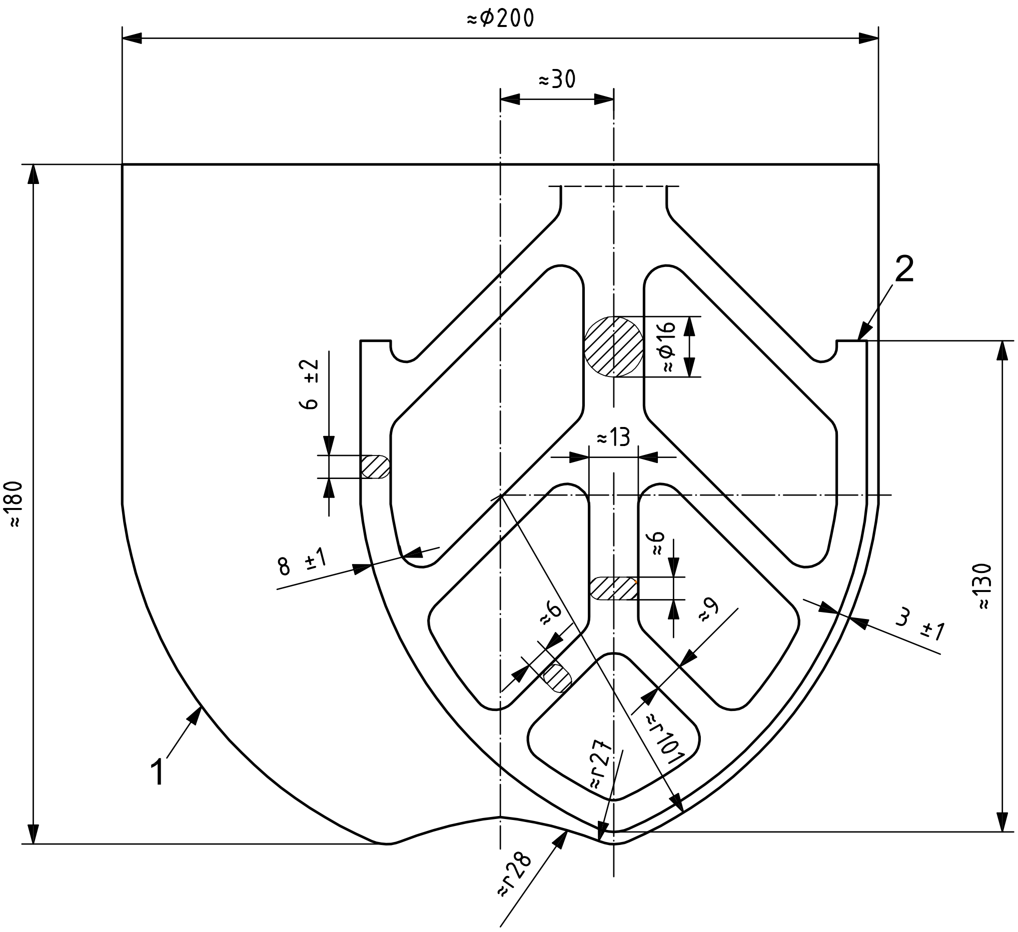
NOTE The dimensions marked as approximate on Figure 1 are for the guidance of manufacturers.

The mixer shall operate at the speeds given in Table 2 when mixing the mortar.

Table 2 — Speeds of mixer blade

Speed	Rotation min^{-1}	Planetary movement min^{-1}
Low	140 ± 5	62 ± 5
High	285 ± 10	125 ± 10

Dimensions in millimetres



Key

1 bowl

2 blade

Figure 1 — Typical bowl and blade

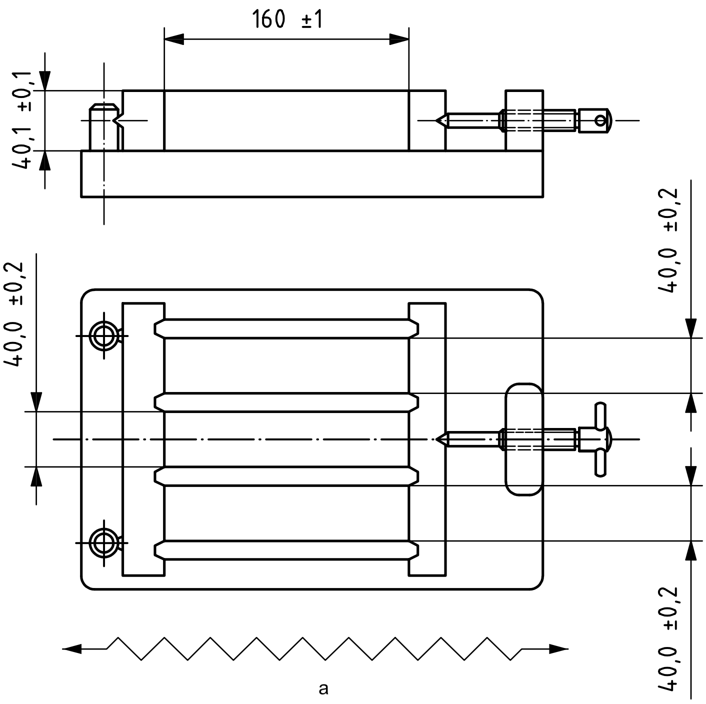
4.6.3 Moulds, consisting of three horizontal compartments so that three prismatic specimens 40 mm × 40 mm in cross-section and 160 mm in length can be prepared simultaneously. A typical design is shown in Figure 2.

The mould shall be made of steel with walls approximately 10 mm thick. Each internal side face of the mould shall be case hardened to a Vickers hardness of at least HV 200, as supplied. However, a minimum Vickers hardness value of HV 400 is recommended.

The mould shall be constructed in such a manner as to facilitate the removal of moulded specimens without damage. Each mould shall be provided with a machined steel or cast iron baseplate. The mould, when assembled, shall be positively and rigidly held together and fixed to the baseplate.

The assembly shall be such that there is no distortion or visible leakage during operation. The baseplate shall make adequate contact with the table of the compacting apparatus and be rigid enough not to induce secondary vibrations.

Dimensions in millimetres



a Striking off direction with sawing motion.

Figure 2 — Typical mould

Moulds and jolting apparatus from different manufacturers may have unrelated external dimensions and masses, so their compatibility needs to be ensured by the purchaser.

Each part of the mould shall be stamped with identifying marks to facilitate assembly and to ensure conformity to the specified tolerances. Similar parts of separate mould assemblies shall not be interchanged.

The assembled mould shall conform to the following requirements.

a) The internal dimensions and tolerances of each mould compartment shall be as follows:

— length: (160 ± 1) mm;

— width: (40,0 ± 0,2) mm;

— depth: (40,1 ± 0,1) mm.

b) The flatness tolerance (see ISO 1101) over the whole of each internal side face shall be not greater than 0,03 mm.

c) The perpendicularity tolerance (see ISO 1101) for each internal face with respect to the bottom surface of the mould and the adjacent internal face as datum faces shall be not greater than 0,2 mm.

d) The surface texture (see ISO 1302) of each internal side face shall be not rougher than N8, as supplied.

Moulds shall be replaced when any one of the specified tolerances is exceeded. The mass of the mould shall comply with the requirement for the combined mass in 4.6.4.

