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Methods of testing cements — Determination of strength

Méthodes d'essai des ciments — Détermination des résistances mécaniques

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Contents

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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

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Methods of testing cements — Determination of strength

1 Scope

This International Standard specifies a method of determining the compressive and flexural strengths of cement mortar.

It describes the reference procedure; it allows the use of alternative procedures only in well defined cases provided that they do not affect the results significantly as specified in clause 11. In the event of a dispute, only the reference procedure described in this International Standard shall be used, excluding any alternatives.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 409-1 : 1982, *Metallic materials — Hardness test — Tables of Vickers hardness values for use in tests made on flat surfaces — Part 1 :* HV 5 *to* HV 100.

ISO 565 : 1983, *Test sieves — Woven metal wire cloth, perforated plate and electroformed sheet — Nominal sizes of openings.*

ISO 1101 : 1983, *Technical drawings — Geometrical tolerancing — Tolerancing of form, orientation, location and run-out — Generalities, definitions, symbols, indications on drawings.*

ISO 1302 : 1978, *Technical drawings — Method of indicating surface texture on drawings.*

ISO 2591 : 1973, *Test sieving.*

ISO 3310-1 : 1982, *Test sieves — Technical requirements and testing — Part 1 : Test sieves of metal wire cloth.*

ISO 4200 : 1985, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length.*

ISO 6507-1 : 1982, *Metallic materials — Hardness test — Vickers test — Part 1 :* HV 5 *to* HV 100.

3 Principal features of method

The method comprises the determination of the compressive, and optionally the flexural, strength of prismatic test specimens 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 and three parts by mass of standard sand with a water/cement ratio of 0,5. Standard sands from various sources and countries may be used provided that they have been shown to give cement strength results which do not differ significantly from those obtained using the ISO Reference sand (see clause 11).

The mortar is prepared by mechanical mixing and is compacted in a mould using standard jolting apparatus. Alternative compaction equipment and techniques may be used provided that they have been shown to give cement strength results which do not differ significantly from those obtained using the standard jolting apparatus (see clause 11).

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

At the required age, the specimens are taken from their wet storage, broken in flexure into two halves and each half tested for strength in compression.

4 Laboratory and equipment

4.1 Laboratory

The laboratory where preparation of specimens takes place shall be maintained at a temperature of 20 °C ± 2 °C and a relative humidity of not less than 50 %.

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

The moist air room or the large cabinet for storage of the specimens in the mould shall be continuously maintained at a temperature of 20 °C ± 1 °C and a relative humidity of not less than 90 %.

The temperature of the water in the storage containers shall be maintained at 20 °C ± 1 °C.

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

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

The temperature and relative humidity of the moist air room or cabinet shall be recorded at least every 4 h. Where temperature ranges are given, the target temperature at which the controls are set shall be the middle value of the range.

4.2 Equipment

4.2.1 General

The tolerances shown on the drawings are important for correct operation of the equipment in the test. When regular control measurements show that the tolerances are not met, the equipment shall be rejected or adjusted or repaired where possible. 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 shall be specified.

4.2.2 Test sieves

Wire cloth test sieves complying with the requirements of ISO 2591 and ISO 3310-1 shall be of the nominal mesh sizes from ISO 565 given in table 1 (series R 20).

Table 1 — Test sieves

Series	Nominal mesh size mm
R 20	2 1,6 1 0,5 0,16 0,08

4.2.3 Mixer

The mixer (see figure 1) shall consist essentially of

a) a stainless steel bowl with a capacity of about 5 l and of the general shape and size shown in figure 1, and provided with means by which it can be fixed securely to the mixer frame during mixing and by which the height of the bowl in

