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**Physical testing methods for
cement**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Cement Association (JCA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently **JIS R 5201:1997** is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

Physical testing methods for cement

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **ISO 9597** published in 2008 and the second edition of **ISO 679** published in 2009 by modifying some of their technical contents to reflect the domestic conditions in Japan.

In this Standard, test methods conventionally used in Japan are given in parallel with the corresponding **ISO** test methods so as to allow users to select between two comparable methods, with Japanese methods given in the main body and the **ISO** methods respectively corresponding thereto given in Annexes A to C, namely, the setting time test in Annex A, cement soundness test in Annex B and cement strength test in Annex C.

This Standard also specifies methods for density test, fineness test, soundness test using pat method, and flow test, which are not included in the corresponding International Standards.

Sidelines and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JA. The comparison table between previous and current editions of this Standard on technically significant revisions is given in Annex JB.

1 Scope

This Standard specifies the physical testing methods for cement.

NOTE : The International Standards corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 679:2009 *Cement—Test methods—Determination of strength*

ISO 9597:2008 *Cement—Test methods—Determination of setting time and soundness* (overall evaluation: MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standards and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 7721 *Tension/compression testing machines—Verification and calibration of the force-measuring system*

NOTE : Corresponding International Standard: 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* (MOD)

JIS K 0050 *General rules for chemical analysis*

JIS K 2203 *Kerosine*

JIS K 2204 *Diesel Fuel*

JIS P 3801 *Filter Paper (for chemical analysis)*

JIS Q 17025 *General requirements for the competence of testing and calibration laboratories*

NOTE : Corresponding International Standard: ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories* (IDT)

JIS R 3505 *Volumetric glassware*

JIS Z 8801-1 *Test sieves—Part 1: Test sieves of metal wire cloth*

NOTE : Corresponding International Standard: ISO 3310-1 *Test sieves—Technical requirements and testing—Part 1: Test sieves of metal wire cloth* (MOD)

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

3 Test items

The tests specified in this Standard are as follows.

a) *Density test*

b) *Fineness test*

1) *Specific surface area test*

2) *Wire sieve test*

c) *Setting time test*

d) *Soundness test*

e) *Strength test*

1) *Compressive strength determination*

2) *Flexural strength determination*

f) *Flow test*

4 Expression of test result

The test results shall be rounded off to the digit number specified in respective test clauses by rounding down to 0 if the last digit is 4 or less, and rounding up to 10 if it is 5 or more. As an exception, for the setting time test, the initial and final setting times determined shall be reported to the nearest 5 min by rounding down to 0 if the last digit is 1 or 2, rounding off to the nearest 5 if it is 3, 4, 5, 6 or 7, and rounding up to 10 if it is 8 or 9.

5 Sample

Extract cement so that it represents the average quality of the inspection unit and then reduce it to obtain a representative sample. Use the sampling and reduction methods determined by the agreement between the parties concerned with delivery.

Preserve the extracted sample in a tightly sealed moisture-proof and airtight vessel after removing impurities with the standard wire sieve of 850 μm specified in **JIS Z 8801-1**. The sample shall be at the laboratory temperature.

6 Water used for testing

Distilled water, deionized water or tap water shall be used for tests. The water shall be at the laboratory temperature.

7 Density test

7.1 Le Chatelier flask

The Le Chatelier flask shall be made of glass, and its capacity and size at 20 °C shall be as follows (see Figure 1).

- Capacity between scale marks 0 and 40: (40.00 ± 0.05) ml
- Capacity between scale marks 0 and 29: (29.00 ± 0.05) ml

The Le Chatelier flask not conforming to the above may still be used if it has been calibrated for capacity and the correction value has been obtained according to the method specified in **JIS K 0050** or **JIS R 3505**.

- The scale shall be visually checked for noticeable uneven spacing in its graduation lines.
- Capacity below scale mark 0: (250 ± 5) ml
- Height from bottom of flask to scale mark 40: (280 ± 20) mm

Unit: mm

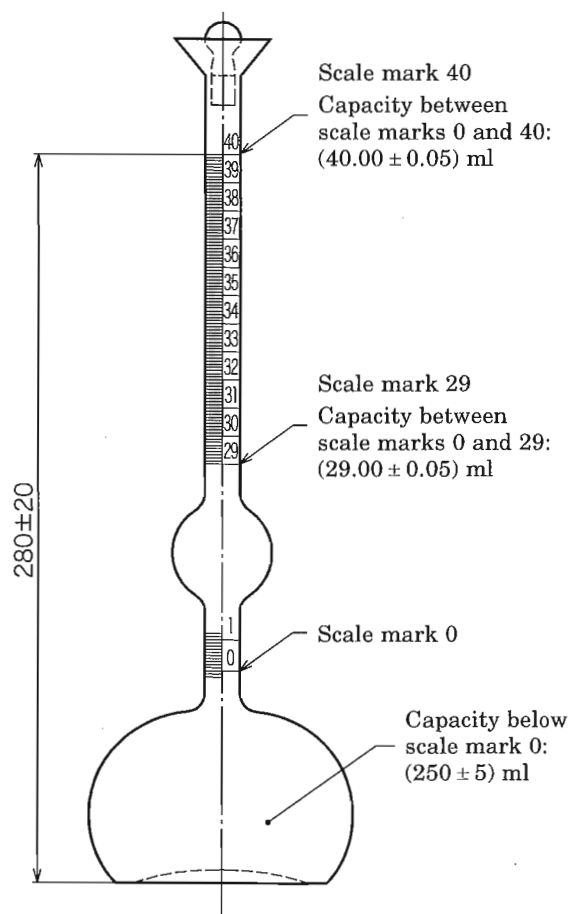


Figure 1 Le Chatelier flask

7.2 Mineral oil

The mineral oil used shall be kerosine specified in **JIS K 2203** or diesel fuel specified in **JIS K 2204**, dehydrated before use.

7.3 Procedure

Pour mineral oil in a Le Chatelier flask (hereafter referred to as flask) up to a level between 0 ml and 1 ml scale marks, place the flask in a water bath and note the oil level on the scale when it has become stationary.

Weigh about 100 g of the sample correctly to the nearest 0.1 g, and put it gently, little by little, into the flask. When the whole amount of the sample has been put in, mildly shake the flask until air is expelled thoroughly. Place the flask in the water bath again and note the oil level on the scale when it becomes stationary. The water temperature in the water bath shall not fluctuate by more than 0.2°C during the density test.

7.4 Calculation

The density shall be calculated from the following equation:

$$\rho = \frac{m}{v}$$

where, ρ : density of the sample (g/cm³)
 m : mass of the sample weighed out (g)
 v : difference between the first and second readings (ml)

Perform this test at least twice, and calculate the mean of consecutive measurements that are equal with difference of within 0.01 g/cm³, and round the result to two decimal places.

8 Fineness test

8.1 Specific surface area test

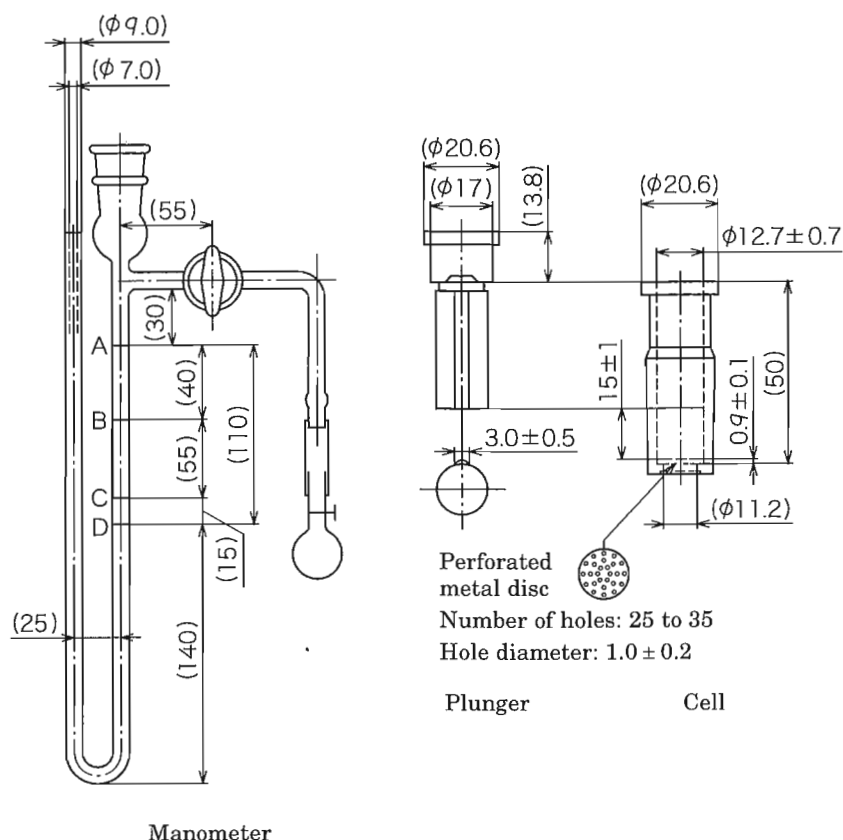
8.1.1 Blaine air permeability apparatus

The Blaine air permeability apparatus used for the specific surface area test shall be as follows.