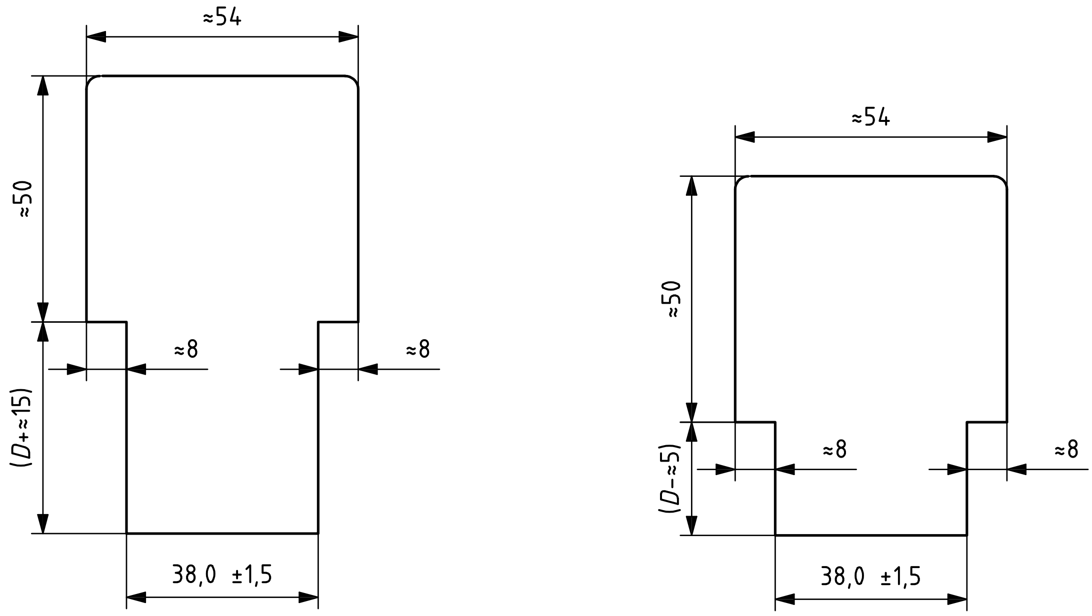
After assembling the cleaned mould ready for use, a suitable material shall be used to coat the outer joints of the mould. A thin film of mould oil shall be applied to the internal faces of the mould.

NOTE Some oils have been found to affect the setting of cement; mineral-based oils have been found to be suitable.

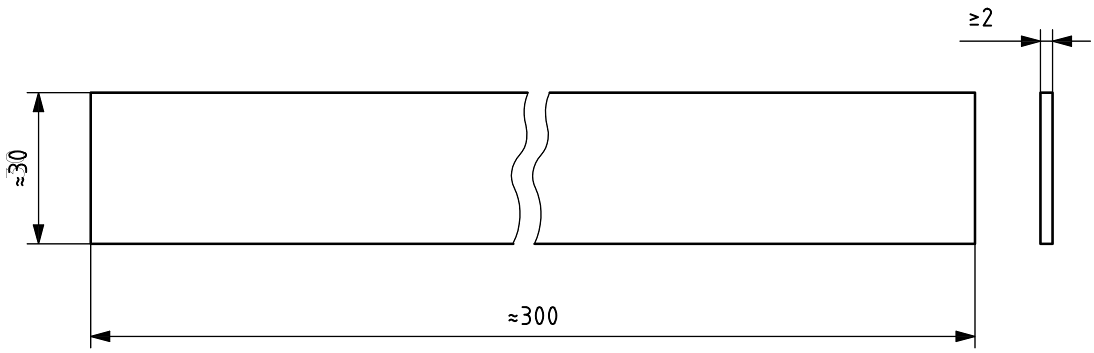
To facilitate the filling of the mould, a tightly fitting metal hopper with vertical walls 20 mm to 40 mm high shall be provided. When viewed in plan, the hopper walls shall overlap the internal walls of the mould by not more than 1 mm. The outer walls of the hopper shall be provided with a means of location to ensure correct positioning over the mould.

For spreading and striking off the mortar, two spreaders and a metal straight-edge of the type shown in Figure 3 shall be provided.

Dimensions in millimetres



a) **Large spreader** b) **Small spreader**



c) **Straight-edge**

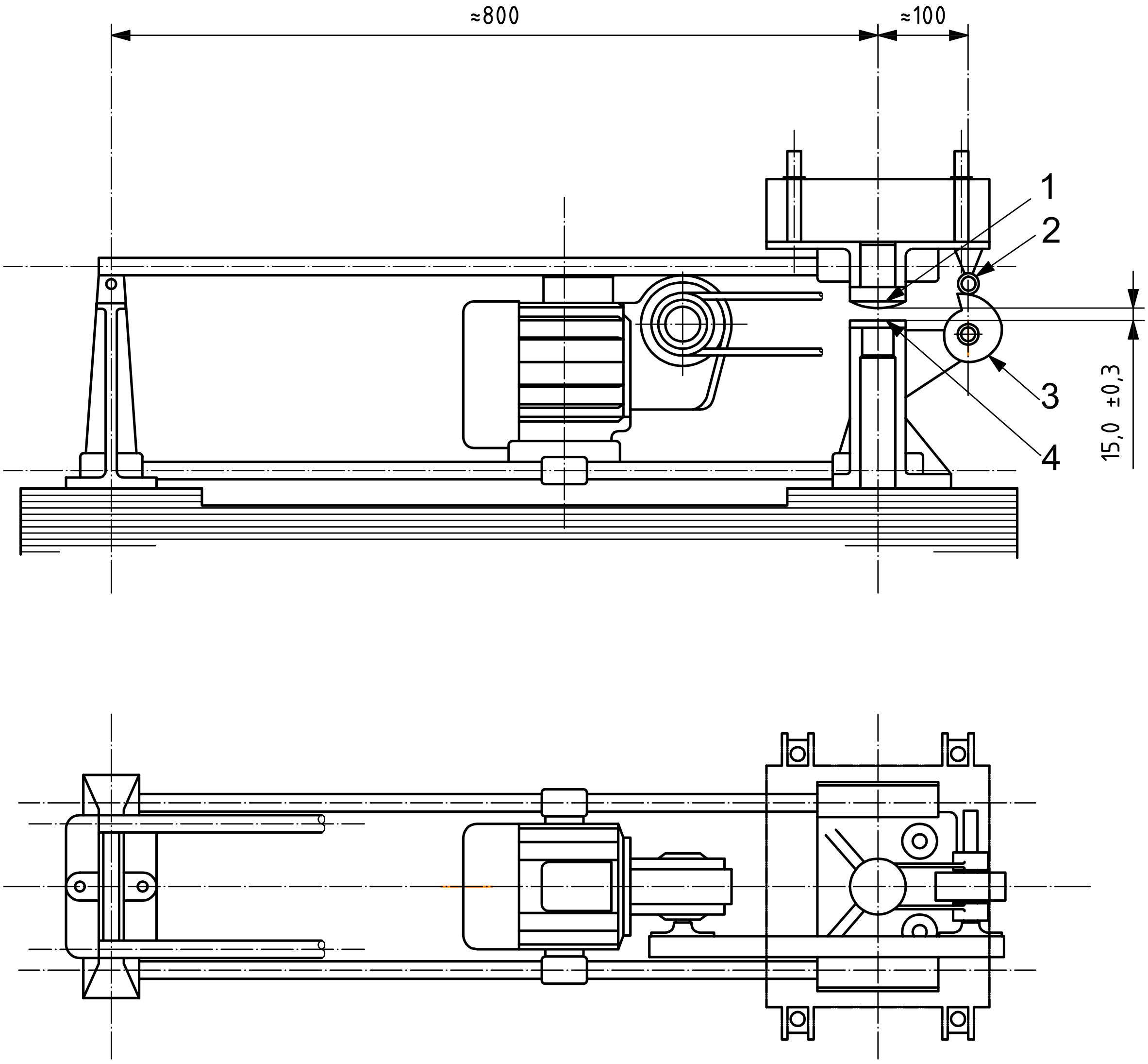
Key

D height of the hopper

Figure 3 — Typical spreaders and metal straight-edge

4.6.4 Jolting apparatus, consisting of a rectangular table rigidly connected by two light arms to a pivot at nominally 800 mm from the centre of the table. A typical design is shown in Figure 4.

Dimensions in millimetres



Key

1 lug

2 cam follower

3 cam

4 stop

Figure 4 — Typical jolting apparatus

The table shall incorporate at the centre of its lower face a projecting lug with a rounded face. Beneath the projecting lug shall be a small stop with a plane upper surface. In the rest position, the common normal through the point of contact of the lug and the stop shall be vertical. When the lug rests on the stop, the top face of the table shall be horizontal so that the level of any of the four corners does not deviate from the mean level by more than 1,0 mm. The table shall have dimensions equal to or greater than those of the mould baseplate, and a plane, machined upper surface. Clamps shall be provided for firm attachment of the mould to the table.

The combined mass of the table, including arms, empty mould, hopper and clamps shall be (20,0 ± 0,5) kg.

