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FOREWORD

This Standard has been prepared to replace the various parts and editions of BS1881 hitherto used, which are not entirely suitable for Hong Kong conditions. It provides methods for sampling and testing concrete and it covers the procedures to be adopted both on site and in the laboratory.

The contents of the Standard are based primarily on the following British Standards, with modifications to suit local conditions and practices:

BS 1881 : Part 1 to 6 :1970
BS 1881 : Part 101 : 1983
BS 1881 : Part 102 : 1983
BS 1881 : Part 103 : 1983
BS 1881 : Part 104 : 1983
BS 1881 : Part 106 : 1983
BS 1881 : Part 107 : 1983
BS 1881 : Part 108 : 1983
BS 1881 : Part 109 : 1983
BS 1881 : Part 110 : 1983
BS 1881 : Part 111 : 1983
BS 1881 : Part 114 : 1983
BS 1881 : Part 115 : 1986
BS 1881 : Part 116 : 1983
BS 1881 : Part 117 : 1983
BS 1881 : Part 118 : 1983
BS 1881 : Part 120 : 1983
BS 1881 : Part 121 : 1983
BS 1881 : Part 124 : 1983
BS 1881 : Part 125 : 1986

The Standard comprises two volumes. Volume 1 generally covers site operations, including methods of sampling fresh concrete, testing of fresh concrete and making and curing test specimens. Volume 2 is intended to be used by laboratory staff and covers sampling of fresh concrete in the laboratory, methods of determining the physical properties of hardened concrete and the sampling and chemical analysis of hardened concrete. This division of the contents is purely for convenience and has no other implications.

The permission of the British Standards Institution to reproduce and modify its publications is gratefully acknowledged.

Any comments on the contents of this Standard should be addressed to the Chairman, Standing Committee on Concrete Technology, Works Branch, Hong Kong Government.

DRAFTING COMMITTEE

The preparation of this Standard was undertaken by a sub-committee of the Hong Kong Government, Works Branch, Standing Committee on Concrete Technology. The organisations represented on the sub-committee and the names of the persons who contributed to the drafting of the Standard are listed below:

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GENERAL NOTES

The following notes are relevant, where applicable, to all the sections of this Standard.

1. Reports

(a) It is a mandatory requirement for all reports to contain the name and signature of the person responsible for the sampling or the test. The person responsible for the test is not necessarily the same as the person actually carrying out the test. For HOKLAS accredited laboratories the person responsible should be an authorised signatory.

(b) The person responsible for the test must ensure that all the information listed for the inclusion in a Report is fully and accurately stated. However, some of the information listed for inclusion in a Report may not be known to the person responsible for the test. In such a case the words `not known' should be entered in the Report.

(c) If any test is performed on a specimen which does not fully comply with this Standard (e.g. a cube which has not been cured in accordance with Section 10) or if the test itself does not fully conform to the requirements of this Standard, the test result, although it may have some indicative value, will be invalid and this must be stated in the Report.

2. Apparatus

In general the lists of required apparatus in the Standard do not include standard items of equipment and consumables which are normally found in a well equipped testing facility.

3. Tolerances

The tolerances stated in various sections of this Standard shall be interpreted as follows:

(a) **Flatness.** The surface specified as having a flatness tolerance shall lie between two parallel planes. The perpendicular distance between the planes is the flatness tolerance quoted.

(b) **Squareness.** Where a surface is specified as having a squareness tolerance relative to another surface, it shall lie between two parallel planes perpendicular to the reference surface. The perpendicular distance between the planes is the squareness tolerance quoted. Where a surface is specified as having a squareness tolerance relative to a datum line (e.g. the axis of a cylinder), it shall lie between parallel planes perpendicular to the datum line. The perpendicular distance between the two planes shall be the squareness tolerance quoted.

(c) **Parallelism.** Where is a surface is specified as having a parallelism tolerance relative to another surface, it shall lie between two planes parallel to the reference surface. The perpendicular distance between the planes shall be the parallelism tolerance quoted.

(d) **Cylindricity.** Where a surface is specified as having a cylindricity tolerance, the surface shall lie between two coaxial cylindrical surfaces. The radial distance between the two coaxial surfaces shall be the cylindricity tolerance quoted.

4. Singular and plural

Words importing the singular only also include the plural and vice versa where the content requires.

SECTION 1

SAMPLING FRESH CONCRETE ON SITE

1.1 SCOPE

This Section describes the methods to be used on site for obtaining and preparing representative samples from a batch of fresh concrete for testing and making specimens in accordance with the following Sections of this Standard:

Section 2	Determination of slump
Section 3	Determination of compacting factor
Section 4	Determination of Vebe time
Section 5	Determination of density of compacted fresh concrete
Section 6	Determination of air content of fresh concrete
Section 7	Making test cubes from fresh concrete
Section 8	Making test beams from fresh concrete
Section 9	Making test cylinders from fresh concrete

Testing or making specimens shall commence as soon as possible after the preparation of the sample.

1.2 DEFINITIONS

Batch is the quantity of concrete mixed in one cycle of operations of a batch mixer, or the quantity of concrete conveyed ready-mixed in a vehicle, or the quantity discharged during 1 minute from a continuous mixer or the quantity mixed by hand in one cycle of operations.

Sample is a quantity of concrete taken from the batch whose properties are to be determined.

Grade of Concrete is a means of describing a particular quality of concrete, usually in terms of its specified compressive strength, nominal maximum size of aggregate and any other distinguishing features such as workability.

1.3 APPARATUS

The following apparatus is required:

(a) Sample container (see C1. A1).
(b) Sample tray (see C1. A2).
(c) Scoop (see C1. A3).
(d) Square-mouthed shovel.

Further details of the apparatus are given in Appendix A.

1.4 SAMPLING PROCEDURE

1.4.1 General

The volume of concrete required for the test or to make the specimen shall be determined by reference to Table 1. The sample container and scoop shall be clean before sampling.

Table 1 - Quantities of Concrete Required

Test or specimen	Min. volume Required (litres)
Slump	8
Compacting factor	12
Vebe time	8
Air content	8
Density	12
100mm cube (per pair of cubes)	4
150mm cube (per pair of cubes)	8
150mm x 150mm x 750mm beam (per pair of beams)	38
150mm x 300mm long cylinder (per pair of cylinders)	12

1.4.2 Sampling from a mixer or ready-mixed vehicle

The first 0.3 m^3 and the last 0.3 m^3 of the batch discharged from the mixer or ready-mixed vehicle shall be disregarded. The sample shall consist of three approximately equal increments taken after about 1/6, 1/2 and 5/6 of the discharge of the remainder of the batch. When sampling for the determination of slump, however, the sample may be obtained from the initial discharge. After allowing a discharge of approximately 0.3 m^3, a sample shall be collected from the moving stream in a sample container.

When sampling from a falling stream, increments shall be obtained by passing a scoop through the whole width and thickness of the stream in a single operation. Alternatively, the entire stream may be diverted so that it discharges into the container. Regulation of the rate of discharge to permit sampling shall not be by suppressing or diverting a part of the discharge stream.

1.4.3 Sampling from a heap

The sample shall be made up of at least six approximately equal increments taken throughout the depth and over the surface of the heap.

1.4.4 Protection of samples

At all stages of sampling, transport and handling, the fresh concrete samples shall be protected against gaining or losing water and against extreme temperatures.

1.5 PREPARING THE SAMPLE FOR TEST

The sample shall be emptied from the container onto the sample tray. No more than a light covering of slurry should be left adhering to the container. The sample shall be thoroughly mixed on the sample tray with the square-mouthed shovel.