- a) For the dimensions of the manometer, see Figure 2.
- b) Inside diameter of the cell: (12.7 ± 0.7) mm (see Figure 2).
- c) The dimensions of the plunger shall be as follows (see Figure 2):
 - width of the vent on the side surface: (3.0 ± 0.5) mm;
 - difference between the inside diameter of the cell and the outside diameter of the plunger: 0.1 mm max.

The length of the plunger from the lower face of the collar shall be sufficient for making a bed of (15 ± 1) mm in height.
- d) The dimensions of the perforated metal disc shall be as follows (see Figure 2):
 - thickness: (0.9 ± 0.1) mm;
 - hole diameter: (1.0 ± 0.2) mm;
 - difference between the diameter of the perforated metal disc and the inside diameter of the cell: 0.5 mm max.
- e) The material of the cell, plunger and perforated metal disc shall be metal resistant to corrosion by cement.
- f) The inner surface of the cell shall be polish-finished, and the cell and the manometer shall be tightly fitted by grinding.
- g) The perforated metal disc shall be provided with 25 to 35 holes that are allocated evenly over the whole disc surface.
- h) Filter paper used shall be that of Class 5A specified in **JIS P 3801**, having a size equal to the inside diameter of the cell.
- i) The manometer liquid shall be of nonvolatile, nonhygroscopic and of low viscosity and low density like dibutylphthalate or light mineral oil, and may be coloured.

Unit: mm



Numbers in parentheses are informative values.

Figure 2 Blaine air permeability apparatus

8.1.2 Standardizing test of apparatus

The standardizing test of the apparatus shall be carried out as follows.

- a) The reference material for specific surface area test shall be used.

The test method described in **8.1.3** shall be used to determine t_0 defined in **8.1.4**. The measurement shall be carried out three or more times replacing the bed each time, and the results obtained shall be averaged, then rounded to one decimal place.
- b) The apparatus shall be subject to the standardizing test every time any of the following occurs.
 - 1) When the cell or plunger has been abraded.
 - 2) When the manometer liquid has been contaminated, or its quantity has increased or decreased.
 - 3) When the filter paper for testing has changed in size or quality.
 - 4) When the temperature of the sample, test apparatus or test atmosphere has changed by $\pm 3\text{ }^{\circ}\text{C}$ or more from the temperature at the standardizing test carried out in advance.

8.1.3 Procedure

The procedure shall be as follows.

- a) **Preparation of bed** Take about 10 g of the sample in a bottle of capacity about 50 ml, apply the stopper tightly, and shake vigorously for about 1 min to thoroughly disintegrate the sample. From this disintegrated sample, weigh the amount calculated by the following equation accurately to the nearest 0.005 g.

$$m = \rho v(1 - e)$$

where, m : mass of the sample to weigh out (g)
 ρ : density of the sample (g/cm³)
 v : bulk volume of the sample bed (cm³)
 e : porosity of the sample bed

The density (ρ) of the sample and the porosity of the sample bed (e) shall conform to Table 1.

Table 1 Density of each sample and porosity of sample bed

Type of sample	Density (g/cm ³)	Porosity
Ordinary portland cement	3.15	0.500 ± 0.005
High-early-strength portland cement	3.12	0.520 ± 0.005
Ultra high-early-strength portland cement	3.11	0.540 ± 0.005
Moderate heat portland cement	3.20	0.500 ± 0.005
Low heat portland cement	3.22	0.520 ± 0.005
Sulfate-resisting portland cement	3.20	0.500 ± 0.005
Ordinary ecocement	3.15	0.520 ± 0.005
Portland blast-furnace slag cement (Classes A, B, and C)	Actually measured value ^{a)}	0.510 ± 0.005
Portland pozzolan cement (Classes A, B, and C)	Actually measured value ^{a)}	0.510 ± 0.005
Portland fly-ash cement (Classes A, B, and C)	Actually measured value ^{a)}	0.510 ± 0.005
Rapid hardening ecocement	Actually measured value ^{a)}	0.520 ± 0.005 ^{b)}
Notes ^{a)} The density (ρ) shall be determined in accordance with clause 7.		
^{b)} Informative value		

Detach the cell from the manometer, place the perforated metal disc on the bottom of the cell, and put a filter paper over the disc so that it is in close contact with the disc. Put the weighed sample on the filter paper and tap lightly on the side of the cell until the sample surface is level. Then place another filter paper on the sample surface and press it gently with a plunger until the plunger collar is in contact with the upper brim of the cell, and then withdraw the plunger gently.

A bed shall be newly prepared for each measurement.

- b) **Descent time measurement of manometer liquid** Attach the cell that contains the bed prepared in a) closely to the manometer, open the cock, use the rubber bulb to raise the liquid head of the manometer in the U-tube to mark A, and then close the cock. Measure the time required for the manometer liquid head to descend from mark B to mark C correctly to the nearest 0.5 s.

When an automatic time measurement device is used for this measurement, use it after validating its repeatability and that it is capable of producing equivalent test results to a manual time measurement.

NOTE : Vaseline etc. should be applied to the contact part of the cell and manometer as well as to the cock, in order to prevent air leakage.

8.1.4 Calculation

The specific surface area shall be calculated from the following equation.

$$S = S_0 \frac{\rho_0}{\rho} T \frac{1 - e_0}{\sqrt{e_0^3}} \frac{\sqrt{e^3}}{1 - e}$$

- where,
- S : specific surface area of the sample (cm²/g)
 - S_0 : specific surface area of the reference material for specific surface area test (cm²/g)
 - ρ_0 : density of the reference material for specific surface area test (g/cm³)
 - ρ : density of the sample (g/cm³)
 - e_0 : porosity of the bed of the reference material for specific surface area test
 - e : porosity of the sample bed
 - T : $\sqrt{t/t_0}$
 - t : time required for the liquid head of the manometer to descend from mark B to mark C when the sample is used as the bed (s)
 - t_0 : time required for the liquid head of the manometer to descend from mark B to mark C when the reference material for specific surface area test is used as the bed (s)

For specific surface area, calculate the mean value of two consecutive measurements that are equal with the difference of within 2 %, and round the result to the second place of integer.

When the density of the reference material for specific surface area test used is 3.15 g/cm³ and the porosity of the bed is 0.500, the calculation may be carried out according to the following equations.

- a) Ordinary portland cement:

$$S = S_0 T$$

- b) High-early-strength portland cement:

$$S = 1.115 S_0 T$$

- c) Ultra high-early-strength portland cement:

$$S = 1.236 S_0 T$$

- d) Moderate heat portland cement and sulfate-resisting portland cement:

$$S = 0.984S_0T$$

- e) Low heat portland cement:

$$S = 1.081S_0T$$

- f) Ordinary ecocement:

$$S = 1.105S_0T$$

- g) Portland blast-furnace slag cement, portland pozzolan cement and portland fly-ash cement:

$$S = 3.310 \frac{S_0}{\rho} T$$

8.2 Wire sieve test

8.2.1 Wire sieve

A test sieve of metal wire cloth with 90 µm aperture size specified in **JIS Z 8801-1** shall be used, together with a sieve frame with a desired diameter of 200 mm or 150 mm.

8.2.2 Procedure

Weigh about 50 g of the sample into the sieve correctly to the nearest 0.05 g. Gently swirl the sieve to allow fine particles to pass through, and then pat the sieve frame with a hand at a rate of 150 times per minute, rotating the sieve 1/6 every 25 taps. Break the lumps with fingers by lightly rubbing against the sieve frame. Stop sieving when the amount passing through the sieve per minute is 0.1 g or under, and weigh the residue on the sieve to the nearest 0.05 g.