The arms connecting the table assembly to the pivot shall be rigid and constructed of round tubing with an outside diameter lying in the range 17 mm to 22 mm selected from tube sizes in accordance with ISO 4200. The total mass of the two arms, including any cross bracing, shall be (2,25 ± 0,25) kg. The pivot bearings shall be of the ball or roller type and protected from ingress of grit or dust. The horizontal displacement of the centre of the table as caused by the play of the pivot shall not exceed 1,0 mm.

The lug and the stop shall be made of through-hardened steel of at least HV 500 Vickers hardness value. The curvature of the lug shall be about 0,01 mm^{-1}.

In operation, the table is raised by a cam and allowed to fall freely from a height of (15,0 ± 0,3) mm before the lug strikes the stop.

The cam shall be made of through-hardened steel of at least HV 400 Vickers hardness value and its shaft shall be mounted in ball bearings of such construction that the free fall is always (15,0 ± 0,3) mm. The cam follower shall be of a construction that ensures minimal wear of the cam. The cam shall be driven by an electric motor of about 250 W through a reduction gear at a uniform speed of one revolution per second. A control mechanism and a counter shall be provided which ensures that during one period of jolting of (60 ± 3) s exactly 60 jolts are given.

The position of the mould on the table shall be such that the longitudinal dimension of the compartments is in line with the direction of the arms and perpendicular to the axis of rotation of the cam. Suitable reference marks shall be provided to facilitate the positioning of the mould in such a way that the centre of the central compartment is directly above the point of impact.

The apparatus shall be firmly mounted on a concrete block with a mass of about 600 kg and volume of about 0,25 m^3 and of dimensions giving a suitable working height for the mould. The entire base of the concrete block shall stand on an elastic pad, e.g. natural rubber, having a sufficient isolation efficiency to prevent external vibrations from affecting the compaction.

The base of the apparatus shall be fixed level to the concrete base by anchor bolts, and a thin layer of mortar shall be placed between the base of the apparatus and the concrete base to ensure overall and vibration-free contact.

4.6.5 Flexural strength testing apparatus (optional), capable of applying loads up to 10 kN with an accuracy of ± 1,0 % of the recorded load in the upper four-fifths of the range being used, at a rate of loading of (50 ± 10) N/s.

NOTE 1 The provision of this apparatus is optional. If only the compressive strength is to be measured, prisms can be broken using other suitable means which do not subject the prism halves to harmful stresses.

NOTE 2 The flexural strength can be measured by using a flexural strength testing machine or by using a suitable device in a compression testing machine.

The apparatus shall be provided with a flexure device incorporating two steel supporting rollers of (10,0 ± 0,5) mm diameter spaced (100,0 ± 0,5) mm apart and a third steel loading roller of the same diameter placed centrally between the other two. The length of these rollers shall be between 45 mm and 50 mm. The loading arrangement is shown in Figure 5.

Dimensions in millimetres

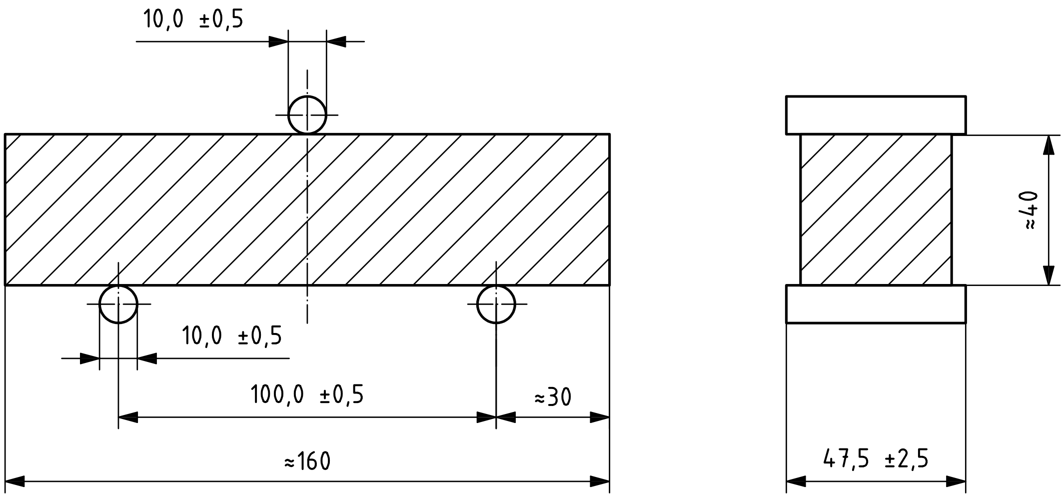


Figure 5 — Arrangement of loading for determination of flexural strength

The three vertical planes through the axes of the three rollers shall be parallel and shall remain parallel, equidistant and normal to the direction of the specimen under test. One of the supporting rollers and the loading roller shall be capable of tilting slightly to allow a uniform distribution of the load over the width of the specimen without subjecting it to any torsional stresses.

4.6.6 Compressive strength testing machine, for determining the compressive strength, of suitable capacity for the test (see paragraph 8 of this subclause), with an accuracy of ± 1,0 % of the recorded load in the upper four-fifths of the range being used when verified in accordance with ISO 7500-1.

It shall provide a rate of load increase of (2 400 ± 200) N/s. It shall be fitted with an indicating device that shall be so constructed that the value indicated at failure of the specimen remains indicated after the testing machine is unloaded. This can be achieved by the use of a maximum indicator on a pressure gauge or a memory on a digital display. Manually operated testing machines shall be fitted with a pacing device to facilitate the control of the load increase.

The vertical axis of the ram shall coincide with the vertical axis of the machine and, during loading, the direction of movement of the ram shall be along the vertical axis of the machine. Furthermore, the resultant of the forces shall pass through the centre of the specimen. The surface of the lower machine platen shall be normal to the axis of the machine and remain normal during loading.

The centre of the upper platen spherical seating shall be at the point of intersection of the vertical machine axis with the plane of the lower surface of the upper machine platen, with a tolerance of ± 1 mm. The upper platen shall be free to align as contact is made with the specimen, but during loading the relative attitude of the upper and lower platens shall remain fixed.

The testing machine shall be provided with platens made of tungsten carbide or alternatively through-hardened steel with a Vickers hardness of at least HV 600. These platens shall be at least 10 mm thick, (40,0 ± 0,1) mm wide and (40,0 ± 0,1) mm long. The flatness tolerance in accordance with ISO 1101 over the entire contact surface with the specimen shall be not greater than 0,01 mm. The surface texture in accordance with ISO 1302 shall be not smoother than N3 and not rougher than N6, as supplied.

Alternatively, two auxiliary plates of tungsten carbide or through-hardened steel with a Vickers hardness of at least HV 600, at least 10 mm thick and conforming to the requirements for the platens, may be provided. Provision should be made for centring the auxiliary plates with respect to the axis of the loading system with an accuracy of ± 0,5 mm. Provision should be made for aligning the auxiliary plates with a tolerance not greater than ± 0,5 mm from the centre of each other.

Where there is no spherical seating in the testing machine, where the spherical seating is blocked or where the diameter of the spherical seating is greater than 120 mm, a jig conforming to 4.6.7 shall be used.

The testing machine may be provided with two or more load ranges. The highest value of the lower range should be approximately one-fifth of the highest value of the next higher range.

The machine should be provided with an automatic method for adjusting the rate of loading and with equipment for recording the results.

The spherical seating of the machine may be lubricated to facilitate adjustment on contact with the specimen but only to such an extent that movement of the platen cannot take place under load during the test. Lubricants that are effective under high pressure are not suitable.

The terms “vertical”, “lower” and “upper” refer to conventional testing machines that are normally aligned in the vertical axis. However, machines whose axis is not vertical are also permitted.

4.6.7 Jig for compressive strength testing machine (when required by 4.6.6), placed between the platens of the machine to transmit the load of the machine to the compression surfaces of the mortar specimen (see Figure 6).