Dimensions in millimetres

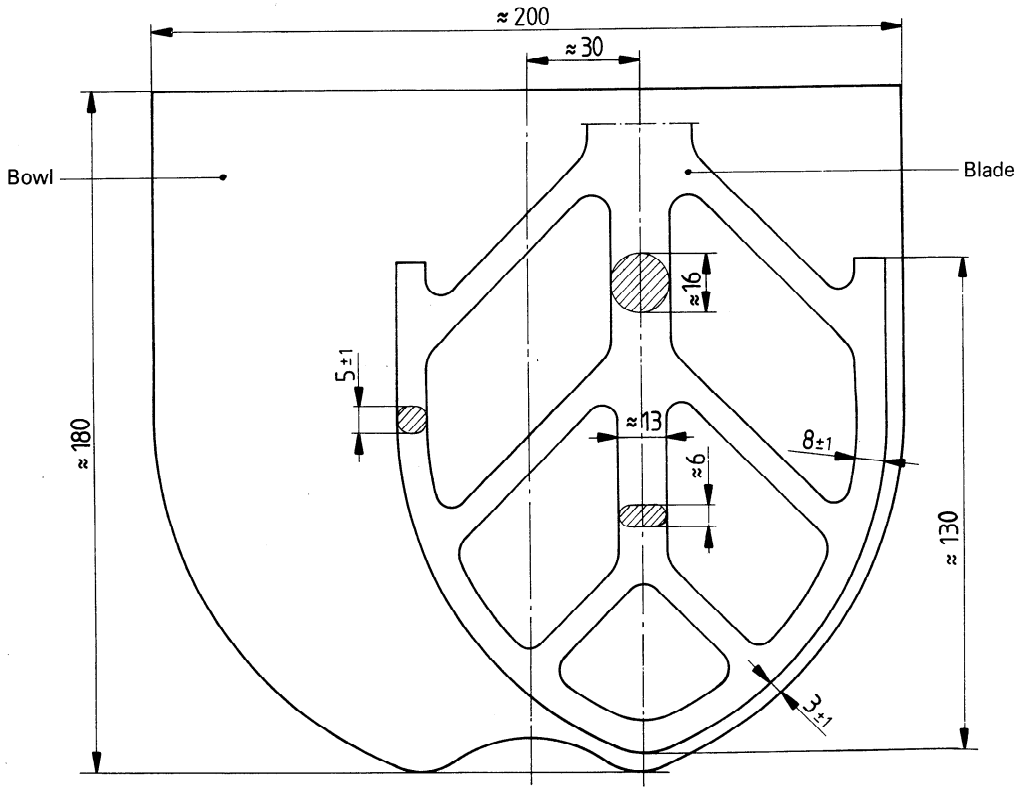


Figure 1 — Mixer

relation to the blade and, to some extent, the gap between blade and bowl can be finely adjusted and fixed;

b) a stainless steel blade of the general 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 by an electric motor at controlled rotational frequencies. The two directions of rotation shall be opposite and the ratio between the two rotational frequencies shall not be a whole number.

Where more than one mixer is used, blades and bowls shall form sets which are always used together.

The gap between blade and bowl shown in figure 1 shall be checked every month.

NOTE — The gap indicated in figure 1 (3 mm ± 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.

The mixer shall operate at the speeds given in table 2.