Mechanical sieving is permissible, provided that the last 1 min of sieving to determine the end point is performed by hand.

8.2.3 Calculation

The residue on the wire sieve shall be calculated from the following equation and the result rounded to one decimal place.

$$f = \frac{m_2}{m_1} \times 100$$

where, f : sample residue on the wire sieve (%)
 m_2 : mass of the residue on the sieve (g)
 m_1 : mass of the sample weighed out (g)

9 Setting time test

9.1 Test method

The setting time test shall be carried out using either the method specified in **9.2** to **9.4** or that specified in Annex A. If the method in Annex A has been used, it shall be so stated in the test results report.

9.2 Apparatus

9.2.1 Vicat needle apparatus

The Vicat needle apparatus shall be as follows (see Figure 3).

a) Main body

1) Graduation accuracy of scale plate

The scale shall allow measurement of the distance, 1 mm and 39 mm, between the end of the standard needle for initial set and the base-plate of the Vicat mould, and the distance, 6 mm, between the end of the standard plunger and the base-plate with an accuracy of ± 0.25 mm.

2) Mass of the sliding rod: (265.0 ± 0.5) g

b) Standard plunger

1) Diameter: (10.0 ± 0.2) mm

2) Mass: (35.0 ± 0.5) g

c) Standard needle

1) Standard needle for initial set

1.1) Diameter: (1.13 ± 0.05) mm

1.2) Mass: (7.0 ± 0.2) g

2) Standard needle for final set

2.1) Diameter: (1.13 ± 0.05) mm

2.2) Diameter of the ring attachment: (3.0 ± 0.2) mm

2.3) Protruding length from the ring: (0.30 ± 0.05) mm

2.4) Mass: (7.0 ± 0.2) g

d) Vicat mould (see Figure 4)

1) Inner diameter of the upper brim: (75 ± 3) mm

2) Inner diameter of the lower brim: (85 ± 3) mm

3) Height: (40.0 ± 0.5) mm

The Vicat mould shall be impermeable and shall not react with cement paste. The base-plate shall be a glass plate which does not react with cement paste, larger in size than the brim of the mould and of an appropriate thickness. The mould shall be brought into close contact with the base-plate using grease etc. so as to prevent water leakage.

e) Disc

1) Weight to correct the mass of the standard plunger and the standard needle for initial set or final set: (28.0 ± 0.2) g

When the amount of water required for standard consistence is determined, the standard plunger shall be attached to the sliding rod. For determination of initial and final setting times, the disc shall be put on the sliding rod and the standard needle for initial or final set shall be attached to the sliding rod. In any case, the total mass of all of the descending parts shall be (300.0 ± 1.0) g.

9.2.2 Automatic measuring apparatus

The automatic measuring apparatus used for the determination of initial and final setting time shall satisfy all the following requirements.

- a) Like the Vicat needle apparatus, the automatic measuring apparatus shall have the descending parts to which the standard needle for initial set specified in 9.2.1 c) is attached and of which the total mass is (300.0 ± 1.0) g.
- b) The automatic measuring equipment shall be able to automatically penetrate its descending parts into the cement paste and record the starting time of each descent of the needle and the distance between the end of the needle and the base-plate.

9.2.3 Mixer for mechanical mixing

The mixer for mechanical mixing shall be as follows (see Figure 5).

- a) **Body** The body of the mixer shall be of a motorized type which can give the mixing blade rotation and revolution in reverse direction to the rotation and the speed of which can be shifted between low speed [rotation: (140 ± 5) rpm, revolution: (62 ± 5) rpm] and high speed [rotation: (285 ± 10) rpm, revolution: (125 ± 10) rpm].
- b) **Mixing blade** The mixing blade shall be made of stainless steel or iron having a smooth surface and shall allow easy detachment.

The mixing blade shall be positioned such that when it is brought closest to the mixing bowl set at the mixing position, its outline is parallel to the inner wall of the bowl and is (3 ± 1) mm away from the inner wall.

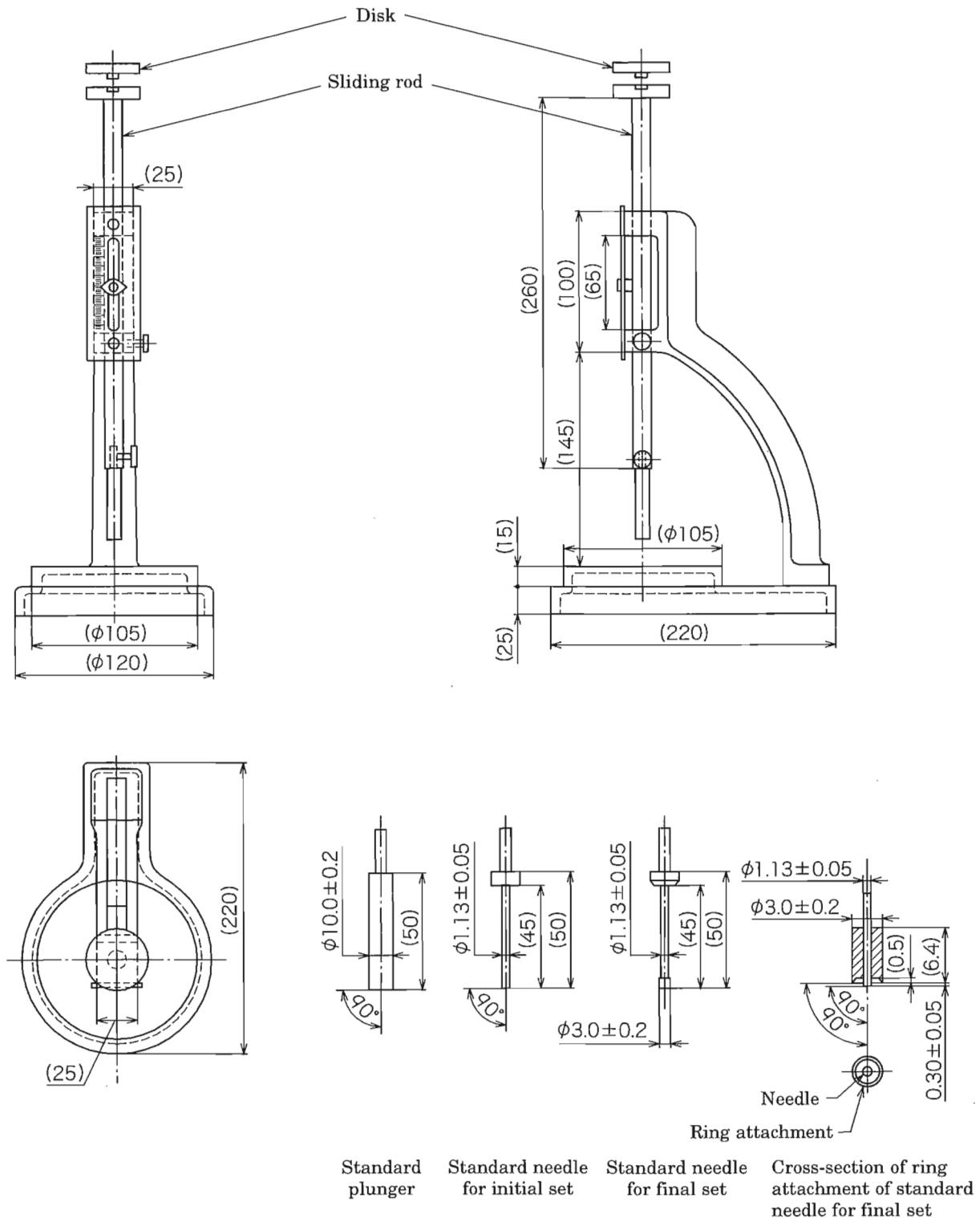
- c) **Bowl** The bowl, made of stainless steel or iron, shall be fixed at a given position on the body during the mixing operation.

9.2.4 Mixing apparatus for hand mixing

The mixing apparatus for hand mixing shall consist of a bowl and a spoon (see Figure 6).

- a) The bowl and the head of the spoon for mixing shall be made of stainless steel or iron.
- b) The upper brim of the bowl shall be curled.
- c) The inner surface of the bowl and the spoon shall be finished to such a degree that cement paste will not adhere to it.