1.6 REPORT

The report shall affirm that sampling was carried out in accordance with this Standard and shall include the following:

(a) Name of works.
(b) Date of sampling.
(c) Name of supplier and source of concrete.
(d) Delivery note number or other means of identifying the batch.
(e) Grade of concrete.
(f) Time of adding water to the mix, as recorded in the delivery note if ready-mixed.
(g) Location in the works where the batch will be placed.
(h) Time of sampling.
(i) Ambient temperature and weather conditions.
(j) Place and method of sampling e.g. at discharge from truck or from a heap.
(k) Name and signature of person responsible for sampling.

NOTE. *This Sampling Report may conveniently be included as part of the reports required in Sections 2 to 9 of this Standard.*

SECTION 2

DETERMINATION OF SLUMP

2.1 SCOPE

This Section describes the method of determining the slump of concrete, made with aggregate having a nominal maximum size not exceeding 40 mm.

2.2 APPARATUS

The following apparatus is required:

(a) Sample tray (see Cl. A2).
(b) Scoop (see Cl. A3).
(c) Slump cone (see Cl. A4).
(d) Tamping rod (see Cl. A5).
(e) Rule (see Cl. A6).
(f) Square-mouthed shovel.

Further details of the apparatus are given in Appendix A.

2.3 SAMPLING

The sample of fresh concrete shall be contained in accordance with the procedure given in Section 1 of this Standard.

2.4 PROCEDURE

The internal surface of the slump cone shall be clean and damp but free from superfluous moisture before commencing the test. The slump cone shall be placed on a smooth, horizontal, rigid and non-absorbent surface free from vibration and shock.

The slump cone shall be held firmly against the surface below. It shall be filled in three layers of approximately equal depth and each layer shall be tamped uniformly to its full depth with 25 strokes of the tamping rod. During the tamping of the first layer, the tamping rod shall not forcibly strike the surface below. For subsequent layers, the tamping rod shall just pass into the layer immediately below. The concrete shall be heaped above the slump cone before the top layer is tamped. If necessary, further concrete shall be added to maintain an excess above the top of the slump cone throughout the tamping operation.

After the top layer has been tamped, the concrete shall be levelled to the top of the slump cone by a sawing and rolling motion of the tamping rod. With the slump cone still being held down, any concrete which has fallen onto the slump cone or leaked from the lower edge of the slump cone shall be removed.

The slump cone shall then be removed by raising it vertically, slowly and carefully, in five to ten seconds, in such a manner as to impart minimum lateral or torsional movement to the concrete. The entire operation from the start of filling to the removal of the slump cone shall be completed within 150 seconds.

Immediately after the slump cone is removed, the slump shall be measured to the nearest 5 mm by determining the difference between the height of the slump cone and the highest point of the specimen being tested.

NOTE. *The workability of concrete changes with time due to the hydration of the cement and, possibly, loss of moisture. Tests on different samples should therefore be carried out at a constant time interval after mixing if strictly comparable results are to be obtained.*

2.5 EXPRESSION OF RESULTS

The test is only valid if it yields a true slump, this being a slump in which the concrete remains substantially intact and symmetrical as shown in Figure 1(a). If the specimen shears, as shown in Figure 1(b), or collapses, as shown in Figure 1(c), another sample shall be taken and the procedure repeated. The slump shall be recorded to the nearest 5 mm.

NOTE. *Concrete with high workability, i.e. slump in excess of 150 mm, may sometimes exhibit a slump pattern similar to that of a collapse slump. In such cases, the slump shall be measured and recorded to the nearest 5 mm.*

2.6 REPORT

The report shall affirm that the test was made in accordance with this Standard and shall include the following:

(a) Sampling Report.
(b) Place of test if different from place of sampling.
(c) Time of completion of test.
(d) Specified range of slump.
(e) Form of slump, whether true, shear or collapse.
(f) Measured slump.
(g) Name and signature of person responsible for carrying out the test.

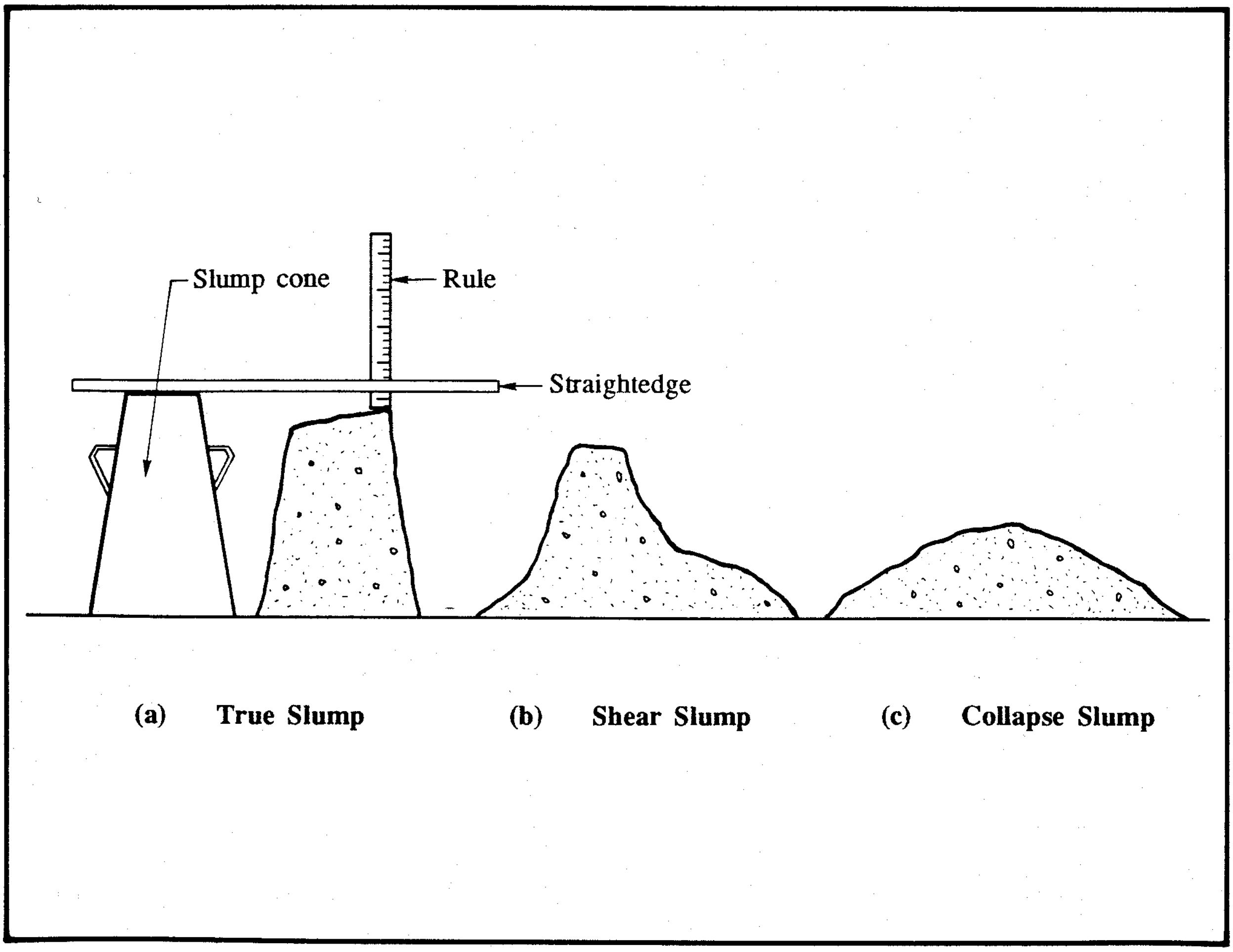


Figure 1 - Forms of Slump

SECTION 3

DETERMINATION OF COMPACTING FACTOR

3.1 SCOPE

This Section describes the method of determining the compacting factor of plain and air-entrained concrete made with aggregate having a nominal maximum size not exceeding 40 mm.