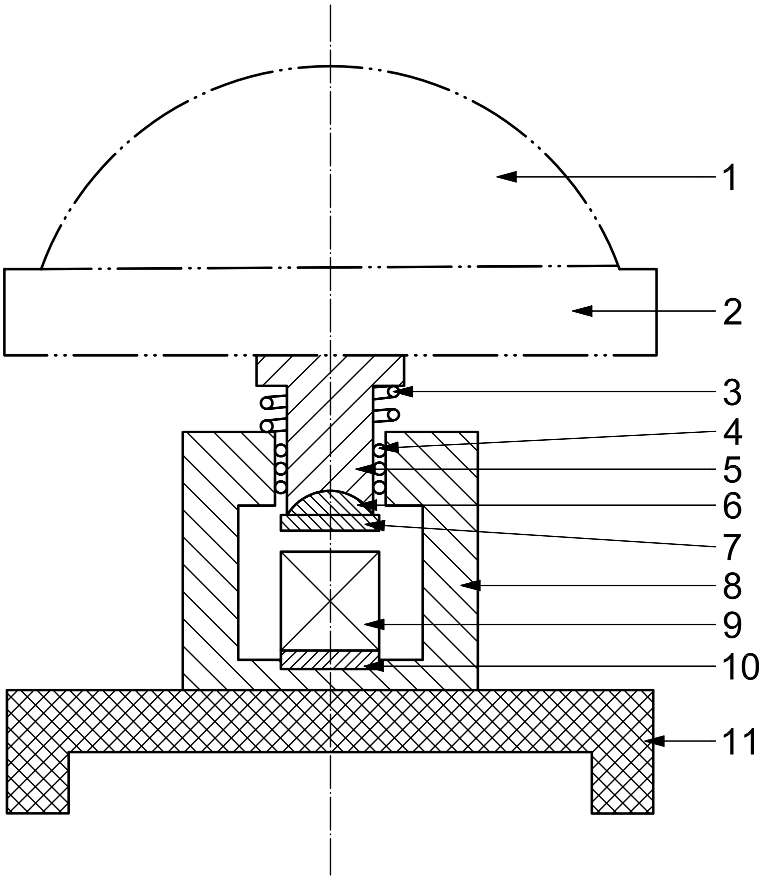
A lower plate shall be used in this jig and it can be incorporated in the lower platen. The upper platen receives the load from the upper platen of the machine through an intermediate spherical seating. This seating forms part of an assembly that shall be able to slide vertically without appreciable friction in the jig guiding its movement. The jig shall be kept clean and the spherical seating shall be free to move in such a way that the platen accommodates itself initially to the shape of the specimen and then remains fixed during the test. All requirements stated in 4.6.6 apply equally when a jig is used.

The spherical seating of the jig may be lubricated but only to such an extent that movement of the platen cannot take place under load during the test. Lubricants that are effective under high pressure are not suitable.

NOTE It is desirable that the assembly should return automatically to its initial position after crushing the specimen.

4.6.8 Balance, capable of weighing to an accuracy of ± 1 g.

4.6.9 Timer, capable of measuring to an accuracy of ± 1 s.



Key

1 spherical seating of machine
2 upper platen of machine
3 return spring
4 ball bearings
5 sliding assembly
6 spherical seating of the jig
7 upper platen of the jig
8 jig
9 specimen
10 lower platen of the jig
11 lower platen of the machine

Figure 6 — Typical jig for compressive strength testing

5 Mortar constituents

5.1 Sand

5.1.1 General

ISO standard sands, which are produced in various countries, shall be used to determine the strength of cement in accordance with this International Standard. "ISO standard sand" shall conform to the requirements stated in 5.1.3.

In view of the difficulties of characterizing ISO standard sands completely, they shall be validated against the ISO reference sand described in 5.1.2 by means of initial qualification testing, verification testing and annual confirmation testing, as described in Clause 11.

5.1.2 ISO reference sand

The ISO reference sand, of which a limited stockpile is maintained as reference material, is a natural, siliceous sand consisting of rounded particles with a silica content of at least 98 %.

Its particle size distribution falls within the limits given in Table 3.

Table 3 — Particle size distribution of the ISO reference sand

Square mesh size, millimetres	2,00	1,60	1,00	0,50	0,16	0,08
Cumulative sieve residue, percent	0	7 ± 5	33 ± 5	67 ± 5	87 ± 5	99 ± 1

NOTE ISO reference sand is the CEN reference sand (Comité Européen de Normalisation). Information on the CEN reference sand can be obtained from the ISO Member Body for Germany, DIN, Postfach 1107, D-1000 Berlin 30.

5.1.3 ISO standard sand

ISO standard sand shall comply with the particle size distribution specified in 5.1.2 as determined by sieve analysis on a representative sample of sand of total mass not less than 1 345 g. Sieving shall be continued until the amount of sand passing through each sieve is less than 0,5 g/min.

The moisture content shall be less than 0,2 %, determined as the loss of mass of a representative sample of sand after drying at 105 °C to 110 °C to constant mass and expressed as a percent mass fraction of the dried sample.

During production, these determinations shall be carried out at least once a day. These requirements are insufficient to ensure that the ISO standard sand gives equivalent performance to the ISO reference sand. Such equivalence shall be initiated and maintained by the validation testing described in Clause 11.

ISO standard sand shall be pre-packed in bags with a content of (1 350 ± 5) g; the type of material used for the bags shall have no effect on the results of the strength testing, and the contents of each bag shall comply with the particle size distribution specified in 5.1.2.

ISO standard sand should be carefully stored to prevent damage or contamination, particularly with moisture, prior to use.

5.2 Cement

The cement being tested shall be exposed to ambient air for the minimum time possible. When it is necessary to keep it for more than 24 h between sampling and testing, it shall be stored in completely filled and airtight containers made from a material that does not react with cement.

The laboratory sample shall be homogenized, by machine or other means, before taking subsamples for testing.

5.3 Water

Distilled or deionized water shall be used for validation testing. For other tests, drinking water may be used. In case of dispute, distilled or deionized water shall be used.

6 Preparation of mortar

6.1 Composition of mortar

The proportions by mass shall be one part of the cement (5.2), three parts of ISO standard sand (5.1), and one-half part of water (5.3) (water/cement ratio 0,50).

A batch, for three test specimens, shall consist of (450 ± 2) g of cement, (1 350 ± 5) g of sand and (225 ± 1) g of water.

6.2 Mixing of mortar

Weigh the cement and water by means of the balance (4.6.8). When water is added by volume, it shall be dispensed with an accuracy of ± 1 ml. Mix each batch of mortar mechanically using the mixer (4.6.2). The timing of the various mixing stages refers to the times at which mixer power is switched on/off and shall be maintained to within ± 2 s.

The mixing procedure shall be as follows.

a) Place the water and the cement into the bowl, taking care to avoid loss of water or cement.

b) Immediately, as the water and cement are brought into contact, start the mixer at low speed (see Table 2) whilst starting the timing of the mixing stages. In addition, record the time, to the nearest minute, as “zero time”. After 30 s of mixing, add the sand steadily during the next 30 s. Switch the mixer to the high speed (see Table 2) and continue the mixing for an additional 30 s;

NOTE “Zero time” is the point from which the times for demoulding specimens (see 8.2) and for determining strength (see 8.4) are calculated.

c) Stop the mixer for 90 s. During the first 30 s, remove, by means of a rubber or plastics scraper, the mortar adhering to the wall and bottom part of the bowl and place it in the middle of the bowl.

d) Continue the mixing at high speed for 60 s.

Normally these mixing operations are carried out automatically, but manual control of these operations and timings may be used.

7 Preparation of test specimens

7.1 Size of specimens

The test specimens shall be 40 mm × 40 mm × 160 mm prisms.

7.2 Moulding of test specimens

Mould the specimens immediately after the preparation of the mortar. With the mould and hopper firmly clamped to the jolting table, introduce, using a suitable scoop and in one or more increments, the first of two layers of mortar (each about 300 g) into each of the mould compartments, directly from the mixing bowl.

Spread the layer uniformly using the large spreader (see Figure 3), held almost vertically with its shoulders in contact with the top of the hopper and drawn forwards and backwards once along each mould compartment. Then compact the first mortar layer using 60 jolts of the jolting apparatus (4.6.4). Introduce the second layer of mortar, ensuring that there is a surplus of mortar, level with the small spreader (see Figure 3) and compact the layer with a further 60 jolts.