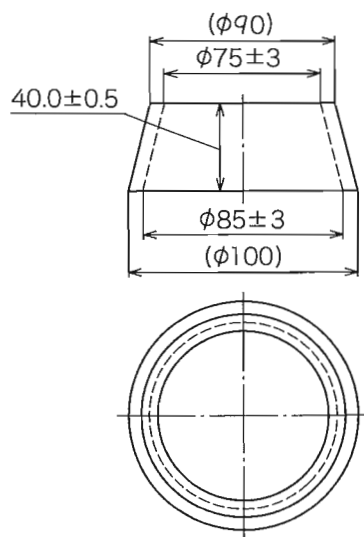
Unit: mm



Numbers in parentheses are informative values.

Figure 3 Vicat needle apparatus

Unit: mm



Numbers in parentheses are informative values.

Figure 4 Vicat mould

Unit: mm

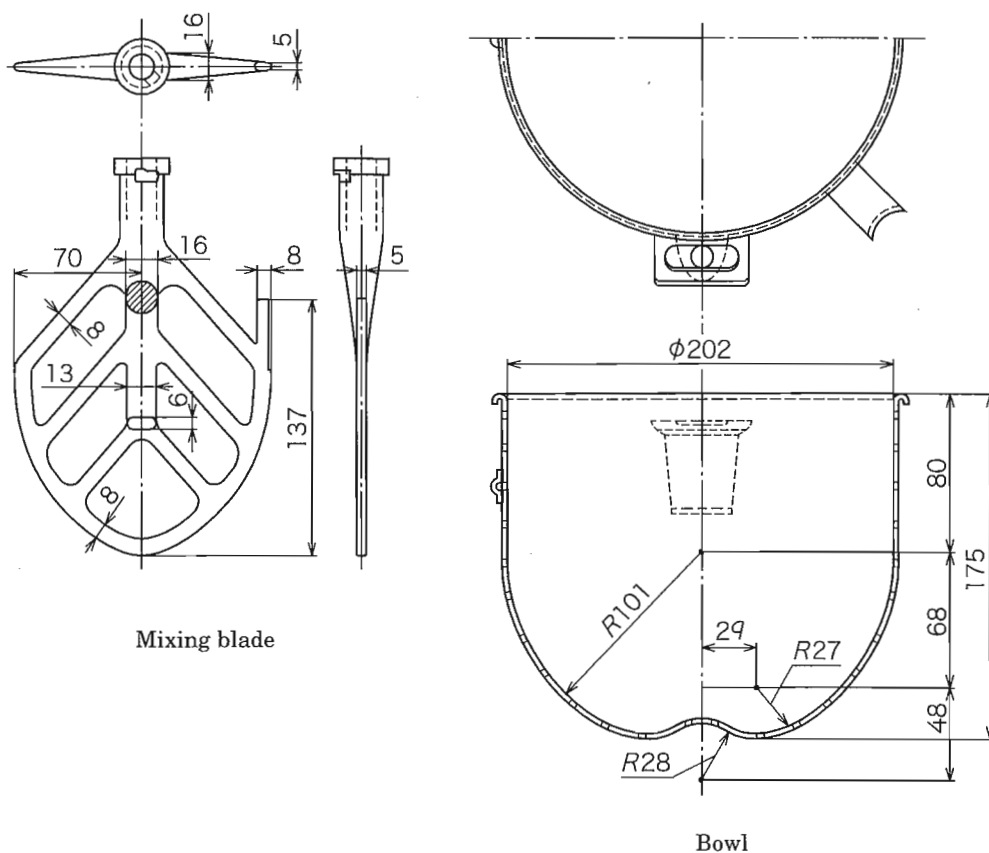


Figure 5 Example of mixing blade and bowl of mixer for mechanical mixing

Unit: mm

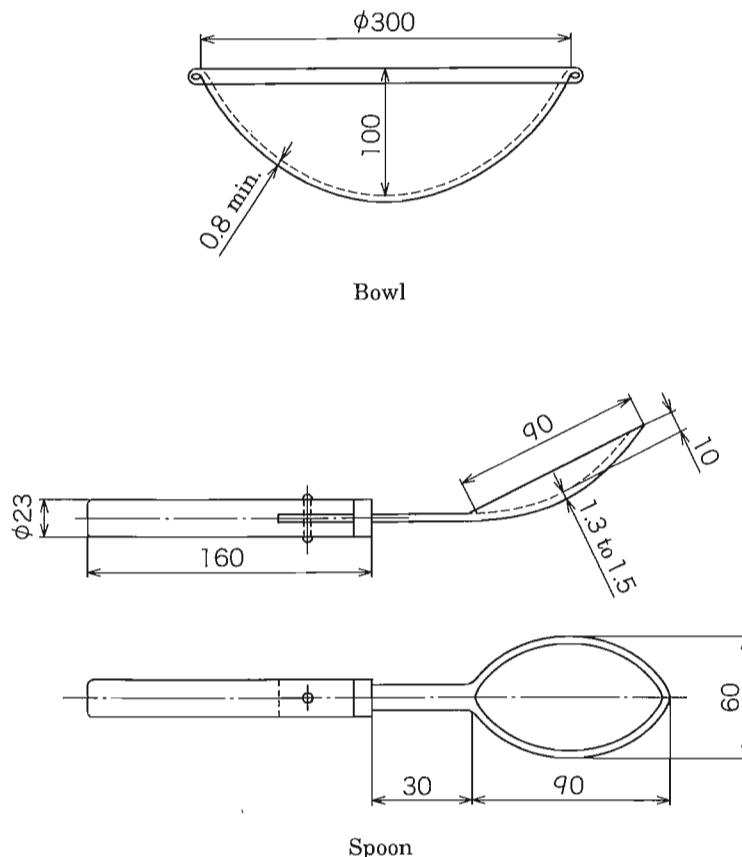


Figure 6 Example of bowl and spoon for hand mixing

9.3 Temperature and humidity

The laboratory where testing is performed shall be maintained at a temperature of $(20 \pm 2) ^\circ\text{C}$ and relative humidity of not less than 50 %. The humidity cabinet for storage of sample contained in a Vicat mould shall be maintained at a temperature of $(20.0 \pm 1.0) ^\circ\text{C}$ and a relative humidity of not less than 90 %.

The apparatus shall be at the laboratory temperature.

9.4 Procedure

9.4.1 Mixing the cement paste

Cement paste shall be basically mixed by mechanical means. Only where mechanical mixing is impracticable, manual mixing may be performed.

a) **Mixing by mechanical means** Use the mixer specified in 9.2.3.

Weigh (500 ± 1) g of sample into the bowl and pour the amount of water considered to be necessary to attain the standard consistence. Immediately start the mixer at low speed and mix for 60 s. Note the time at which the mixer is started as the mixing start time. After 60 s, stop the mixer for 30 s, during which time detach, by means of a suitable spoon or scraper, all the paste adhering to the inner wall of the bowl and the blade and place it in the middle of the bowl.

Restart the mixer and run at high speed for a further 90 s.

- b) **Mixing by hand** Use the bowl and spoon specified in 9.2.4.

Weigh (400 ± 1) g of sample into the bowl and pour the amount of water considered to be necessary to attain the standard consistence and immediately mix thoroughly by spoon for 3 min. Note the time at which the hand mixing is started as the mixing start time.

9.4.2 Preparation of cement paste of standard consistence

Put the mixed cement paste in a Vicat mould within 60 s after mixing, remove the excess cement paste and level off the surface. Set this mould to the Vicat needle apparatus, gently lower the standard plunger attached to the sliding rod until it is in contact with the paste, and after pausing in that position for about 1 s or 2 s, gradually lower the plunger. Read the scale, which indicates the distance between the end of the plunger and the base-plate, at least 5 s after the descent of the plunger has ceased or 30 s after the release of the plunger, whichever is the earlier.

Cement paste of standard consistence is obtained when this distance is (6 ± 1) mm. The amount of water used at this time shall be taken as the amount of water required for standard consistence, and expressed in percentage to the mass of cement by rounding off to one decimal place.

9.4.3 Determination of initial and final setting times

The determination of initial and final setting times shall be carried out using the cement paste of standard consistence. Level off the surface of the cement paste of standard consistence contained in the mould, and determine the initial setting time according to a) and the final setting time according to b). Between measurements, store the mould containing the sample in a humidity cabinet.