3.2 APPARATUS

The following apparatus is required:

(a) Sample tray	(see Cl. A2).
(b) Scoop	(see Cl. A3).
(c) Tamping rod	(see Cl. A5).
(d) Compacting factor apparatus	(see Cl. A7).
(e) Two steel floats	(see Cl. A8).
(f) Compacting bar	(see Cl. A9).
(g) Vibrating hammer or table	(see Cl. A10).
(h) Weighing equipment Type 1	(see Cl. A11).
(i) Square-mouthed shovel.	

Further details of the apparatus are given in Appendix A.

3.3 PROCEDURE

3.3.1 General

The internal surfaces of the hoppers and cylinder shall be smooth, clean and damp but free from superfluous moisture. The frame shall be placed in a stable position free from vibration or shock. The axes of the hoppers and the cylinder shall all lie on the same vertical line. The two trap doors shall be closed and the top of the cylinder covered by the two floats.

The sample of concrete shall be gently placed in the upper hopper until the hopper is filled to the level of the rim. The upper tray door shall then be opened to allow the concrete to fall into the lower hopper. Immediately after the concrete has come to rest, the floats shall be removed from the top of the cylinder and the trap door of the lower hopper shall then be opened to allow the concrete to fall into the cylinder.

Certain mixes have a tendency to stick in one or both of the hoppers. If this occurs, the concrete shall be dislodged by pushing the tamping rod gently into the concrete from the top until the lower end emerges from the bottom of the hopper. If this does not dislodge the concrete, the rod shall be raised and the process repeated until the concrete falls through the hopper.

Excess concrete shall be removed by holding a float in each hand with the plane of the blades horizontal, and moving them simultaneously one from each side across the top of the cylinder and at the same time keeping them pressed on the top edge of the cylinder. The outside of the cylinder shall be wiped clean.

The cylinder and its contents shall be weighed and the mass of the partially compacted concrete calculated and recorded to the nearest 10 g. The measurement shall be made within 150 seconds of commencing the test.

The cylinder shall be emptied and refilled with concrete from the same sample in such a way as to remove as much entrapped air as possible without significantly reducing the amount of entrained air (if present) and to produce full compaction of the concrete with neither excessive segregation nor laitance. For this purpose, the concrete shall be placed in six approximately equal layers in the cylinder. Each layer shall be compacted either by using the compacting bar or by vibrating. After the top layer has been compacted, it shall be levelled to the top of the cylinder with a steel float. The outside of the cylinder shall be wiped clean.

The cylinder and its contents shall be weighed and the mass of the fully-compacted concrete calculated and recorded to the nearest 10 g.

3.3.2 Compacting with compacting bar

During the compaction of each layer with the compacting bar, the strokes shall be distributed uniformly over the surface of the concrete and each layer shall be compacted to its full depth.

During the compacting of the first layer, the compacting bar shall not forcibly strike the base of the cylinder. For subsequent layers, the compacting bar shall just pass into the layer immediately below. The number of strokes per layer required to produce full compaction will depend upon the consistency of the concrete but in no case shall the concrete be subjected to fewer than 30 strokes per layer.

3.3.3 Compacting with vibrating hammer or table

During the compaction of each layer by means of the vibrating hammer or table, the applied vibration shall be of the minimum duration necessary to achieve full compaction of the concrete. Vibration shall cease as soon as the surface of the concrete becomes relatively smooth and air bubbles no longer appear.

NOTE. *Workability of a concrete changes with time owing to the hydration of the cement and possibly loss of moisture. Tests on different samples should therefore be carried out at a constant time interval after mixing if strictly comparable results are to be obtained.*

3.3 CALCULATION AND EXPRESSION OF RESULTS

The compacting factor shall be calculated from the equation:

$$\text{compacting factor} = \frac{m_p}{m_f} \qquad \textbf{(3 - 1)}$$

where

m_p is the mass of the partially-compacted concrete

m_f is the mass of the fully compacted concrete

The results shall be expressed to two decimal places.

3.5 REPORT

The report shall affirm that the compacting factor was determined in accordance with this Standard and shall include the following:

(a) Sampling Report.
(b) Place of test if different from place of sampling.
(c) Time of completion of test.
(d) Specified range of compacting factor.
(e) Measured compacting factor.
(f) Name and signature of person responsible for carrying out the test.

SECTION 4

DETERMINATION OF VEBE TIME

4.1 SCOPE

This Section describes the method of determining the Vebe time of concrete of very low to low workability. The method applies to plain and air-entrained concrete made with aggregate having a nominal maximum size not exceeding 40 mm.

4.2 APPARATUS

The following apparatus is required:

(a) Sample tray (see Cl. A2).
(b) Scoop (see Cl. A3).
(c) Tamping rod (see Cl. A5).
(d) Consistometer (Figure 2) (see Cl. A14).
(e) Stop-watch or stop-clock (see Cl. A15).
(f) Square-mouthed shovel.

Further details of the apparatus are given in Appendix A.

4.3 PROCEDURE

The vibrating table of the consistometer (Figure 2) shall be placed on a rigid, horizontal surface free from external vibration or shock. The container shall be clean and clamped to the table by means of two wing-nuts (D). The inner surface of the cone shall be clean and damp but free from superfluous moisture. The cone shall be placed concentrically in the container and the funnel shall be lowered onto the cone. The screw (E) shall be tightened so that the cone is held in contact with the base of the container.

The cone shall be filled with concrete in three layers, each approximately one-third of the height of the cone when tamped. Each layer shall be tamped to its full depth with 25 strokes of the tamping rod, distributed uniformly over the surface of the concrete. During the tamping of the first layer, the tamping rod shall not forcibly strike the base of the container. For subsequent layers, the tamping rod shall just pass into the layer immediately below. The concrete shall be heaped above the cone before the top layer is tamped. If necessary, more concrete shall be added to maintain an excess above the top of the cone throughout the tamping operation. After the top layer has been tamped, the screw (E) shall be loosened and the funnel raised and swung through 90° and the screw (E) shall be re-tightened. The concrete shall be levelled to the top of the cone by a sawing and rolling motion of the tamping rod. While the concrete is being struck off, the cone shall not be allowed to rise nor any concrete allowed to fall into the container.

The cone shall be removed from the concrete by raising it vertically slowly and carefully, in five to ten seconds, in such a manner as to impose minimum lateral or torsional movement to the concrete. After the cone has been removed, the screw (E) shall be loosened and the transparent disc swung over the container. The screw (E) shall be tightened and the disc lowered to touch the highest point of the slumped concrete.

If the concrete shears as shown in Figure 1(b), collapses as shown in Figure 1(c), or slumps to the extent that it touches the wall of the container, the disc shall be allowed to rest upon the subsided concrete with the screw (C) loose. If the concrete does not slump into contact with the wall of the container and a true slump as shown in Figure 1(a) is obtained, the screw (C) shall be tightened when the disc just touches the highest point of the concrete without disturbing it. The slump from the scale shall be read and the screw (C) loosened to allow the disc to rest upon the concrete.

The vibration and the stop-watch shall start simultaneously. The remoulding of the concrete shall be observed through the transparent disc.

The watch shall be stopped immediately the lower surface of the disc is completely coated with cement grout and the time recorded. The procedure shall be completed within a period of five minutes from the commencement of filling the cone.