Lift the mould gently from the jolting table and remove the hopper. Immediately strike off the excess mortar with the metal straight-edge (see Figure 3), held almost vertically but inclined in the direction of striking. Move slowly, pulling with a transverse sawing motion once in each direction. Repeat this striking off procedure with the straight-edge held at a more acute angle to smooth the surface.

NOTE The number of sawing motions and the angle of the straight-edge depends on the consistency of the mortar; stiffer mortars require more sawing motions and a more acute angle; a smaller number of transverse sawing motions are required for smoothing than for striking off (see Figure 2).

Wipe off the mortar left on the perimeter of the mould as a result of the striking-off.

Label or mark the moulds for identification purposes.

8 Conditioning of test specimens

8.1 Handling and storage before demoulding

Place a plate of glass, steel or other impermeable material that does not react with cement, of approximate size 210 mm × 185 mm × 6 mm, on the mould.

SAFETY PRECAUTIONS — In the interest of safety, ensure that any glass plates used have ground edges.

Place each covered mould, without delay, on a horizontal base in the moist-air room or cabinet (see 4.2). The moist air shall have access to all sides of the mould. Moulds shall not be stacked one upon the other. Each mould shall be removed from storage at its appropriate time for demoulding.

8.2 Demoulding of specimens

Carry out demoulding, taking care not to damage the specimens. Plastic or rubber hammers, or devices specially made, can be used for demoulding. Carry out demoulding not more than 20 min before the specimens are tested for 24 h tests. Carry out demoulding between 20 h and 24 h after moulding for tests at ages greater than 24 h.

Demoulding may be delayed by 24 h if the mortar has not acquired sufficient strength at 24 h to be handled without risk of damage. Any delay in demoulding should be recorded in the test report.

Keep the demoulded specimens selected for testing at 24 h (or at 48 h when delayed demoulding was necessary) covered by a damp cloth until tested. Suitably mark specimens selected for curing in water for identification later, e.g. by water-resistant ink or crayon.

As a check on the mixing and compacting operations and air content of the mortar, it is recommended that the specimens from each mould be weighed.

8.3 Curing of specimens in water

Submerge the marked specimens without delay in a convenient manner, either horizontally or vertically, in water at (20,0 ± 1,0) °C [or (25 ± 2) °C or (27 ± 2) °C in warm countries] in the containers (4.3). With horizontal storage, keep vertical faces as cast vertical.

Place the specimens on the grates (see 4.3) and keep them apart from each other so that the water has free access to all six faces of the specimens. At no time during storage shall the spaces between the specimens or the depth of water above the upper faces of the specimens be less than 5 mm.

Unless it has been established that the composition of the cement being tested does not influence the strength development of other cements under test, separate storage shall be provided; cements known to contain more than 0,1 % chloride ion shall be stored separately.

Use tap water for the initial filling of the containers and for occasional topping up to maintain a reasonably constant level. During storage of the specimens, not more than 50 % of the water shall be replaced at any one time.

The installation shall ensure a uniform storage temperature; if a system of circulation within the storage container is used, the flow rate shall be as low as possible and not cause visible turbulence.

Remove the specimens required for testing at any particular age (other than 24 h, or 48 h in cases of delayed demoulding) from the water not more than 15 min before the test is carried out. Remove any deposit on the test faces. Cover the specimens with a damp cloth until tested.

8.4 Age of specimens for strength tests

Calculate the age of specimens as from zero time (see 6.2). Carry out strength tests at the following different ages:

24 h ± 15 min;

48 h ± 30 min;

72 h ± 45 min;

7 d ± 2 h;

⩾ 28 d ± 8 h.

9 Testing procedures

9.1 Flexural strength

Use the three-point loading method with one of the types of apparatus described in 4.6.5.

Place the prism in the apparatus (4.6.5) with one side face on the supporting rollers and with its longitudinal axis normal to the supports. Apply the load vertically, by means of the loading roller, to the opposite side face of the prism and increase it smoothly at the rate of (50 ± 10) N/s until fracture.

Keep the prism halves covered with a damp cloth until tested in compression.

Calculate the flexural strength, R_f, expressed in megapascals, from Equation (1):

$$R_f = \frac{1{,}5 F_f l}{b^3} \quad (1)$$

where

b is the side of the square section of the prism, expressed in millimetres;

F_f is the load applied to the middle of the prism at fracture, expressed in newtons;

l is the distance between the supports, expressed in millimetres.

9.2 Compressive strength

Carry out the test on halves of the prism broken either as described in 9.1 or using suitable means which do not subject the prism halves to harmful stresses.

Test each prism half by loading its side faces using the equipment described in 4.6.6 and 4.6.7.

Centre the prism halves laterally to the platens of the machine to within ± 0,5 mm and longitudinally such that the end face of the prism overhangs the platens or auxiliary plates by about 10 mm.

Increase the load smoothly at the rate of (2 400 ± 200) N/s over the entire load application until fracture.

Where the load increase is regulated by hand, care should be taken when making adjustments for the decrease of the loading rate near the fracture load as this can significantly affect the result.

Calculate the compressive strength, R_c, expressed in megapascals, from Equation (2):

$$R_c = \frac{F_c}{1\,600} \tag{2}$$

where

F_c is the maximum load at fracture, expressed in newtons;

1 600 is the area of the platens or auxiliary plates (40 mm × 40 mm), expressed in square millimetres.

10 Results

10.1 Flexural strength

10.1.1 Calculation and expression of test results

Calculate the flexural strength test result as the arithmetic mean of the three individual results, each expressed at least to the nearest 0,1 MPa, obtained from a determination made on a set of three prisms.

Express the arithmetic mean to the nearest 0,1 MPa.

10.1.2 Reporting of results

Record all individual results. Report the calculated mean.

10.2 Compressive strength

10.2.1 Calculation and expression of test results

Calculate the compressive strength test result as the arithmetic mean of the six individual results, each expressed at least to the nearest 0,1 MPa, obtained from the six determinations made on a set of three prisms.

If one result within the six individual results varies by more than ± 10 % from the mean, discard this result and calculate the arithmetic mean of the five remaining results. If one result within the five remaining results varies by more than ± 10 % from their mean, discard the set of results and repeat the determination.

Express the arithmetic mean to the nearest 0,1 MPa.

10.2.2 Reporting of results

Record all individual results. Report the calculated mean and whether any result has been discarded in accordance with 10.2.1.

10.2.3 Estimates of the precision of the method for compressive strength

10.2.3.1 Short-term repeatability

Short-term repeatability of the method for compressive strength testing gives the closeness of agreement between test results obtained on nominally identical samples of cement, using the same ISO standard sand, tested in the same laboratory by the same operator using the same equipment within short intervals of time.

In the case of 28 d compressive strength, the short-term repeatability for “normal performance” achievable under the above conditions, should be less than 2,0 % when expressed as the coefficient of variation.

NOTE Experience has indicated that better performance is achievable and can be routinely met in some laboratories. It corresponds to a value of 1 % for short-term repeatability, when expressed as the coefficient of variation.

Short-term repeatability is a measure of the precision of the test method when used for validation testing of ISO standard sand and alternative compaction equipment.

10.2.3.2 Long-term repeatability

Long-term repeatability of the method for compressive strength testing gives the closeness of agreement between test results obtained from frequent testing of different samples taken from the same homogenized sample of cement, tested in the same laboratory, under the following conditions: possibly different operators, possibly different equipment, same ISO standard sand and over long time periods (up to one year).

In the case of 28 d compressive strength, the long-term repeatability for “normal performance” achievable under the above conditions should be less than 3,5 % when expressed as the coefficient of variation.

NOTE Experience has indicated that better performance is achievable and can be routinely met in some laboratories. It corresponds to a value of 2,5 % for long-term repeatability, when expressed as the coefficient of variation.

Long-term repeatability is a measure of the precision of the test method when used for the auto-control testing of cement or the monthly verification testing of ISO standard sand and for assessing the maintenance of the laboratory’s precision over time.

10.2.3.3 Reproducibility

Reproducibility of the method for compressive strength testing gives the closeness of agreement between test results obtained on nominally identical samples of cement tested in different laboratories under the following conditions: different operators, different equipment, possibly different ISO standard sands and possibly at different times.