In addition, for the determination of initial and final setting times, the automatic measuring apparatus specified in 9.2.2 may be used.

- a) **Determination of initial setting time** Set the standard needle for initial set to the Vicat needle apparatus, put a disc on the upper end of the sliding rod, and adjust the total mass of the descending parts to (300.0 ± 1.0) g. Lower the needle gradually from around the surface of the cement paste and allow it to penetrate into the cement paste. Read the scale, which indicates the distance between the end of the needle and the base-plate either at the point where the needle has stopped the descent or at 30 s after the start of the descent, whichever is earlier. Initial set is attained when the end of the needle stops at a distance of 1 mm above the upper face of the base-plate. Note the time from the start of mixing to the initial set as the initial setting time. The initial setting time shall be rounded off to the nearest 5 min.

NOTE 1 The position of penetration of the needle should be changed appropriately each time so that valid test results can be obtained.

- b) **Determination of final setting time** Perform procedures described in 1) and 2) in the following.
- 1) **Method using the standard needle for final set** Set the standard needle for final set to the Vicat needle apparatus, put a disc on the upper end of the sliding rod, and adjust the total mass of the descending parts to (300.0 ± 1.0) g. Lower the needle gradually from around the surface of the cement paste and allow it to

penetrate into the cement paste. Final set is attained when the needle penetration leaves a mark, but the ring attachment fails to mark the paste. Note the time from the start of mixing to the final set as the final setting time. If a crust has formed on the surface of the cement paste, which may make the determination of final set difficult, final setting time should be measured on the bottom surface of the paste by removing the base-plate. The final setting time shall be rounded off to the nearest 5 min.

NOTE 2 The position of penetration should be changed each time so that the marks of the ring attachment do not overlap with each other.

- 2) **Method using the standard needle for initial set** Like the determination of initial setting time, adjust the total mass of the descending parts to (300.0 ± 1.0) g, and gradually lower the needle for initial set from around the surface of the cement paste to allow it to penetrate into the cement paste at 5 min intervals. Read the scale, which indicates the distance between the end of the needle and the base-plate either at the point where the needle has stopped the descent or at 30 s after the start of the descent, whichever is earlier, to the nearest 0.5 mm, and record this result for every 5 min. Final set is attained when the distance between the end of the needle and the base-plate stays unchanged in three consecutive descents of the needle. Note the time from the start of mixing to the final set as the final setting time. The final setting time shall be rounded off to the nearest 5 min.

If, at a point near the final set where the distance between the needle and the base-plate is 38 mm or more, this distance is found to be reduced by 1 mm or more from the last measurement due to influence of air bubbles or the like, discard this result and record the mean of the distances noted before and after this measurement. In the case where this occurs twice or more consecutively, repeat the determination.

NOTE 3 The position of penetration of the needle should be changed appropriately each time so that valid test results can be obtained.

NOTE 4 Normally, final set is attained around the time when the distance between the end of the needle for initial set and the base-plate is near 39 mm.

10 Soundness test

10.1 Test method

The soundness test shall be carried out using either the pat method specified in 10.2 to 10.6 or the Le Chatelier method specified in Annex B.

10.2 Apparatus

The apparatus specified in 9.2.3 or 9.2.4 shall be used.

10.3 Temperature and humidity

The laboratory where testing is performed shall be maintained at a temperature of (20 ± 2) °C and relative humidity of not less than 50 %. The humidity cabinet for storage of the pats shall be maintained at a temperature of (20 ± 1) °C and a relative humidity of not less than 90 %.

The apparatus shall be at the laboratory temperature.

10.4 Preparation of pats of cement

Prepare a cement paste of standard consistence according to the method specified in 9.4.1. Take an appropriate amount of this paste on a glass plate of about 130 mm square, and using a suitable scraper, smooth the paste from the periphery toward the centre so as to obtain a round pat about 100 mm in diameter which is thickest (about 15 mm) at the centre, and becomes thinner towards its circumference. Immediately after preparation, place the pats in the humidity cabinet specified in 10.3 and leave for (24 ± 1) h.

10.5 Procedure

Immerse the two pats of cement, which have been cured according to the above procedure, on the glass plates in a scalding filled with water, heat gradually and boil for 90 min. After allowing them to cool naturally, remove from the scalding, and examine for cracks or distortions due to expansion.

10.6 Expression of measurement results

The cement shall be evaluated as “sound” if the two pats did not show cracking or distortion, and “not sound” if they did. If one of the two pats is evaluated as “sound” and the other as “not sound”, repeat the test.

11 Strength test

11.1 Test method

The strength test shall be carried out using either the method specified in 11.2 to 11.7 or that specified in Annex C. If the method in Annex C has been used, it shall be so stated in the test results report.

11.2 Apparatus

11.2.1 Mixer

The mixer specified in 9.2.3 shall be used.

11.2.2 Mould for mortar specimen

The mould for mortar specimen shall be as given in the following (see Figure 7).

- a) The mould shall be a three gang mould which consists of three compartments so that three prismatic specimens can be prepared simultaneously.
- b) The mould shall consist of a frame and a base-plate. The frame shall consist of end frames and partition frames.
- c) The material of parts of the frame shall be steel, and that of the base-plate shall be cast iron.
- d) The tolerance on the flatness of the faces of the frame to be in contact with mortar shall be 0.03 mm. The surface of the frame and upper surface of the base-plate shall be finished by polishing, and the joints of the partition frames and the end frames shall be finished by grinding.

e) The dimensions of the mould shall be as follows.

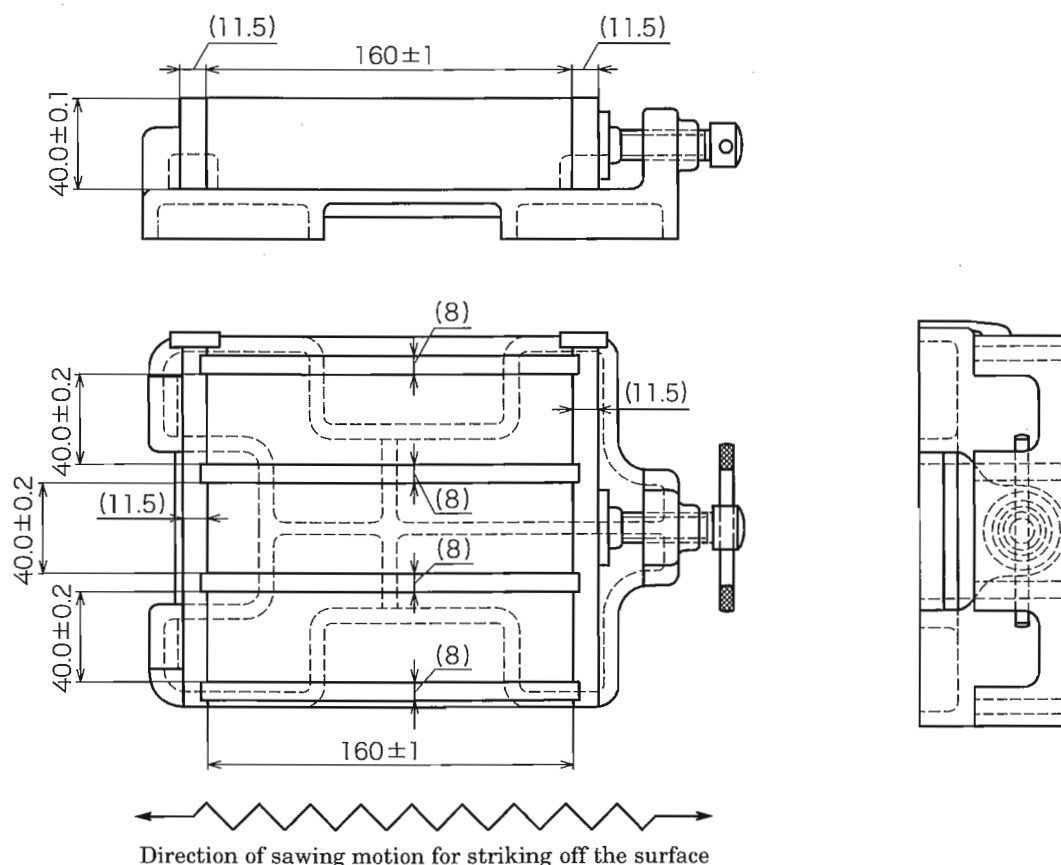
- 1) Distance between the two end frames: (160 ± 1) mm
- 2) Height of the end frames: (40.0 ± 0.1) mm
- 3) Height of the partition frames: (40.0 ± 0.1) mm
- 4) Distance between partition frames: (40.0 ± 0.2) mm

Where other dimensions are in conformance but only the height of the frames fails to satisfy the tolerance, the use of that mould is permissible provided that the height is (40.0 ± 0.2) mm, in which case, the compression area shall be calculated using the loading area of the specimen which is obtained by the actually measured value ($40.0 \times$ the actually measured value of the frame height). However, when the loading face is a square platen, correction shall be made only when the frame height of the mould is 39.9 mm to 39.8 mm.