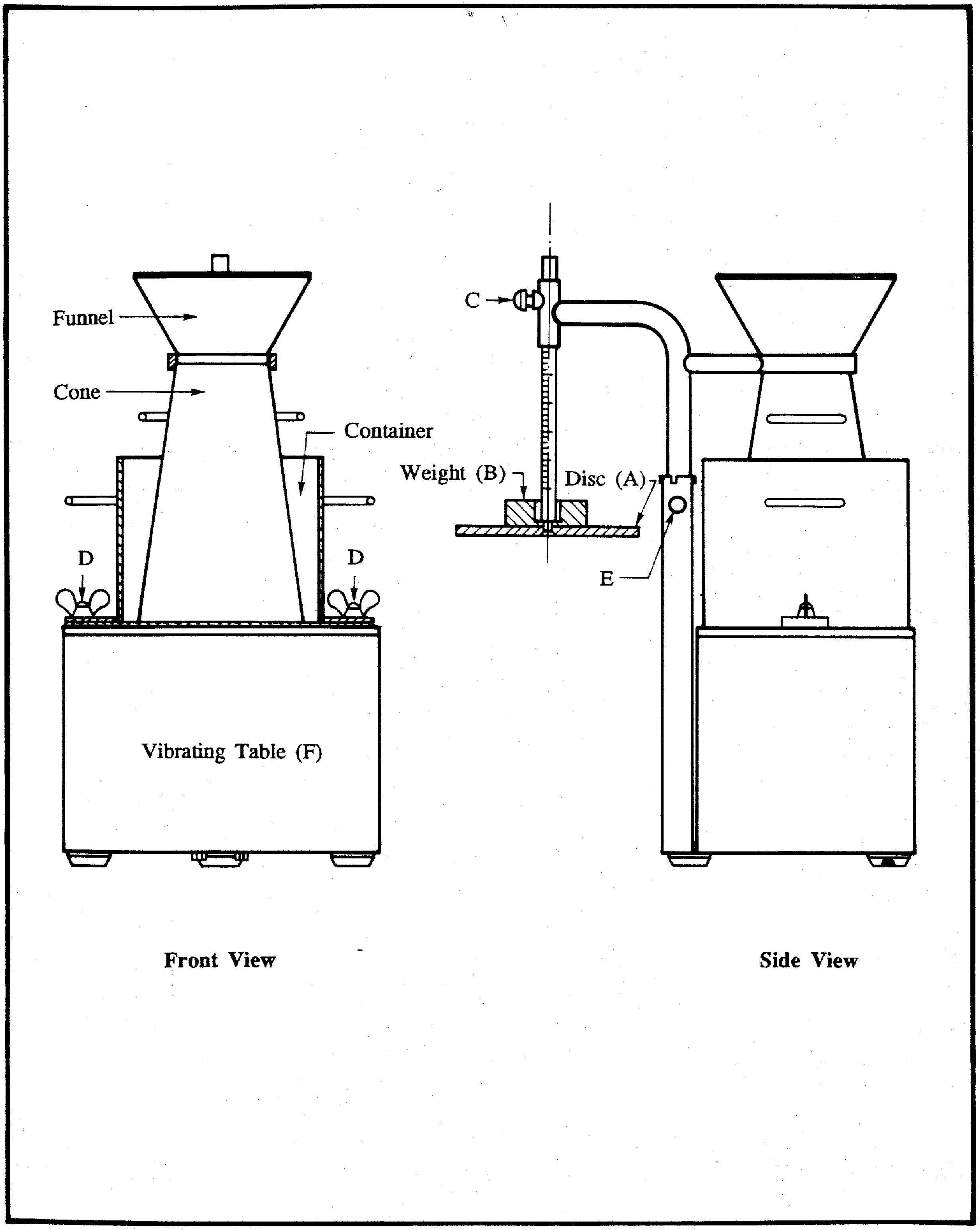


Figure 2 - Consistometer

NOTE. *The workability of a concrete changes with time due to hydration of the cement and possibly loss of moisture. Tests on different samples should therefore be carried out at a constant time interval after mixing if strictly comparable results are to be obtained.*

4.4 EXPRESSION OF RESULTS

The Vebe time indicated by the stop-watch shall be recorded to the nearest second.

4.5 REPORT

The report shall affirm that the Vebe time was determined in accordance with this Standard and shall include the following:

(a) Sampling Report.
(b) Place of test if different from place of sampling.
(c) Time of completion of test.
(d) Form of slump, whether true, shear or collapse, or into contact with wall of the container.
(e) Measured slump.
(f) Specified Vebe time, if any.
(g) Vebe time.
(h) Name and signature of person responsible for carrying out the test.

SECTION 5

DETERMINATION OF DENSITY OF COMPACTED FRESH CONCRETE

5.1 SCOPE

This Section describes the methods of determining the compacted density, the volume per batch and the cement content per cubic metre of fresh concrete. The methods apply to plain and air-entrained concrete, made with aggregate having a nominal maximum size not exceeding 40 mm.

5.2 APPARATUS

The following apparatus is required:

(a) Sample tray (see Cl. A2).
(b) Scoop (see Cl. A3).
(c) Steel float (see Cl. A8).
(d) Vibrating hammer of table (see Cl. A10).
(e) Weighing equipment Type 1 (see Cl. A11).
(f) Container for the determination of density of fresh concrete (see Cl. A16).
(g) Steel straightedge (see Cl. A17).
(h) Square-mouthed shovel.

Further details of the apparatus are given in Appendix A. The method of calibrating the container is described in Appendix B.

5.3 PROCEDURE

The container shall be filled with concrete in such a way as to remove as much entrapped air as possible without significantly reducing the amount of entrained air (if present), and to produce full compaction of the concrete with neither excessive segregation nor laitance. For this purpose, the concrete shall be placed in the container in six approximately equal layers and each layer shall be vibrated by the vibrating hammer or table. The applied vibration shall be of the minimum duration necessary to achieve full compaction of the concrete. Vibration shall cease as soon as the surface of the concrete becomes relatively smooth and air bubbles no longer appear. After the top layer has been compacted, it shall be levelled to the top of the container. The surface shall be skimmed with the straightedge and the outside of the container cleaned. The container and its content shall be weighed to the nearest 10 g. The mass of the fully compacted concrete shall be calculated by subtracting the mass of the empty container and recorded to the nearest 10 g.

5.4 CALCULATION AND EXPRESSION OF RESULTS

5.4.1 Calculation of density

The density D (in kg/m^3) shall be calculated from the following equation:

$$D = \frac{m}{V} \qquad \textbf{(5 - 1)}$$

where

m is the mass of the concrete sample in the container (in kg)
V is the volumetric capacity of the container (in m^3)

The result shall be expressed to the nearest 10kg/m^3.

5.4.2 Calculation of volume of concrete per batch

If the volume of concrete produced per batch V_b (in m^3) is required, it shall be calculated from the following equation based on the measured masses:

$$\frac{m_c + m_s + m_a + m_w + m_p + m_x}{D} \qquad \textbf{(5 - 2)}$$

where

m_a is the mass per batch of coarse aggregate in condition used (in kg)
m_c is the mass per batch of cement (in kg)
m_s is the mass per batch of fine aggregate in condition used (in kg)
m_w is the mass of mixing water added to batch (in kg)
m_p is the mass of PFA if used (in kg)
m_x is the mass of admixture used (in kg)
D is the density of fully-compacted fresh concrete (in kg/m^3)

The result shall be recorded to an accuracy of 1%.

5.4.3 Calculation of cement content

If the cement content C (in kg/m^3) of the fresh concrete is required, it shall be calculated from the equation:

$$C = \frac{m_c}{V_b} \qquad \textbf{(5 - 3)}$$

The result shall be expressed to the nearest 5kg/m^3.

5.5 REPORT

The report shall affirm that the density, the calculated volume of concrete and the calculated cement content were determined in accordance with this Standard. The report shall include the following:

(a) Sampling Report.
(b) Workability of the concrete, if measured.
(c) Specified density, if any.
(d) Density of compacted sample.
(e) Calculated volume of concrete per batch, if required.
(f) Calculated cement content of the concrete, if required.
(g) Name and signature of person responsible for carrying out the test.

SECTION 6

DETERMINATION OF AIR CONTENT OF FRESH CONCRETE

6.1 SCOPE

This Section describes the method of determining the air content of compacted fresh concrete, made with normal weight aggregate having a nominal maximum size not exceeding 40 mm. The method does not apply to aerated concrete, very stiff concrete which cannot be compacted by vibration alone or to concrete made with aggregate of high porosity.