In the case of 28 d compressive strength, the reproducibility between laboratories achieving “normal performance” under the above conditions should be less than 4,0 % when expressed as the coefficient of variation.

NOTE Experience has indicated that better performance is achievable and can be routinely met in some laboratories. It corresponds to a value of 3 % for reproducibility, when expressed as the coefficient of variation.

Reproducibility is a measure of the precision of the test method when used for evaluation of conformity of cement or ISO standard sand.

11 Validation testing of ISO standard sand and of alternative compaction equipment

11.1 General

An ISO standard sand complying with 5.1.3 or alternative compaction equipment may be used, according to Clause 3, provided that they have been shown to give cement strength results which do not differ significantly from those obtained using the ISO reference sand (5.1.2) or the reference jolting apparatus (4.6.4) and procedure, respectively.

In 11.2 and 11.3, the conditions are described under which ISO standard sands and alternative compaction equipment, respectively, shall be validated. Validation can be provided by an appropriate body and is based on the results of tests carried out by a testing laboratory.

Users of this International Standard should consider the use of conformity assessment methods relevant to the needs of this standard. Certification by an independent third party can provide a higher level of confidence in the conformity of products and processes.

Appointed testing laboratories should conform to ISO/IEC 17025 and are expected to participate in proficiency testing programmes to ensure that validation testing is against comparable testing levels.

The test methods that are described and that shall be applied are based on comparisons of compressive strength test results at the age of 28 d.

11.2 Validation testing of ISO standard sand

11.2.1 Principle

Validation testing of ISO standard sand is comprised of:

a) initial qualification testing;

b) verification testing;

c) annual confirmation testing.

Initial qualification testing of ISO standard sand is described in 11.2.2.1 and the annual confirmation testing is described in 11.2.2.2. Provided that the requirements in 11.2.3.3 are met, sand shall be validated as being in conformity with this International Standard.

Verification testing of ISO standard sand is described in 11.2.4. Provided that the requirements in 11.2.5.3 are met, it ensures that a validated ISO standard sand remains in conformity with this International Standard. Records of the verification testing results shall be retained and shall be examined as part of the annual confirmation testing.

A validated sand shall be designated “ISO standard sand”.

11.2.2 Qualification testing of ISO standard sand

11.2.2.1 Initial qualification testing

The producing plant shall be operating prior to the initial qualification testing of the sand.

During a production period of at least three months, three independent samples of the sand shall be taken at the point of release. The number of bags taken in each of the three samples shall be calculated in order to provide the sufficient amount of sand required by the method of testing in accordance with 11.2.3.1. In addition, the size of one of the three samples shall be sufficiently large as to provide the amount of sand required by the method of verification testing according to 11.2.5.1 for a period of at least one year. For that purpose, this sample shall be divided and the subsample used for verification testing kept separately.

Each of the three samples shall be tested against the ISO reference sand, applying the method described in 11.2.3, using each one of three cements of different standard strength classes. Tests shall be carried out in an appointed testing laboratory (see 11.1).

Where each of the results obtained from the three samples, expressed according to 11.2.3.2, fulfils the requirements in 11.2.3.3, the sand shall be regarded as validated.

11.2.2.2 Annual confirmation testing

The continuing validation of the ISO standard sand shall result from the following actions:

a) inspection of records of verification testing carried out in accordance with 11.2.4 and, provided that the requirements in 5.1.3 and 11.2.5.3 are met,

b) testing by the appointed testing laboratory (see 11.1) of a random sample of sand against the ISO reference sand, applying the method described in 11.2.3, using a Portland cement of strength class 42,5 or 52,5.

The random sample of sand shall be taken at the point of release. The number of bags taken shall be calculated so as to provide the amount of sand required by the method of testing according to 11.2.3.1 and by the method of verification testing according to 11.2.5.1 for a period of at least one year. For that purpose, the sample shall be divided and the subsample used for verification testing kept separately.

The sand shall be validated where

— the results of the verification testing fulfil the requirements in 5.1.3 and 11.2.5.3; and

— the results of the annual confirmation testing fulfil the requirements in 11.2.3.3.

11.2.3 Method of validation testing

11.2.3.1 Procedure

Prepare 20 pairs of batches of mortar using a sample of the selected cement (see 11.2.2.1 and 11.2.2.2). Use the sand being validated for one batch and the ISO reference sand for the other. Prepare the two batches in each pair in a randomized order, one immediately after the other, in accordance with this International Standard.

Test the prisms for compressive strength at 28 d and record all individual results.

11.2.3.2 Calculation and expression of results

For each pair of batches, calculate and express the compressive strength results in accordance with 10.2.1 and report them in accordance with 10.2.2, with x representing the result obtained with the sand to be validated and y, the result obtained with the ISO reference sand.

Calculate the coefficient of variation for each of the two sets of results and check that they meet the requirement for short-term repeatability specified in 10.2.3.1.

If the two sets of results do not fulfil this requirement, discard all results and repeat the whole testing procedure.

If one set of results does not meet this requirement, proceed as follows.

a) Calculate the mean value of the 20 results, $\bar{x}$ or $\bar{y}$.

b) Calculate the standard deviation of the 20 results, s.

c) Calculate the arithmetic difference between each result and the mean value, ignoring the sign.

d) Where one of these differences is greater than $3s$, discard the corresponding result and calculate the mean value of the remaining 19 results; where two or more of these differences are greater than $3s$, discard all results and repeat the whole testing procedure; where no difference is greater than $3s$, keep the 20 results.

Calculate the validation criterion, D, expressed in percent, using Equation (3):

$$D = \frac{(\bar{x} - \bar{y})}{\bar{y}} \times 100 \quad (3)$$

where

$\bar{x}$ is the mean value of the results obtained with the sand being validated, expressed in megapascals;

$\bar{y}$ is the mean value of the results obtained with the ISO reference sand, expressed in megapascals.

Report D to the nearest 0,1 %, ignoring the sign.

11.2.3.3 Requirements

For validating a sand in accordance with the initial qualification testing procedure (see 11.2.2.1), each of the three values of the validation criterion, D, calculated and expressed in accordance with 11.2.3.2, shall be less than 5,0 %. Where one or more of the calculated values of D is equal to or greater than 5,0 %, the sand shall not be validated.

For validating an ISO standard sand in accordance with the annual confirmation testing procedure (11.2.2.2), the value of the validation criterion, D, calculated and expressed in accordance with 11.2.3.2, shall be less than 5,0 %. Where the calculated value of D is equal to or greater than 5,0 %, the ISO standard sand shall not be validated, the reason shall be identified and the initial qualification testing procedure (11.2.2.1) shall be carried out for a further validation.

11.2.4 Verification testing of ISO standard sand

In order to demonstrate that an ISO standard sand remains in conformity with this International Standard, the producer of the sand shall carry out continuous auto-control testing that shall be comprised of

a) daily testing of the particle-size distribution and moisture content in accordance with 5.1.3;

b) monthly testing in accordance with 11.2.5 of a sample of the ISO standard sand produced against a sample of the same ISO standard sand used for the initial qualification testing or annual confirmation testing (see 11.2.2.1 and 11.2.2.2).

For that purpose, samples shall be taken by the producer of sand at the point of release, once per day for daily testing and once per month for monthly testing.

The producer of sand shall check that requirements in 5.1.3 and 11.2.5.3 are met and shall investigate any non-conforming result.

All results shall be recorded and kept for at least three years.

11.2.5 Method of verification testing of ISO standard sand

11.2.5.1 Procedure

Prepare 10 pairs of batches of mortar using a sample of the cement selected, as described in 11.2.2.2 b). Use the sample taken once per month (11.2.4) for one batch and the sample taken once per year for initial qualification testing or annual confirmation testing (11.2.2.1 and 11.2.2.2) for the other. Prepare the two batches in each pair in a randomized order, one immediately after the other, in accordance with this International Standard.

Test the prisms for compressive strength at 28 d and record all individual results.

11.2.5.2 Calculation and expression of results

For each pair of batches, calculate and express the compressive strength results in accordance with 10.2.1 and report them in accordance with 10.2.2, with x representing the result obtained with the sample taken once per month and y, the result obtained with the sample taken once per year.