- f) The frame clamp for the base-plate and the support for the fastening bolt shall generally be manufactured integrally with the base-plate, but it is permissible that they are attached to the base-plate after surface finishing of the base-plate.
- g) The end of the fastening bolt shall be attached using a socket joint and have a structure not to be rotated when it is fastened.
- h) The core of the fastening bolt shall be so constructed that it pushes the frame perpendicularly.
- i) The base-plate shall have ribs on its lower surface. The lower surfaces of the ribs shall be so finished as to prevent jolting.
- j) The structure of the mould shall be such that the upper surface of the base-plate and that of the frame after assembling are horizontal.
- k) The longitudinal and lateral clamps shall be at right angles with each other as well as with the upper surface of the base-plate.
- l) The width of the slots on both end frames and the inserting portions of the partition frames shall be such that the end frame and partition frame can be fitted together in good contact.
- m) The mould frame shall be fastened after applying grease etc. to prevent water leakage.

To facilitate the filling of the mould, a metal hopper with vertical walls having a suitable height may be provided. The hopper inner walls shall be vertical and overlap the inner walls of the mould.

Unit: mm



Numbers in parentheses are informative values.

Figure 7 Mould for mortar specimen

11.2.3 Compaction equipment

For compaction equipment, a vibrating table conforming to the requirements in **C.10.3** shall be used. The following is an example of vibrating table specifications validated to be in conformance with the requirements.

- The vibrating table shall consist of a vibration table (table, vibrating motor and clamps for attaching the mould), and a base.
- The speed of rotation of the vibrating motor shall be $(2\,800 \pm 50)$ rpm.
- The table, clamps for mould and base shall be made of steel or cast iron.
- The amplitude of the vibration table shall be (0.80 ± 0.05) mm.
- The mass of the vibration table shall be 90 kg or over.
- The top face of the vibration table shall be horizontal.
- The clamps shall be used to fix the Vicat mould, and shall not loosen during vibration of the table.

11.2.4 Compressive strength testing machine

The compressive strength testing machine shall be at least that of Grade 1 specified in **JIS B 7721**.

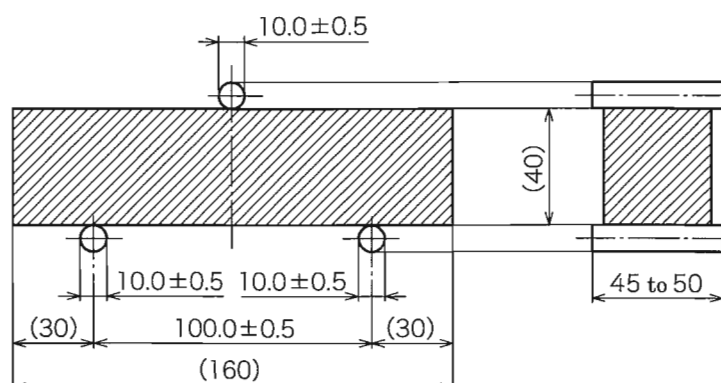
- a) It shall provide a rate of load increase of $(2\,400 \pm 200)$ N/s.
- b) The compression platens shall be provided with spherical seating, which serves to keep the compression surfaces of the upper and lower platens parallel to each other during loading. The diameter of the spherical seating shall not exceed 120 mm.
- c) The compression platens or loading plates shall be capable of correctly applying a load over the specimen area of (40.0 ± 0.1) mm $\times$ (40.0 ± 0.1) mm.
- d) The flatness tolerance for the loading surface of the compression platens or the loading plates shall be 0.01 mm.
- e) The material of the loading plates shall be quenched high carbon steel finished by polishing, which is HS 70 or over in Shore hardness.

11.2.5 Flexural strength testing machine

The flexural strength testing machine shall be as follows.

- a) The machine shall be capable of applying a load up to 10 kN at a rate of (50 ± 10) N/s with an accuracy of $\pm 1\%$ in the range from the 1/5 of the selected upper limit load to the upper limit load.
- b) The material of the loading roller and the supporting rollers shall be quenched high carbon steel which is HS 70 or over in Shore hardness.
- c) The dimensions and arrangement of the loading and supporting rollers shall be as follows (see Figure 8).
 - 1) Diameter of the loading roller: (10.0 ± 0.5) mm
 - 2) Diameter of the supporting rollers: (10.0 ± 0.5) mm
 - 3) Centre-to-centre distance between the supporting rollers: (100.0 ± 0.5) mm
 - 4) Length of the supporting rollers: 45 mm to 50 mm
- d) The loading roller and the supporting rollers shall be parallel to each other, and the loading roller shall be located centrally between the right and left supporting rollers.

Unit: mm



Numbers in parentheses are informative values.

Figure 8 Arrangement of loading for determination of flexural strength

11.3 Standard sand

The standard sand shall be used for making mortar specimens for strength testing.

The standard sand shall be in conformance with the requirements in **C.4.1.3**, and prepared by washing the natural siliceous sand with water and drying to a moisture content of less than 0.2 %. Its particle size distribution shall fall within the limits shown in the following.

- Residue on test sieve of aperture size 2 mm: 0 %
- Residue on test sieve of aperture size 1.6 mm: $(7 \pm 5) \%$
- Residue on test sieve of aperture size 1 mm: $(33 \pm 5) \%$
- Residue on test sieve of aperture size 500 μm : $(67 \pm 5) \%$
- Residue on test sieve of aperture size 160 μm : $(87 \pm 5) \%$
- Residue on test sieve of aperture size 80 μm : $(99 \pm 1) \%$

11.4 Temperature and humidity

The laboratory in which moulding of specimens is performed shall be maintained at a temperature of $(20 \pm 2) ^\circ\text{C}$ and relative humidity of not less than 50 %. The humidity cabinet for storage of the specimens in the mould shall be maintained at a temperature of $(20.0 \pm 1.0) ^\circ\text{C}$ and relative humidity of not less than 90 %. The temperature of water in the storage container in which the specimens are cured shall be maintained at $(20.0 \pm 1.0) ^\circ\text{C}$.

The apparatus and standard sand shall be at the temperature of the laboratory in which the specimen will be moulded.

11.5 Preparation of test specimens

11.5.1 Mortar constituents

The proportions of mortar by mass shall be one part of the cement, three parts of standard sand, and one-half part of water. One batch of mortar shall consist of the following amounts of cement, standard sand and water. Water may be measured by volume $(225 \pm 1) \text{ ml}$.

One batch can produce three specimens.

- a) Cement (450 ± 2) g
- b) Standard sand ($1\,350 \pm 5$) g
- c) Water (225 ± 1) g

11.5.2 Mixing of mortar

Mix each batch of mortar mechanically using the mixer specified in 9.2.3. Pour the specified amount of water into the mixing bowl and add the cement. Then immediately start the mixer at the low speed [rotation: (140 ± 5) rpm, planetary movement: (62 ± 5) rpm] taking the start of the mixer as the mixing start time. After 30 s of mixing, add the specified amount of standard sand steadily during the next 30 s. Switch the mixer to the high speed [rotation: (285 ± 10) rpm, planetary movement: (125 ± 10) rpm] and continue the mixing for an additional 30 s. Stop the mixer for 90 s. During the first 30 s, remove, by means of a suitable spoon or a scraper, the mortar adhering to the wall of the bowl and blade and place it in the middle of the bowl. Restart the mixer and run at high speed for a further 60 s. The mixing time is 4 min including the stopping time.

When mixing in a mixer is complete, remove the mixing bowl from the mixer, and stir the mortar 10 times with a suitable spoon.

11.5.3 Moulding

Mould the specimens immediately after the preparation of the mortar. Using a vibrating table, place mortar in the mould in two layers. The vibrating table shall be continuously operated during moulding without any stop. The total vibrating time shall be (120 ± 1) s.