6.2 TEMPERATURE MEASUREMENT AT SAMPLING

The temperature at the centre of the sample shall be measured immediately after sampling.

6.3 APPARATUS

The following apparatus is required:

(a)	Compacting bar	(see Cl. A9).
(b)	Vibrating hammer or table	(see Cl. A10).
(c)	Weighing equipment Type 2	(see Cl. A12).
(d)	Weighing equipment Type 3	(see Cl. A13).
(e)	Air content apparatus	(see Cl. A18).
(f)	Mallet	(see Cl. A19).
(g)	Thermometer	(see Cl. A20).

Further details of the apparatus are given in Appendix A.

6.4 CALIBRATION OF APPARATUS

Details of the following calibration tests are given in Appendix B:

(a) Capacity of the calibration cylinder.
(b) Capacity of the container.
(c) Pressure expansion constant, e.
(d) Calibration constant, K.
(e) Required operating pressure.
(f) Alternative operating pressure.
(g) Aggregate correction factor.

6.5 PROCEDURE

6.5.1 Placing of concrete

The sample of concrete to be tested shall be placed in the container in such a way as to remove as much entrapped air as possible without significantly reducing the amount of entrained air (if present), and to produce full compaction of the concrete with neither excessive segregation nor laitance. The concrete shall be placed in the container in three approximately equal layers. Each layer shall be compacted either by using the compacting bar or by vibrating. If the concrete has a slump greater than about 75 mm, the concrete should not be vibrated.

The quantity of material used in the final layer shall be just sufficient to fill the container without having to remove excess material. If necessary, a small quantity of additional concrete may be added and further compacted in order to just fill the container.

6.5.2 Compacting with compacting bar

During the compaction of each layer with the compacting bar, the strokes shall be distributed in a uniform manner over the surface of the concrete and each layer shall be tamped to its full depth.

During the compaction of the first layer, the compacting bar shall not forcibly strike the base of the container. For subsequent layers, the compacting bar shall just pass into the layer immediately below. The number of strokes per layer required to produce full compaction will depend upon the consistency of the concrete but in no case shall the concrete be subjected to fewer than 25 strokes per layer.

In order to remove pockets of entrapped air but not the entrained air, after compaction of each layer the sides of the container shall be tapped lightly with the mallet until air bubbles cease to appear on the surface and depressions left by the compacting bar are removed.

6.5.3 Compacting with vibrating hammer or table

During the compaction of each layer by means of the vibrating hammer or table, vibration of the minimum duration necessary to achieve full compaction of the concrete should be used. Vibration shall cease as soon as the surface of the concrete becomes relatively smooth and air bubbles no longer appear.

6.5.4 Applying pressure (Figure 5)

The flanges of the container and the cover assembly shall be thoroughly wiped clean. The deflecting plate shall be placed centrally on the concrete and pressed into contact with it. The cover assembly shall be clamped in place, care being taken to ensure a good pressure seal between the cover and the container. The apparatus shall be filled with water and tapped lightly with the mallet to remove air adhering to the interior surfaces of the cover. By opening the air vent and bleeding through the small valve, the water level shall be brought to zero. The air vent shall then be closed and the operating pressure P applied by means of the air pump.

The reading on the gauge tube h_1 shall be recorded and the pressure released. The gauge tube shall be ready again and if the reading h_2 indicates 0.2% air content or less, the value h_1-h_2 shall be recorded as the apparent air content A_1 to the nearest 0.1% air content. If h_2 is greater than 0.2% air content the operating pressure P shall be applied again to give a gauge tube reading h_3 and a final reading h_4 after the release of the pressure. If h_4-h_2 is 0.1% air content or less, the value h_3-h_4 shall be recorded as the apparent air content. If h_4-h_2 is greater than 0.1% air content, it is probable that leakage is occurring, and the test shall be disregarded.

6.6 CALCULATION AND EXPRESSION OF RESULTS

The air content of the concrete in the container, A_c, shall be calculated from the equation:

$$A_c = A_1 - G \qquad \textbf{(6 - 1)}$$

where

A_1 is the apparent air content of the sample
G is the aggregate correction factor

The air content shall be expressed as a percentage to the nearest 0.1%.

6.7 REPORT

The report shall affirm that the air content was determined in accordance with this Standard and shall include the following:

(a) Sampling Report.
(b) Temperature of the concrete at the time of sampling.
(c) Density of the concrete, if known.
(d) Workability of the concrete, if measured.
(e) Specified air content, if any.
(f) Measured air content of sample tested.
(g) Name and signature of person responsible for carrying out the test.

SECTION 7

MAKING TEST CUBES FROM FRESH CONCRETE

7.1 SCOPE

This Section describes the method of making test cubes from fresh concrete. The method applies to plain and air-entrained concrete but does not apply to aerated concrete or very stiff concrete which cannot be compacted by vibration alone.

Cubes of 100 mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 20 mm. Cubes of 150 mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 40 mm.

7.2 APPARATUS

The following apparatus is required:

(a) Sample tray (see Cl. A2).
(b) Scoop (see Cl. A3).
(c) Steel float (see Cl. A8).
(d) Compacting bar (see Cl. A9).
(e) Vibrating hammer or table (see Cl. A10).
(f) Mould for making test cube (see Cl. A21).
(g) Square-mouthed shovel.

Further details of the apparatus are given in Appendix A.

7.3 PROCEDURE

7.3.1 Filling the mould

The mould shall be placed on a rigid horizontal surface or on the vibrating table and filled with concrete in such a way as to remove as much entrapped air as possible without significantly reducing the amount of entrained air (if present) and to produce full compaction of the concrete with neither excessive segregation nor laitance. The concrete shall be placed in the mould in layers approximately 50 mm deep and each layer shall be compacted either by using the compacting bar or by vibrating. After the top layer has been compacted, it shall be levelled to the top of the mould with a steel float, and the outside of the mould shall be wiped clean. The mould shall not be overfilled.

7.3.2 Compacting with compacting bar

During the compaction of each layer with the compacting bar, the strokes shall be distributed in a uniform manner over the surface of the concrete and each layer shall be compacted to its full depth. During the compaction of the first layer, the compacting bar shall not forcibly strike the bottom of the mould. For subsequent layers, the compacting bar shall just pass into the layer immediately below. The minimum number of strokes per layer required to produce full compaction will depend upon the workability of the concrete but in no case shall the concrete be subjected to less than 35 strokes per layer for 150 mm cubes or 25 strokes per layer for 100 mm cubes, except in the case of very high workability concrete.

7.3.3 Compacting with vibrating hammer or table

During the compaction of each layer by means of the vibrating hammer, the mould shall preferably be placed on a level piece of timber. The concrete shall be vibrated by holding the foot of the hammer against a piece of timber placed over but not completely covering the top of the mould.

The applied vibration by either the vibrating hammer or table shall be of the minimum duration necessary to achieve full compaction of the concrete. Vibration shall cease as soon as the surface of the concrete becomes relatively smooth and air bubbles cease to appear.

7.4 TOLERANCES

The cube shall be accurate within the following tolerances:

(a) Dimensions. The dimensional tolerance of the cube shall be ± 1 mm on its sides and ± 2 mm on its height.

(b) Squareness. The squareness tolerance of the moulded sides of the cube relative to adjacent moulded sides shall be 1% of its nominal dimension.

(c) Parallelism. The parallelism tolerance for the trowelled surface of the cube with respect to the bottom surface shall be 2 mm.

7.5 REPORT

The report shall affirm that the cube was made in accordance with this Standard and shall include the following:

(a) Sampling Report.
(b) Workability of the concrete, if measured.
(c) Identification number of each cube.
(d) Time at which the cube was completed.
(e) Age at which cube is to be tested.
(f) Name and signature of person responsible for making cube.