Calculate the coefficient of variation for each of the two sets of results and apply the procedure in 11.2.3.2 adapted to 10 pairs of batches.

NOTE Where one set of results fails to meet the requirements for short-term repeatability, the procedure set out in 11.2.3.2 is carried out based on sets of 10 results reducing to a minimum of 9 results for the purpose of assessment based on 11.2.3.2 d).

Calculate and report the validation criterion, D, as described in 11.2.3.2.

11.2.5.3 Requirements

Within a series of 12 successive monthly tests, the validation criterion, D, calculated and expressed in accordance with 11.2.5.2 shall not exceed 2,5 % more than twice. If more than two values of D are greater than 2,5 %, the reason shall be identified and the initial qualification testing procedure (11.2.2.1) shall be carried out for further validation.

11.2.6 Report

The producer of ISO standard sand shall make available to the purchaser, on request, a report detailing

a) the date of issue,

b) the name and registered address of the producer,

c) the date of the initial qualification of the sand,

d) the date of the latest annual confirmation testing,

e) the name and registered address of the appointed testing laboratory, and

f) confirmation that the tests show that the sand conforms to the requirements of this International Standard and that the sand qualifies as an ISO standard sand.

11.3 Validation testing of alternative compaction equipment

11.3.1 General requirements

Where validation testing of alternative compaction equipment is requested, the following documents shall be assembled into a dossier:

a) full description of the compaction procedure;

b) full description of the compaction equipment (design and construction);

c) instructions for servicing, including the checks to ensure correct operation.

Three commercially available sets of the equipment shall be selected for validation. The three sets of equipment shall be tested by an appointed testing laboratory against a reference jolting apparatus conforming to the requirements in 4.6.4.

The testing laboratory shall compare the characteristics of the equipment to be validated with the description supplied. Where the correspondence of one with the other is verified, the testing laboratory shall carry out three comparative tests in accordance with 11.3.2 using, for each set of the equipment to be validated, a different cement. For that purpose, three cements of different strength classes shall be selected.

Where the results of each of the three comparative tests fulfil the requirements in 11.3.2.3, the alternative compaction equipment shall be regarded as validated.

Following the validation, the technical description of the equipment and the description of the compaction procedure shall be deemed to be a validated alternative to 4.6.4 and 7.2 respectively. The results of the validation tests shall be added to the dossier and the whole shall be retained for the period during which the equipment is in use.

NOTE The technical description of alternative equipment and description of alternative compaction procedures that have been validated are included in Annex A.

11.3.2 Method of testing of alternative compaction equipment

11.3.2.1 Procedure

Prepare 20 batches of mortar using one of the selected cements (see 11.3.1) and the ISO reference sand. Prepare the two batches in each pair in a randomized order, one immediately after the other, in accordance with this International Standard.

Compact the specimens using one set of the alternative equipment for one batch and the reference jolting apparatus (4.6.4) for the other.

After compaction, proceed in accordance with this International Standard.

Test the prisms for compressive strength at 28 d and record all individual results.

11.3.2.2 Calculation and expression of results

For each pair of batches, calculate and express the compressive strength results in accordance with 10.2.1 and report them in accordance with 10.2.2, with x representing the result obtained with the set of alternative compaction equipment being validated and y, for the result obtained with the reference jolting apparatus.

Calculate the coefficient of variation for each of the two sets of results and check that they meet the requirement for short-term repeatability specified in 10.2.3.1.

If the two sets of results do not fulfil this requirement, discard all results and repeat the whole testing procedure.

If one set of results does not meet this requirement, proceed as follows.

a) Calculate the mean value of the 20 results, $\bar{x}$ or $\bar{y}$.

b) Calculate the standard deviation of the 20 results, s.

c) Calculate the arithmetic difference between each result and the mean value, ignoring the sign.

d) Where one of these differences is greater than $3s$, discard the corresponding result and calculate the mean value of the 19 remaining results; where two or more of these differences are greater than $3s$, discard all results and repeat the whole testing procedure; where no difference is greater than $3s$, keep the 20 results.

Calculate the validation criterion, D, expressed in percent, using Equation (4):

$$D = \frac{(\bar{x} - \bar{y})}{\bar{y}} \times 100 \tag{4}$$

where

$\bar{x}$ is the mean value of the results obtained with the alternative compaction equipment to be validated, expressed in megapascals;

$\bar{y}$ is the mean value of the results obtained with the reference jolting apparatus, expressed in megapascals.

Report D to the nearest 0,1 %, ignoring the sign.

11.3.2.3 Requirements

The three values of the validation criterion, D, calculated and expressed in accordance with 11.3.2.2, each one corresponding to one of the three selected cements and one of the three selected sets of the equipment being validated, shall be less than 5,0 %. Where one or more of the calculated values of D is equal to or greater than 5,0 %, the alternative compaction equipment shall not be validated.

11.3.3 Report

The producer of the alternative compaction equipment shall make available to a purchaser, on request, a report detailing

a) the date of issue;

b) the name and registered address of the producer;

c) the date of the validation of the alternative compaction equipment;

d) the name and registered address of the appointed testing laboratory;

e) confirmation that the tests show that the alternative compaction equipment conforms to the requirements of this International Standard.

Annex A
(normative)

Alternative vibration compaction equipment and procedures validated as equivalent to the reference jolting compaction equipment and procedure

A.1 General

The reference jolting apparatus is described in 4.6.4. However, alternative equipment and procedures may be used "...provided that they have been validated in accordance with the appropriate provisions in this International Standard".

For the purposes of validation, a procedure is described in Clause 11 for validating alternatives to the reference procedure. Validation testing programmes have been undertaken on the vibrating tables and compaction procedures identified as A and B in Clauses A.2 and A.3. They are, therefore, examples of validated alternative compaction equipment.

In accordance with 11.3.1, each technical description (see A.2.1 and A.3.1) shall be deemed to be a validated alternative to 4.6.4 and each description of the compaction procedure (see A.2.2 and A.3.2) shall be deemed to be a validated alternative to that given in 7.2.

A.2 Vibrating table A

A.2.1 Technical description

Vibrating table A, which may be used as alternative compaction equipment, has the following characteristics:

a) Method of operation: electromagnetic vibrator with a nominally sinusoidal vibration.

b) Electrical supply

- voltage: 230/240 V;
- phase: single;
- current: maximum 6,3 A;
- frequency: nominal 50 Hz.

c) Vibrating mass (including empty mould, hopper and clamp but excluding the vibrator): (35,0 ± 1,5) kg.

d) Operating peak-to-peak vertical amplitude measured at the level of the centre separating walls and the outer corners of the empty mould: (0,75 ± 0,05) mm.

   Acceleration, measured at the centre separating walls and the outer corners of the empty mould may be an alternative characteristic for describing the operational vibration of the table. A value of (26,0 ± 3,0) m/s^2 corresponds to the value given in A.2.1 d).

   NOTE The vibrating table is designed to produce uniaxial vertical vibrations only. The vertical amplitude of vibration is displayed continuously.

e) Natural frequency of the vibrating mass: (53,00 ± 0,25) Hz.

f) Vibrating plate: plate with a ground finish to the working surface; minimum dimensions nominally 400 mm × 300 mm consisting of either

- a rigid single layer of stainless steel, with support ribs, or
- a rigid double layer of metal (minimum thickness 20 mm), the top layer made of stainless steel with a minimum thickness of 2 mm, bonded permanently to the bottom layer by means of a frictional and interlocking connection.

It is recommended that the centre of gravity of the vibrating mass (including clamps but excluding the empty mould and hopper), is marked on the working surface of the vibrating plate at the intersection of two orthogonal vertical axes.

g) Adjustable fixing lugs: three adjustable fixing lugs which allow the filled mould to be located on the vibrating plate such that its centre of gravity coincides with the centre of gravity of the vibrating mass, as marked on the working surface of the vibrating plate.

h) Clamp for moulds: fixing attachment suitable for moulds 40 mm × 40 mm × 160 mm, including the mounted hopper.

i) Mass of vibrating table: greater than 100 kg.