Table 2 — Mixer blade speeds

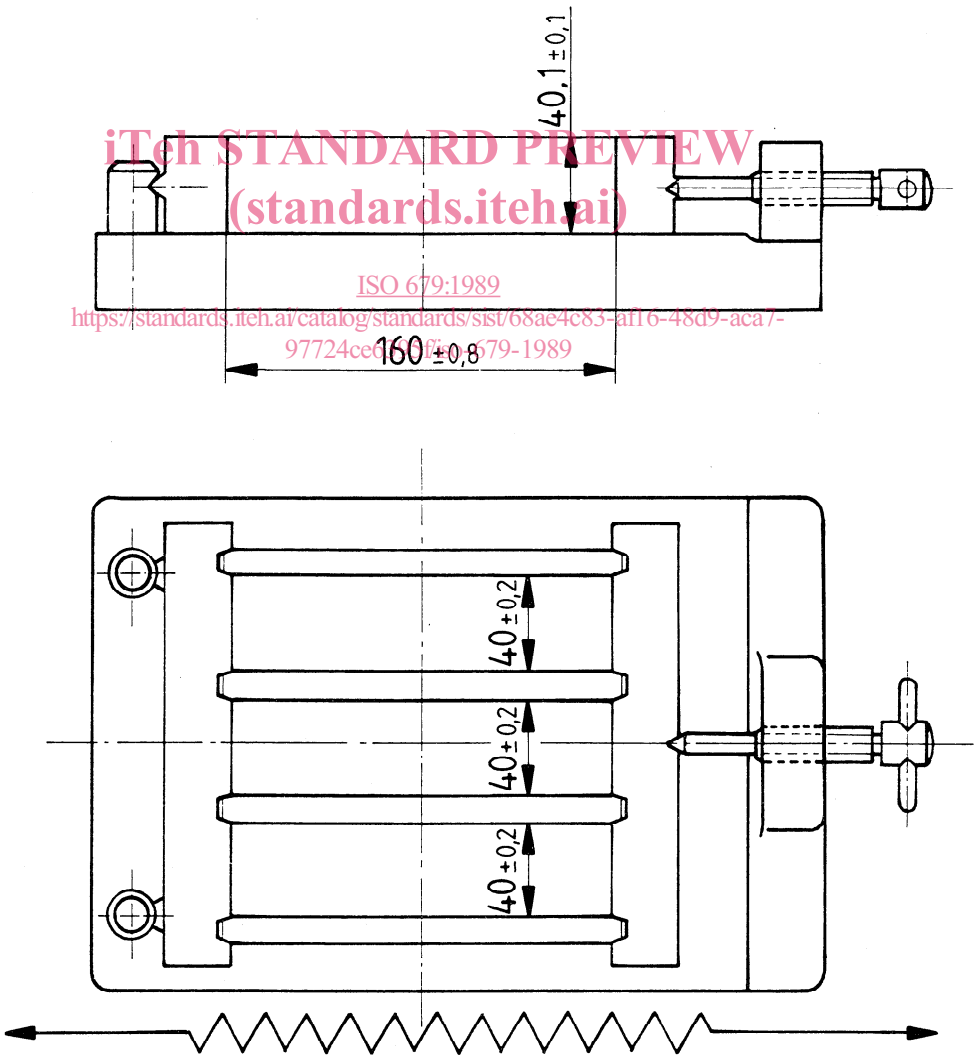
Values in reciprocal minutes

Speed	Rotation	Planetary movement
Low	140 ± 5	62 ± 5
High	285 ± 10	125 ± 10

4.2.4 Moulds

The mould (see figure 2) shall consist 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.

Dimensions in millimetres



NOTE — Moulds and jolting tables from different manufacturers may have differing dimensions and unrelated part-weights, so compatibility should be specified by the purchaser.

Figure 2 — Typical mould

The mould shall be made of steel with walls at least 10 mm thick. The surface Vickers hardness of each internal side face shall be at least HV 200 (see ISO 409-1 and ISO 6507-1).

NOTE — 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 base plate.

The mould, when assembled, shall be positively and rigidly held together and fixed to the base plate. The assembly shall be such that there is no distortion or leakage. The base plate shall make adequate contact with the table of the compacting apparatus and be rigid enough not to induce secondary vibrations.

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

The assembled mould shall comply with the following requirements :

a) the internal dimensions and tolerances of each mould compartment, based on four symmetrically placed measurements, shall be as follows :

length : 160 mm ± 0,8 mm

width : 40 mm ± 0,2 mm

depth : 40,1 mm ± 0,1 mm

b) the flatness tolerance (see ISO 1101) over the whole of each internal side face shall be 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 0,2 mm;

d) the surface texture of each internal side face shall be N 8 or less (see ISO 1302).

Moulds shall be replaced when any one of the specified tolerances is exceeded. The mass of the mould shall accord with the requirement for the combined mass in 4.2.5.

In assembling the cleaned mould ready for use, a suitable sealing 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.

To facilitate the filling of the mould, a tightly fitting metal hopper with vertical walls 20 mm to 40 mm in height 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 have a means of location to ensure correct positioning over the mould.

For spreading and striking off the mortar, two spreaders and a metal straightedge of the type shown in figure 3 shall be provided.

4.2.5 Jolting apparatus

The jolting apparatus (see figure 4) shall comply with the following requirements.

The apparatus consists essentially of a rectangular table rigidly connected by two light arms to a pivot at 800 mm from the centre of the table. 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 perpendicular through the point of contact of the lug and stop shall be vertical. When the projecting 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 mm. The table shall have dimensions equal to or greater than those of the mould base plate, 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 kg ± 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 meeting the specifications of ISO 4200. The total mass of the two arms, including any cross-bracing, shall be 2,25 kg ± 0,25 kg. The pivot bearings shall be of 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 mm.

The lug and the stop shall be made of through-hardened steel of at least HV 500 Vickers hardness value (see ISO 409-1). 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 mm ± 0,3 mm before the lug strikes the stop.

The cam shall be made of steel of at least HV 400 Vickers hardness value and its shaft shall be mounted in ball bearings of such construction that the free drop requirement of 15 mm ± 0,3 mm is always satisfied. The cam follower shall be of a construction which ensures least wear of the cam. The cam shall be driven by an electric motor of about 250 W through reduction gear at a uniform speed of 1 r/s. A control mechanism and a counter shall be provided which ensure that one period of jolting of 60 s ± 3 s comprises exactly 60 jolts.