NOTE. *The Report on curing for the period the cube is on site may conveniently be added to this Report.*

SECTION 8

MAKING TEST BEAMS FROM FRESH CONCRETE

8.1 SCOPE

This Section describes the method of making 150 mm x 150 mm x 750 mm long test beams from fresh concrete. The method applies to plain and air-entrained concrete made with aggregate having a nominal maximum size not exceeding 40 mm, but does not apply to aerated concrete or very stiff concrete which cannot be fully compacted by vibration alone.

8.2 APPARATUS

The following apparatus is required:

(a) Sample tray (see Cl. A2).
(b) Scoop (see Cl. A3).
(c) Steel float (see Cl. A8).
(d) Vibrating hammer or table (see Cl. A10).
(e) Mould for making test beam (see Cl. A22).
(f) Square-mouthed shovel.

Further details of the apparatus are given in Appendix A.

8.3 PROCEDURE

The mould shall be placed on a rigid horizontal surface or on the vibrating table and filled with concrete in such a way as to remove as much entrapped air as possible without significantly reducing the amount of entrained air (if present) and to produce full compaction of the concrete with neither excessive segregation nor laitance. The concrete shall be placed in the mould in layers approximately 50 mm deep and each layer shall be vibrated by the vibrating hammer or table. The applied vibration shall be of the minimum duration necessary to achieve full compaction of the concrete. Vibration shall cease as soon as the surface of the concrete becomes relatively smooth and air bubbles cease to appear. After the top layer has been compacted, it shall be levelled to the top of the mould with a steel float, and the outside of the mould shall be wiped clean. The mould shall not be overfilled.

8.4 TOLERANCES

The beam shall be accurate within the following tolerances:

(a) Dimensions. The dimensional tolerance of the beam shall be ± 1 mm on its sides and ± 2 mm on its height.

(b) Squareness. The squareness tolerance of the side faces of the beam relative to adjacent moulded surfaces shall be 1.5 mm.

(c) Parallelism. The parallelism tolerance for the opposite moulded faces of the beam shall be 2.0 mm.

8.5 REPORT

The report shall affirm that the beam was made in accordance with this Standard and shall include the following:

(a) Sampling Report.
(b) Specified flexural strength, if any.
(c) Workability of the concrete, if measured.
(d) Identification number of each beam.
(e) Time at which the beam was completed.
(f) Age at which the beam is to be tested.
(g) Name and signature of person responsible for making the beam.

NOTE. *The Report on curing for the period the test beam is on site may conveniently be added to this Report.*

SECTION 9

MAKING TEST CYLINDERS FROM FRESH CONCRETE

9.1 SCOPE

This Section describes the method of making 150 mm diameter x 300 mm long cylinders from fresh concrete. The method applies to plain and air-entrained concrete made with aggregate having a nominal maximum size not exceeding 40 mm, but does not apply to aerated concrete or very stiff concrete which cannot be fully compacted by vibration alone.

9.2 APPARATUS

The following apparatus is required :

(a) Sample tray (see Cl. A2).
(b) Scoop (see Cl. A3).
(c) Steel float (see Cl. A8).
(d) Compacting bar (see Cl. A9).
(e) Vibrating hammer or table (see Cl. A10).
(f) Mould for making test cylinder (see Cl. A23).
(g) Square-mouthed shovel.

Further details of the apparatus are given in Appendix A.

9.3 PROCEDURE

9.3.1 Filling the mould

The mould shall be placed on a rigid horizontal surface or on the vibrating table and filled with concrete in such a way as to remove as much entrapped air as possible without significantly reducing the amount of entrained air (if present) and to produce full compaction of the concrete with neither excessive segregation nor laitance. The concrete shall be placed in the mould in layers approximately 50 mm deep and each layer shall be compacted either by using the compacting bar or by vibrating. After the top layer has been compacted, it shall be levelled to the top of the mould with a steel float, and the outside of the mould shall be wiped clean. The mould shall not be overfilled.

9.3.2 Compacting with compacting bar

During the compaction of each layer with the compacting bar, the strokes shall be distributed in a uniform manner over the surface of the concrete and each layer shall be compacted to its full depth. During the compaction of the first layer, the compacting bar shall not forcibly strike the bottom of the mould. For subsequent layers, the compacting bar shall just pass into the layer immediately below. The number of strokes per layer required to produce full compaction will depend upon the workability of the concrete but in no case shall the concrete be subject to less than 30 strokes per layer, except in the case of very high workability concrete.

9.3.3 Compacting with vibrating hammer or table

During the compaction of each layer by means of the vibrating hammer or table, the applied vibration shall be of the minimum duration necessary to achieve full compaction of the concrete. Vibration shall cease as soon as the surface of the concrete becomes relatively smooth and air bubbles cease to appear.

9.4 METHOD OF PREPARATION OF UPPER SURFACE OF CYLINDER

For the tensile splitting strength test, the upper surface of the cylinder shall be levelled to the top of the mould with a steel float.

For the static modulus of elasticity test, the concrete shall be allowed to harden and the upper surface shall be ground or capped in accordance with Section 17 of this Standard.

9.5 TOLERANCES

The cylinder shall be accurate within the following tolerances:

(a) **Dimensions.** The dimensional tolerance of the cylinder shall be ± 2 mm on its length and ± 1 mm on its diameter.

(b) **Squareness.** The squareness tolerance for the moulded end of the cylinder relative to the axis of the cylinder shall be 2 mm.

(c) **Cylindricity.** The cylindricity tolerance for the cylinder shall be 2 mm.

9.6 REPORT

The report shall affirm that the cylinder was made in accordance with this Standard and shall include the following:

(a) Sampling Report.
(b) Specified tensile splitting strength, if any.
(c) Workability of the concrete, if measured.
(d) Identification number of each cylinder.
(e) Time at which the cylinder was completed.
(f) Age at which the cylinder is to be tested.
(g) Type of test required.
(h) Name and signature of person responsible for making the cylinder.

NOTE. *The Report on curing for the period the cylinder is on site may conveniently be added to this Report.*

SECTION 10

CURING TEST SPECIMENS

10.1 SCOPE

This Section describes the method of curing concrete specimens (cubes, beams, cylinders and cores) for tests at ages of 1 day and over.

10.2 APPARATUS

The following apparatus is required:

(a) Thermometer (see Cl. A20).
(b) Curing tank (see Cl. A24).
(c) Mist room (see Cl. A25).

Further details of the apparatus are given in Appendix A.

10.3 PROCEDURE

10.3.1 Curing prior to demoulding

Immediately after it is made, the specimen shall be stored in a place free from vibration and in conditions which will prevent the loss of moisture and avoid extremes of temperature. The specimen shall be stored either :

(a) away from direct sunlight, under damp matting or other suitable damp material and wrapped completely with polythene, or
(b) in a mist room.

10.3.2 Curing after demoulding

A specimen to be tested at 24 hours shall be demoulded just before testing. A specimen to be tested at a greater age shall be demoulded within 16 hours to 28 hours after mixing. If the concrete has not achieved sufficient strength to enable the specimen to be demoulded, demoulding shall be delayed for a further 24 hours. During this further period, the specimen shall continue to be stored in the conditions described in Cl. 10.3.1.

After being demoulded, each specimen shall be marked clearly and indelibly with an identification number or code. Unless required for test at 24 hours, the specimen shall be placed immediately in the curing tank or mist room.

The curing temperature of the specimen shall be maintained at 27 ± 3°C. If curing is in a mist room, the relative humidity shall be maintained at no less than 95%. All surfaces of the specimen shall look moist and feel moist at all times. Curing shall continue as long as possible up to the time of testing.

10.3.3 Transportation of specimen

When a specimen is to be transported, it shall be carried in such a way that physical damage is prevented, loss of moisture is minimized and temperature extremes are avoided. This can be achieved by using a special box having compartments lined with wet felt or other suitable material. Each box shall be sealed or enclosed in plastic sheet.