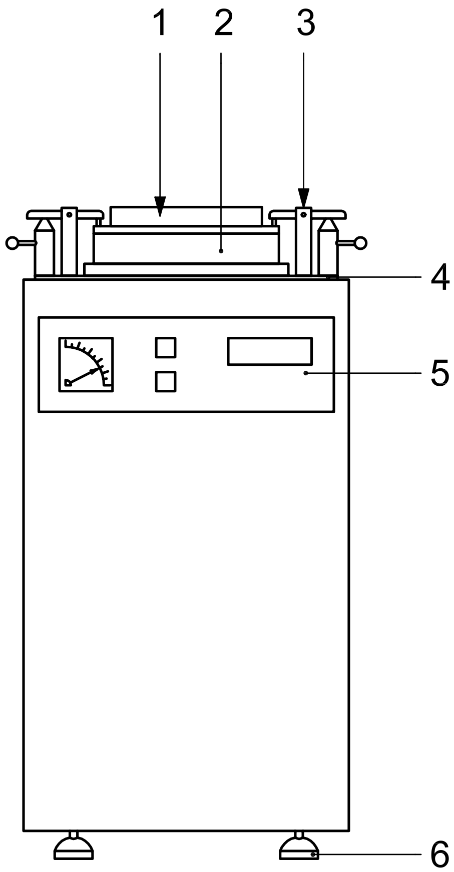
Where the vibrating table is built into laboratory furniture, it is recommended that the electromagnetic vibrator is permanently fixed to a mass of concrete, of at least 200 kg, standing on vibration isolating material, in order to minimize transference of vibration to other equipment.

j) Anti-vibration mounts: rubber springs located between the vibrating plate and the frame, with

- Shore hardness: 45,
- spring rate: 145 MPa,
- dimensions: diameter 50 mm,
height 45 mm.

k) Levelling of the vibrating table: with the aid of the adjusting screws (see Figure A.1) attached to the lower surface, adjust the working surface of the vibrating plate so that it does not deviate from the horizontal by more than 1 mm/m.

l) Automatic timer: timer, capable of being set at 120 s and of timing operations to an accuracy of ± 1 s.



Key

1 hopper

2 mould

3 clamp

4 vibration plate

5 control panel with display of amplitude, amplitude setting, timer and main switch

6 adjusting screws

Figure A.1 — Schematic of typical vibrating table, type A

A.2.2 Compaction procedure using vibrating table A

Cast the specimens immediately after the preparation of the mortar.

Mount the mould with the hopper firmly in the centre on the vibrating table. Set the automatic timer to switch off after a total of (120 ± 1) s. Switch on the vibrator. Fill the compartments of the mould with two layers of mortar within a maximum of 45 s, proceeding as follows.

a) Working from one end to the other, introduce the first layer of mortar, using a suitable scoop, into the compartments of the mould within 15 s so that the compartments are approximately half-full.

b) After an interval of 15 s, introduce the second layer of mortar into the mould within a further 15 s, again working from one end to the other, in the same direction as the first layer was introduced. Use the total amount of mortar.

c) When the vibrator has been switched off for a total of (120 ± 1) s, lift the mould gently from the vibrating table and remove the hopper.

Follow the procedures for striking off, wiping and labelling of moulds described in 7.2.

A.3 Vibrating table B

A.3.1 Technical description

Vibrating table B (see Figure A.2), which may be used as alternative compaction equipment, has the following characteristics:

a) Method of operation: electromagnetic vibrator with a nominally sinusoidal vibration.

b) Electrical supply

- voltage: 230/240 V;
- phase: single;
- current: approximately 6,3 A;
- frequency: nominal 50 Hz.

c) Vibrating mass (including empty mould and hopper but excluding the vibrator): (43,0 ± 2,0) kg.

d) Operating vertical acceleration, measured at the base of the mould at the centre of the middle compartment: (4,50 ± 0,25)g rms.

NOTE The maximum acceleration in any horizontal direction is 0,5g rms.

e) Natural frequency of the vibrating mass: (55,50 ± 0,25) Hz.

f) Vibrating plate: plate, with a ground finish to the working surface and minimum dimensions nominally 630 mm × 250 mm consisting of

- a rigid single layer of mild steel of finished thickness (13 ± 2) mm, and
- support ribs and drive plate.

g) Clamp for moulds: swing clamps suitable for moulds, 40 mm × 40 mm × 160 mm including the mounted hopper.

h) Levelling of vibrating table: the vibrating table is permanently fixed to the floor and levelled so that the working surface of the vibrating plate does not deviate from the horizontal by more than 1 mm/m.

i) Automatic timer: timer capable of being set at 120 s and of timing operations to an accuracy of ± 1 s.

A.3.2 Compaction procedure using vibrating table B

Set the vibrating table top horizontal and clean it. Prepare and assemble the mould in accordance with 4.6.3. Ensure that the lower surface of the mould base plate is flat and clean. Clamp the mould and filling hopper firmly to the vibrating table and set the acceleration of the vibrating table to be (4,50 ± 0,25)g rms.

Mould the specimens immediately after the preparation of the mortar. When using the automatic timer, set it to switch off after a total of (120 ± 1) s. Switch on the vibrator. Fill the compartments of the mould with mortar immediately, completing the following operation within at most 45 s.

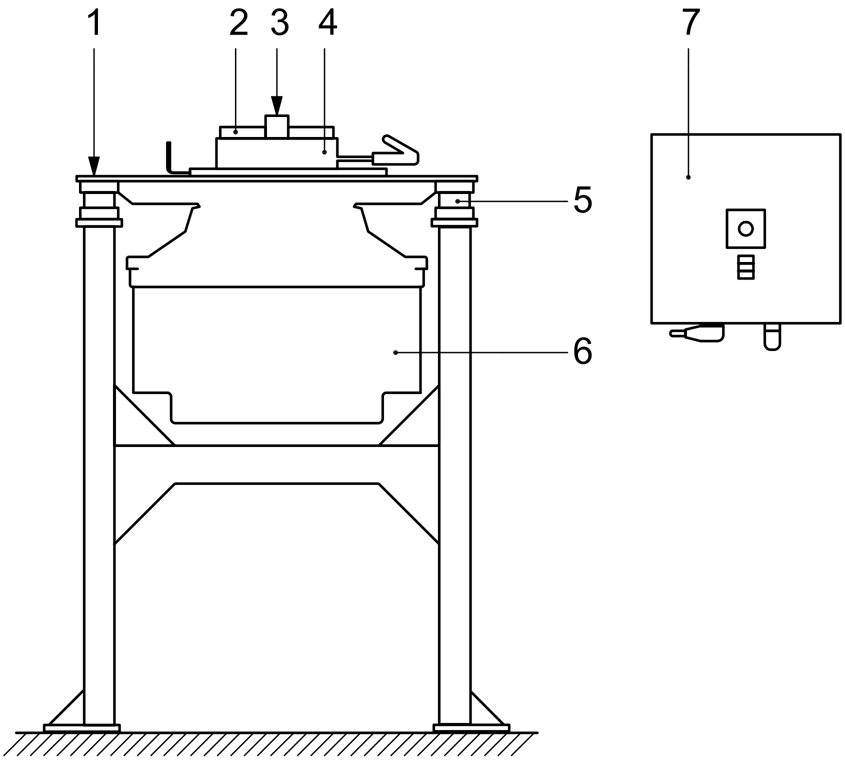
a) Fill the compartments of the mould, using a suitable scoop, within 15 s, up to about half the depth.

b) Without switching the vibrator off, and after a pause of 15 s, add the second layer within the next 15 s, in the same sequence. The mould should be just slightly overfilled.

c) After a total period of (120 ± 1) s, allow the vibrator to switch off automatically, or switch it off manually.

d) Lift the mould gently from the vibrating table and remove the hopper.

Follow the procedures for striking off, wiping and labelling of moulds described in 7.2.



Key

1 vibrating plate
2 hopper
3 swing bolt clamp
4 mould
5 anti-vibration mounts
6 electromagnetic vibrator
7 control panel

Figure A.2 — Schematic of typical vibrating table, type B

Bibliography

[1] ISO 565:1990, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings*

[2] ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ICS 91.100.10

Price based on 29 pages