The mould for mortar specimen, with the hopper mounted, shall be fixed to the vibrating table before the test.

Start the vibrating table and place the first layer of mortar to half the height of the mould using a spoon during the first 15 s. After 15 s interval, gather up the rest of the mortar with a spoon and place in the mould in the same sequence as the first layer was placed, and vibrate the mortar for a further 75 s.

When the vibrating compaction is complete, lift the mould gently from the vibrating table. Immediately remove the hopper from the mould, and strike off the excess mortar to level the surface, with the metal straightedge (see Figure 9) held almost vertically and moved slowly, with a transverse sawing motion (see Figure 7) once in each direction. Smooth the surface of specimens once using the same straightedge held almost flat without pushing the mortar.

Place a plate glass, approximately 190 mm × 160 mm in size and approximately 6 mm in thickness on the mould. A plate of steel or other impermeable material of similar size may be used. Place each covered mould, suitably identified, in the humidity cabinet.

Carry out demoulding with precautions for tests at ages between 20 h and 24 h after moulding and mark specimens. Submerge the marked specimens in the water in the storage containers without delay in a convenient manner horizontally or vertically.

Carry out demoulding, for specimens of 1-day age, within 20 min before the test, and cover the specimens with a damp cloth until tested. During storage of the specimens, replacement of more than 50 % of water in the storage containers is not permitted. When a circulation system for controlling water temperature is used, a visible flow shall not be produced.

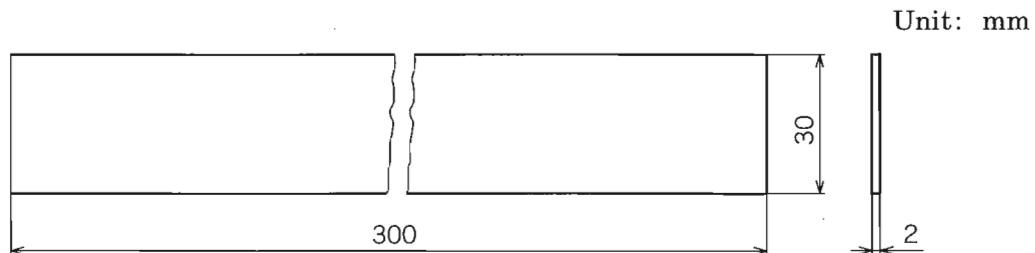


Figure 9 Example of metal straightedge

11.6 Measurement

The flexural strength test shall be carried out on three specimens prepared in accordance with 11.5.

The compressive strength test shall be carried out on halves of three prism specimens broken either in the flexural strength test or using other suitable means that do not subject the prism halves to harmful stresses. The compressive test may be carried out using whole (unbroken) specimens on their both ends. In this case, however, loading positions on one specimen should be sufficiently apart from each other.

NOTE : Breaking a specimen in half should be performed by the three points loading as shown in Figure 8.

The age of the specimen is based on starting time of mixing of cement and water.

The strength tests at different ages shall be carried out within the following limits:

- a) 1 day of age: 24 h $\pm$ 15 min;
- b) 3 days of age: 72 h $\pm$ 45 min;
- c) 7 days of age: 7 d $\pm$ 2 h;
- d) 28 days of age: 28 d $\pm$ 8 h;
- e) 91 days of age: 91 d $\pm$ 8 h.

For the flexural strength test, immediately after taking out the specimens from water, place the specimens in the apparatus with one side face on the supporting rollers and with its longitudinal axis normal to the supporting rollers. Apply the load vertically to centre of the opposite side face of the prism and increase it smoothly at the rate of (50 $\pm$ 10) N/s and obtain the maximum load before fracture (see Figure 8).

For the compressive strength test, apply a load on the centre of both side faces of the prism half at the rate of (2 400 $\pm$ 200) N/s by means of the loading plates, and obtain the maximum load before fracture.

11.7 Calculation

11.7.1 Compressive strength test

The compressive strength shall be calculated from the following equation using the maximum load determined in **11.6**, and be rounded off to one decimal place.

$$c = \frac{w}{1600}$$

where, c : compressive strength (N/mm²)
 w : maximum load (N)

Calculate the compressive strength test result as the arithmetic mean of the six individual results, each rounded to one decimal place, obtained from a determination made on a set of three prisms. If one result within the six individual results varies by more than $\pm 10\%$ 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 $\pm 10\%$ from their mean, discard the set of results and repeat the determination.

11.7.2 Flexural strength test

The flexural strength shall be calculated from the following equation using the maximum load determined in **11.6**, and be rounded off to one decimal place.

$$b = w \times 0.00234$$

where, b : flexural strength (N/mm²)
 w : maximum load (N)

Calculate the flexural strength test result as the arithmetic mean of the three individual results, each rounded to one decimal place, obtained from a determination made on a set of three prisms.

12 Flow test

12.1 Apparatus

The flow table, flow cone and tamping rod shall be as follows (see Figures 10 and 11).

The apparatus shall be at the laboratory temperature.

- a) The material of the flow table, supports and flow cone shall be cast iron and that of the vertical spindle shall be mild steel. The material of the vertical spindle roll and cam shall be quenched high carbon steel which is HS 70 or over in Shore hardness.
- b) The dimensions of the flow table and flow cone shall be as follows. The mass of the table (including the vertical spindle) shall be $(8\,600 \pm 30)$ g.
 - 1) Diameter of the table: (300 ± 1) mm
 - 2) Diameter of the vertical spindle: (24 ± 1) mm
 - 3) Length of the vertical spindle: (103 ± 2) mm
 - 4) Outside diameter of the vertical spindle roll: (22.0 ± 0.5) mm
 - 5) Diameter of the vertical spindle roll: (10.0 ± 0.5) mm