Alternatively, the specimen may be packed in damp sand or in wet sack and enclosed in a plastic bag. The transported specimen shall be stored in the curing tank or mist room for not less than 24 hours before testing. The transfer of a specimen may take place at any time after demoulding but not less than 24 hours before the time of testing and it shall be effected in as short a time as is practicable.

10.3.4 Stacking of specimens during curing

In order to provide adequate circulation of water, adequate space shall be provided between the specimens and between the specimens and the side of the curing tank. Curing in water shall continue for as long as possible up to the time of testing. If curing is in a mist room, there shall be sufficient space between specimens to ensure that all surfaces of the specimens look and feel moist at all times.

10.4 AGE OF TEST SPECIMEN

Tests shall be carried out within the following tolerances on the ages for testing:

(a) ± 30 minutes for ages up to and including 30 hours
(b) ± 2 hours for ages above 30 hours and up to and including 4 days
(c) ± 8 hours for ages above 4 days and up to and including 60 days
(d) ± 1 day for ages above 60 days.

The ages shall be calculated from the time of adding water to the mix.

10.5 REPORT

The report shall affirm that the specimen was cured in accordance with this Standard and shall include the following:

(a) Identification number of each specimen.
(b) Location of storage prior to demoulding.
(c) Method of curing after demoulding (water or mist room curing).
(d) Date of removal from curing if different from date of testing.
(e) Name and signature of person responsible for curing.

NOTE. *Two reports may be needed if the specimen has been cured both on site and in the laboratory. The Report for the period on site may conveniently be added to the Reports required in Sections 7 to 9 of this Standard. The Report for the period in the laboratory may conveniently be added to the Reports required in Sections 12 to 17 of this Standard.*

APPENDIX A

APPARATUS

CONTENTS

APPENDIX A - APPARATUS

A1 Sample container

The sample container shall be a bucket or other suitable container made of plastic or metal, of minimum eight litres capacity.

A2 Sample tray

The sample tray shall be 1.2m x 1.2m in area, made of metal and have sufficient capacity to contain the concrete sample. It shall have sides to prevent the loss of water or cement paste.

A3 Scoop

The scoop shall be made of metal of a size suitable for sampling concrete. The scoop shall not allow water to escape from concrete contained in it.

A4 Slump cone

The slump cone shall be made of metal not readily attacked by cement paste and not thinner than 1.5 mm. The interior of the slump cone shall be smooth and free from projections such as protruding rivets and shall be free from dents. The slump cone shall be in the form of a hollow frustum of a cone having the following internal dimensions:

diameter of base:	200 ± 2 mm
diameter of top:	100 ± 2 mm
height:	300 ± 2 mm

The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The slump cone shall be provided with two handles at two-thirds of the height, and with foot pieces to enable it to be held steady.

A5 Tamping rod

The tamping rod shall be a 16 mm diameter straight steel bar, 600 mm long with both ends hemispherical.

A6 Rule

The rule shall be graduated from 0 mm to 300 mm at 5 mm maximum intervals, the zero point being at one end of the rule.

A7 Compacting factor apparatus

The apparatus shall consist of two conical hoppers mounted above a cylinder; its essential dimensions are shown in Table 2 and Figure 3.

The hopper and cylinder shall be of rigid construction made of metal not readily attacked by cement paste. The interior surfaces shall be smooth and free from projections such as protruding rivets and shall be free from dents. The rims of the cylinder shall be machined to a plane surface at right angles to its axis. The lower ends of the hoppers shall have tightly fitting hinged trap doors made of rigid non-corrodible metal plate, 3 mm thick. The doors shall have quick release catches which allow them to swing rapidly to a position at which they are caught by retaining catches which hold them clear of concrete falling through the bottom of the hopper.

The frame on which the hoppers and cylinder are mounted shall be of rigid construction and shall firmly locate them in the relative positions indicated in Table 2. The cylinder shall be easily detachable from the frame.

A8 Steel float

The steel float shall be at least 200 mm long plasterer's steel float.

A9 Compacting bar

The compacting bar shall be a 380 mm long steel bar weighing 1.8 kg and having a ramming face 25 mm square.

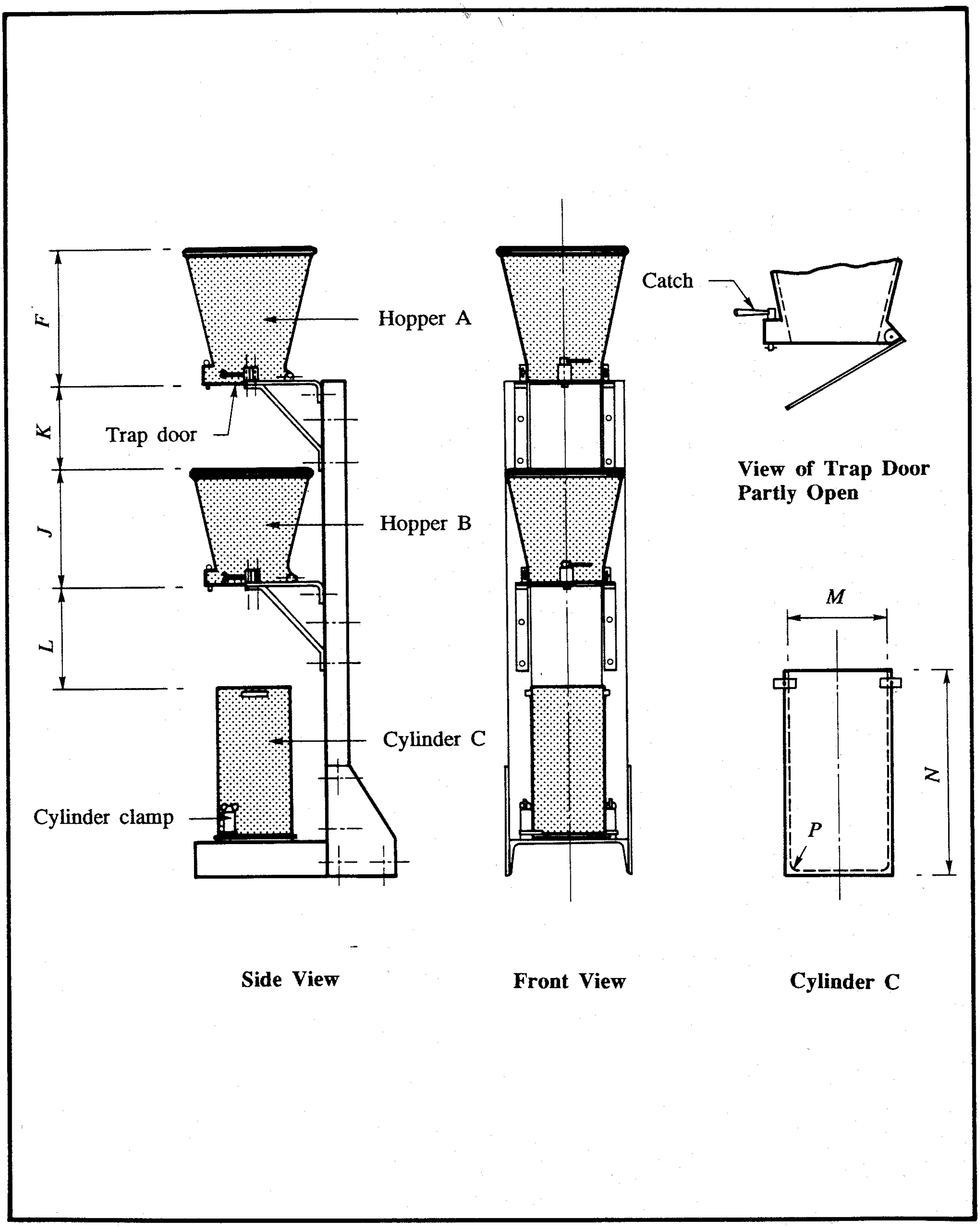


Figure 3 - Compacting Factor Apparatus

Table 2 - Essential Dimensions of the Compacting Factor Apparatus

Detail	Dimension mm
Upper hopper A:	
Top internal diameter, D	260 ± 2
Bottom internal diameter, E	130 ± 2
Internal height, F	280 ± 2
Lower hopper B:	
Top internal diameter, G	240 ± 2
Bottom internal diameter, H	130 ± 2
Internal height, J	240 ± 2
Distance between bottom of upper hopper A and top of lower hopper B, K	200 ± 5
Distance between bottom of lower hopper B and top of cylinder C, L	200 ± 5
Cylinder C:	
Internal diameter, M	150 ± 1
Internal height, N	285 ± 1
Radius between wall and base, P	20

A10 Vibrating hammer or table

The vibrating hammer or table shall be suitable for compacting concrete in the manner specified.