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 of about 600 kg mass and of about 0,25 m^3 volume and of dimensions giving a suitable working height for the mould. The entire

Dimensions in millimetres

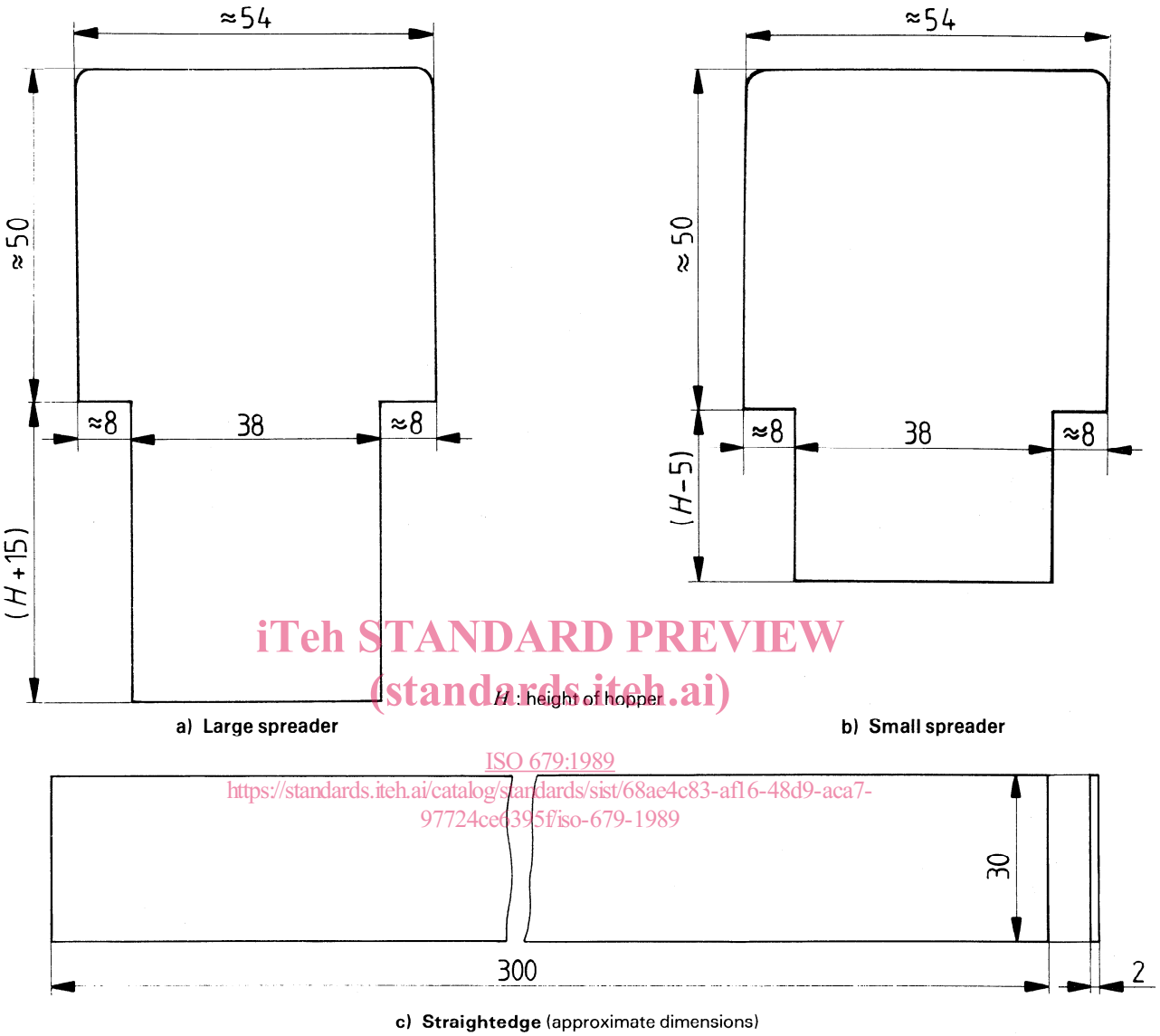


Figure 3 — Typical spreaders and metal straightedge

base of the concrete block shall stand on an elastic pad, e.g. natural rubber, having a suitable isolation efficiency preventing external vibrations from affecting the compaction.

The bases 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.