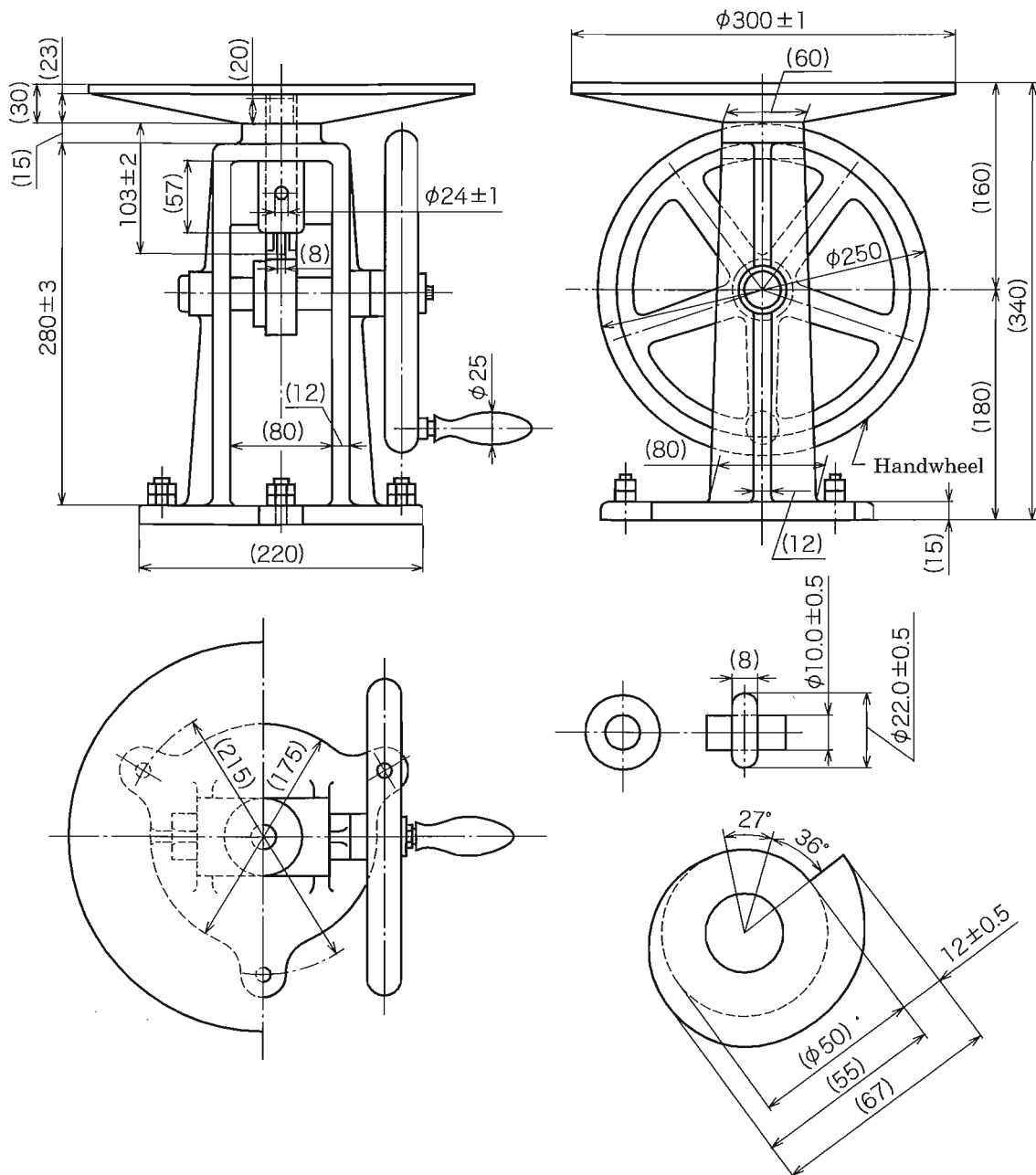
- 6) Eccentricity of the cam: (12.0 ± 0.5) mm
- 7) Fall of the table: (10.0 ± 0.5) mm
- 8) Height of the support: (280 ± 3) mm
- 9) Inside diameter of the cone at the top: (70.0 ± 0.5) mm
- 10) Inside diameter of the cone at the bottom: (100.0 ± 0.5) mm
- 11) Height of the cone: (60.0 ± 0.5) mm
- c) The upper surface of the flow table and the bottom surface of the flow cone shall be ground to ensure close contact with each other, and the vertical spindle shall be finished by polishing.
- d) The upper surface of the flow table shall be engraved with four tangential lines to a circle representing the cone periphery when the flow cone is installed on the table, for the purpose of marking the correct position for placing the cone.
- e) The lower surface of the flow table and the upper surface of the support shall be in close contact with each other.
- f) The vertical spindle shall be so fitted with the table as not to separate easily, and the upper surface of the flow table shall be at right angles to the vertical spindle.
- g) The shape of the cam shall be such that it has an effective contact angle of 270° while increasing its radius by 1 mm for every increase of 27° starting from 36° .
- h) The handwheel of 250 mm in outside diameter and the grip of 25 mm in outside diameter shall be used.
- i) The flow table shall be fixed to a concrete foundation of 150 kg or over with the foundation bolts for installation so that the table and the concrete foundation are integral (see Figure 10).
- j) The material of the tamping rod shall be mild steel.
- k) The dimensions and mass of the tamping rod shall be as follows:
 - 1) diameter: (20 ± 1) mm;
 - 2) mass: (500 ± 3) g.
- l) The bottom surface of the tamping rod shall be at right angles to its side face.
- m) The tamping end portion of the tamping rod shall be finished by polishing, and the grip shall be of non-slip finish.

12.2 Measurement of flow value

Place the mortar, which has been mixed according to the proportion and mixing method specified in 11.5, in two layers in the flow cone placed correctly at the centre of the flow table which has been wiped carefully with dry cloths. Tamp each layer 15 times all over the surface so that the end of the tamping rod will sink approximately $1/2$ of the depth of that layer, and after supplementing the mortar if necessary, smooth the surface. Immediately after completion of filling, remove the cone by lifting it vertically, and give the mortar 15 times of dropping motion during 15 s. Measure, to the nearest

1 mm, the largest diameter of the resulting spread of the mortar and the diameter at right angles thereto. Express the result by the arithmetic mean of the obtained measurements as a unitless integer in millimetres. Record the flow value as the mean of the two test results, expressing the mean by a unitless integer.

Unit: mm

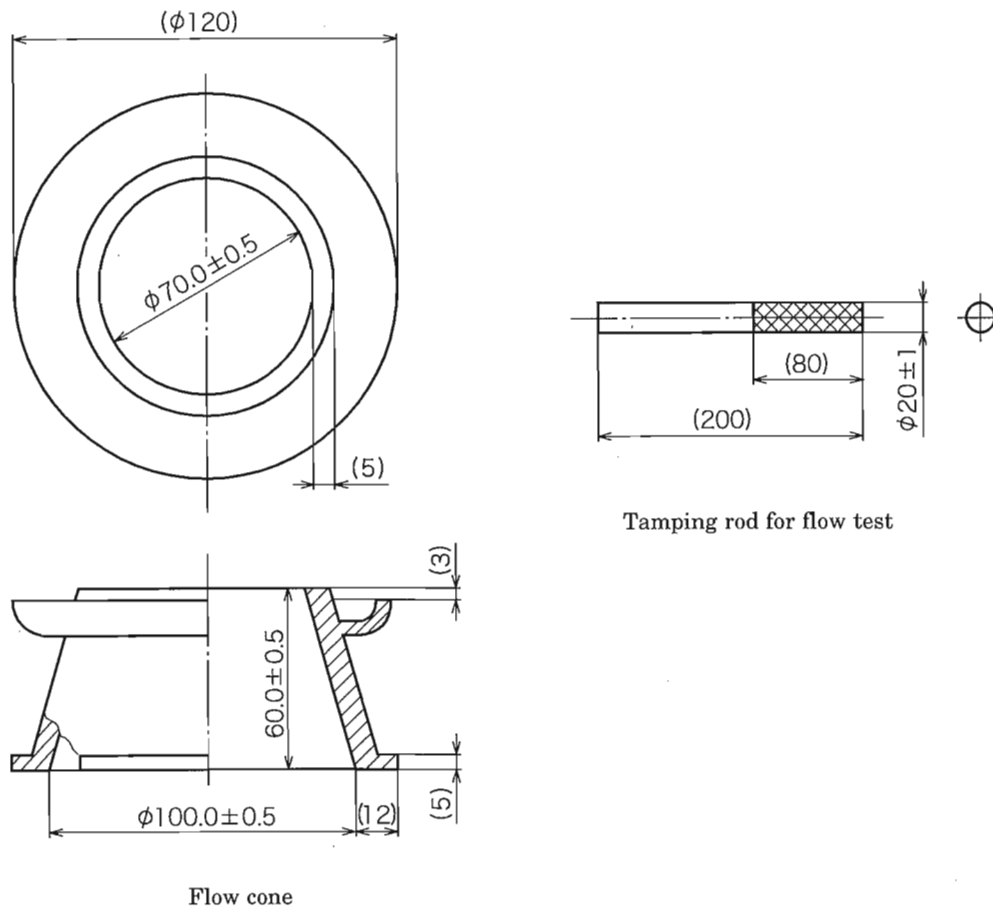


Roll and cam of vertical spindle

Numbers in parentheses are informative values.

Figure 10 Flow table

Unit: mm



Numbers in parentheses are informative values.

Figure 11 Flow cone and tamping rod

Annex A (normative)

Setting time test

A.1 General

This Annex has been prepared based on the setting time test given in **ISO 9597**, except that the reported test results shall be corrected for ensuring equivalency to the corresponding test method given in the main body. For the test temperature, the standard temperature given in **ISO 9597** is adopted which is suitable for the climatic condition in Japan.

This Annex specifies the method for preparation of cement paste of standard consistence and the method for determination of setting time.

This test method is applicable to general-purpose cement, and other cement or substances and standards for which this test method is cited. This method is not applicable to cement types that have a very short initial setting time. This method is used for evaluation of conformance of the setting time of a cement to the specification.

This Annex describes the reference methods and allows the use of alternative procedures and equipment, provided that they have been validated as equivalent to the reference methods.

A.2 Principle

Cement paste of standard consistence has a specified resistance to penetration by a standard plunger. The water required for such a paste is determined by trial penetrations of pastes with different water contents.

The setting time is determined by observing the penetration of a needle into cement paste of standard consistence until it reaches a specified value.

A.3 Laboratory, equipment and materials

A.3.1 Laboratory

The laboratory in which preparation of samples and testing are performed shall be maintained at a temperature of (20 ± 2) °C and relative humidity of not less than 50 %.

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 cement, water, and apparatus used for the test shall be at the laboratory temperature.

NOTE : For condition of storage applied to the alternative setting time test method, see Annex AA.

Where temperature ranges are given, the target temperature at which the controls are set shall be the middle value of the range.