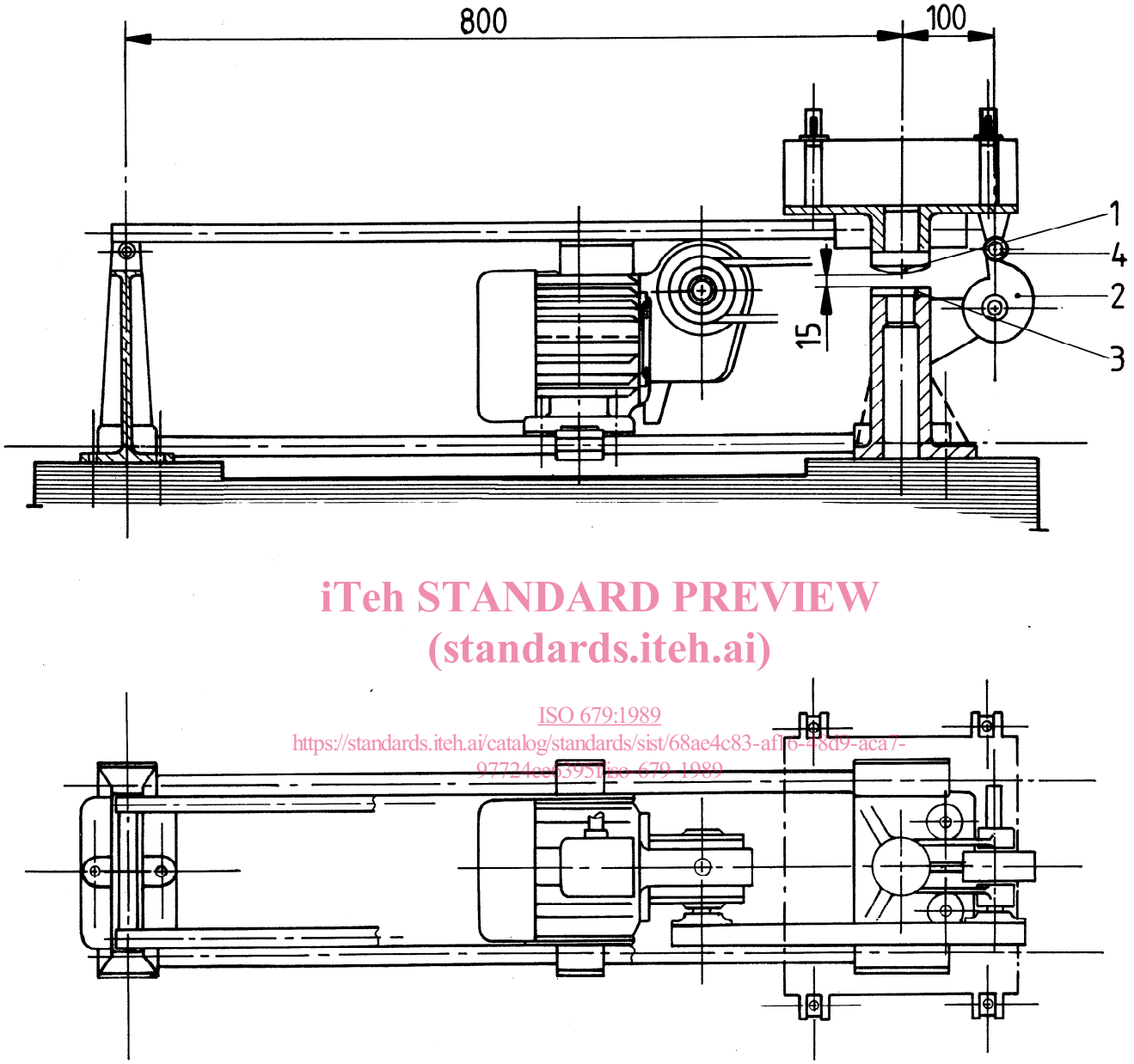
4.2.6 Flexural strength test machine

The test machine for the determination of flexural strength shall be capable of applying loads up to 10 kN, with an accuracy of ± 1 % of the recorded load in the upper four-fifths of the range being used, at a rate of loading of 50 N/s ± 10 N/s. The machine shall have a flexure device incorporating two steel supporting rollers of 10 mm ± 0,5 mm diameter spaced 100 mm ± 0,5 mm apart and a third steel loading roller of the same diameter placed centrally between the other two. The length a of these rollers shall be between 45 mm and 50 mm. The loading arrangement is shown in figure 5.

The three vertical planes through the axes of the three rollers shall be parallel and 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.

The determination of flexural strength may be carried out in a compressive strength test machine (see 4.2.7). In this case a device complying with the specification given above shall be used.

Dimensions in millimetres



Key

1 Lug
2 Cam
3 Stop
4 Cam follower

NOTE — Moulds and jolting tables from different manufacturers may have differing dimensions and unrelated part-weights, so compatibility should be specified by the purchaser.

Figure 4 — Typical jolting apparatus

Dimensions in millimetres

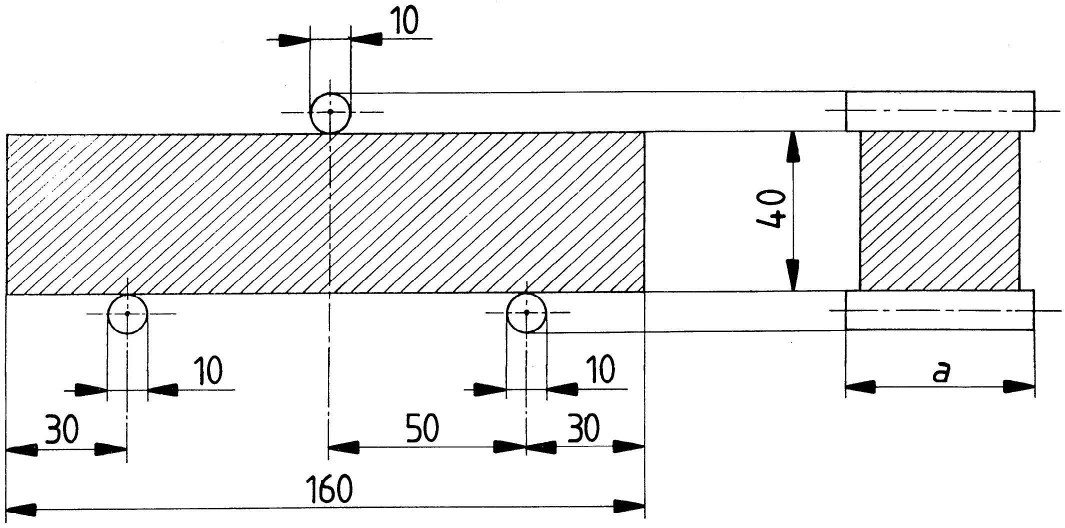


Figure 5 — Loading for determination of flexural strength

4.2.7 Compressive strength test machine

The test machine for the determination of compressive strength shall be of suitable capacity for the test : it shall have an accuracy of ± 1 % of the recorded load in the upper four-fifths of the range being used and it shall provide a rate of loading of 2 400 N/s ± 200 N/s. It shall be fitted with an indicating device which shall be so constructed that the value indicated at failure of the specimen remains indicated after the test 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 test 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 test machine shall have platens made of hard steel, with a Vickers hardness (see ISO 409-1) of at least HV 600, or preferably of tungsten carbide. These platens shall be at least 10 mm thick, 40 mm ± 0,1 mm wide, and at least 40 mm long. The flatness tolerance over the entire contact surface with the specimen shall be 0,01 mm (see ISO 1101). The surface texture shall be greater than N 3 and less than N 6 (see ISO 1302).

Alternatively, two auxiliary plates of hard steel, or preferably of tungsten carbide, at least 10 mm thick and complying with the requirements for the platens may be provided. Provision shall be made for centring the auxiliary plates with respect to the axis of the loading system with an accuracy of ± 0,5 mm.

Where there is no spherical seating in the test machine or where the spherical seating is blocked, or where the diameter of the spherical seating is greater than 120 mm, a jig according to 4.2.8 shall be used.

NOTES

1 The test machine may have 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.

2 It is considered advisable for the machine to have an automatic method for adjusting the rate of loading and with equipment for recording the results.

3 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 which are effective under high pressure are not suitable.

4 The terms "vertical", "lower" and "upper" refer to conventional test machines. However, machines the axis of which is not vertical are also permitted provided that they satisfy an acceptance test procedure analogous to that in 11.7 and that the other requirements specified above are fulfilled.

4.2.8 Jig for compressive strength test machine

When use of a jig (see figure 6) is required, it shall be placed between the platens of the machine to transmit the load of the machine to the compression surfaces of the mortar specimen.

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.