A11 Weighing equipment Type 1

The equipment shall be capable of weighing up to 50 kg to an accuracy of 10g or better.

A12 Weighing equipment Type 2

The equipment shall be capable of weighing up to 20 kg to an accuracy of 5g or better.

A13 Weighing equipment Type 3

The equipment shall be capable of weighing up to 1 kg to an accuracy of 0.5 g or better.

A14 Consistometer

The consistometer shall comprise a container, a cone, a transparent disc and a vibrating table; the consistometer and its essential dimensions are shown in Figure 4.

The container shall be made of metal not readily attacked by cement paste. It shall be of cylindrical shape, the thickness of the wall being 3 mm and of the base being 7.5 mm. The container shall have an internal diameter of 240±5 mm and a height of 200 mm and shall be watertight and of sufficient rigidity to retain its shape under rough usage. It shall be fitted with handles and with brackets, the latter enabling it to be clamped to the top of the vibrating table (F) by wing-nuts (D).

The cone shall be rigid and made of metal not readily attacked by cement paste and not thinner than 1.5 mm. The interior of the cone shall be smooth and free from projections such as protruding rivets and shall be free from dents. The cone shall be hollow and have the following internal dimensions:

diameter of base:	200 ± 2 mm
diameter of top:	100 ± 2 mm
height	300 ± 2 mm

The base and top shall be open and parallel to each other and at right angles to the axis of the cone. The cone shall be provided with two handles about 250 mm from the base.

The transparent disc (A) shall be horizontal and attached to the end of a rod which slides vertically through a guide sleeve mounted on a swivel arm. The guide sleeve shall be fitted with a screw (C) to enable the rod to be fixed in position. The swivel arm also carries a funnel, the bottom of which locates on the top of the cone when this is positioned concentrically in the container. The swivel arm is located by a holder and can be fixed in position by a set screw (E). When in the appropriate positions, the axes of the rod and of the funnel shall be coincident with the axis of the container. The transparent disc shall be 230 ± 2 mm in diameter and 10 ± 2 mm thick. A weight (B) shall be located directly above the disc such that the moving assembly, comprising rod, disc and weight, shall weigh 2750 ± 50 g.

The rod shall be provided with a scale to enable the slump of the concrete to be recorded.

The vibrating table (F) shall be 380 mm long and 260 mm wide and shall be supported on four rubber shock absorbers. A vibrator unit, carried on a base resting on three rubber feet, shall be securely fixed beneath it. The vibrator shall operate at a frequency of 50 Hz and the vertical amplitude of the table, with the empty container clamped to it, shall be approximately ±0.35 mm about the mean position.

A15 Stop-watch or stop-clock

The stop-watch or stop-clock shall be accurate to 0.5 second.

A16 Container for the determination of density of fresh concrete

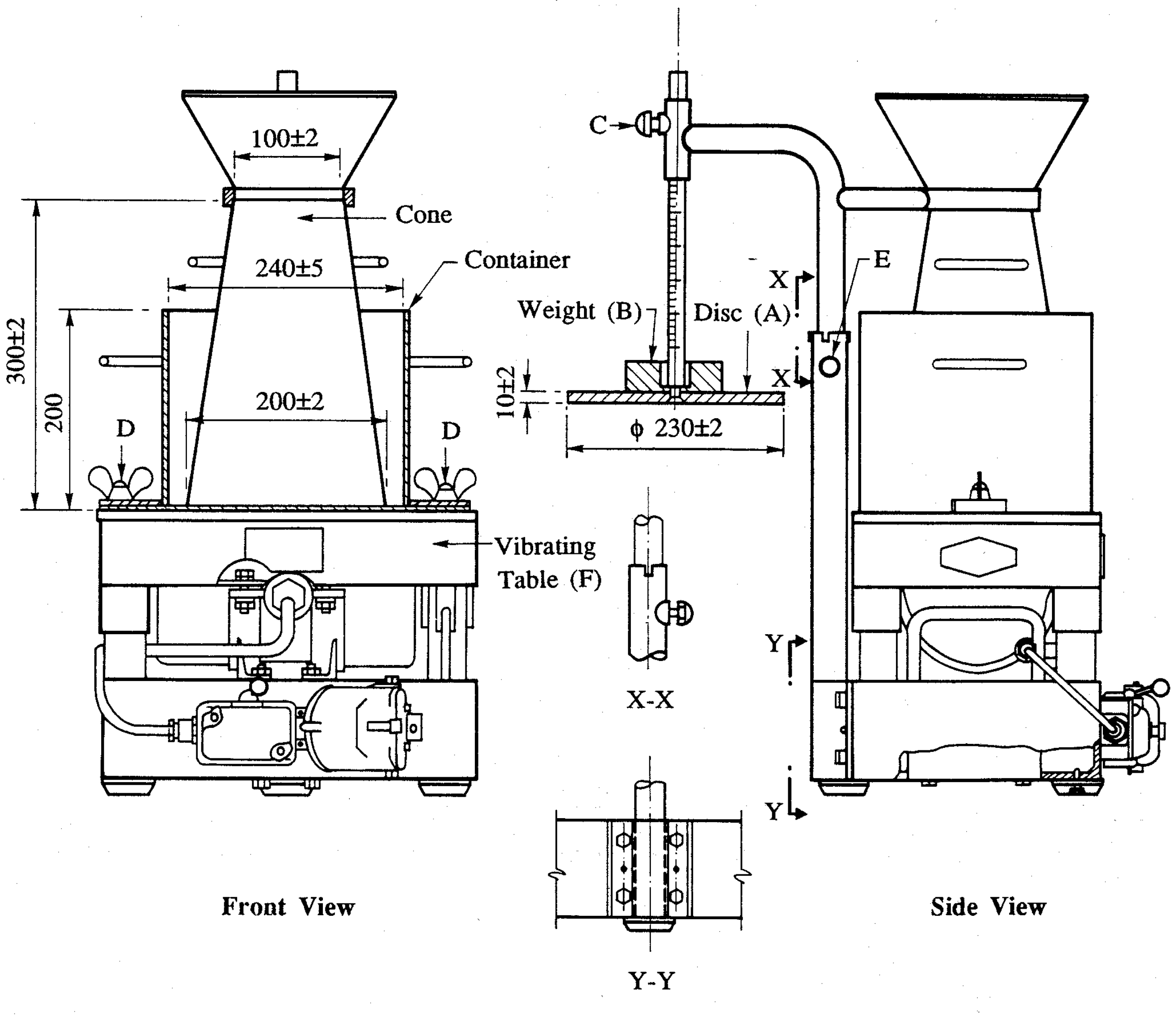
The container shall be a rigid watertight cylindrical container conforming to the dimensions specified in Table 3. The container shall be made of metal not readily attacked by cement paste and shall be provided with handles. The internal face shall be smooth and the rim machined to a plane surface. The rim and base shall be at right angles to the axis of the container.

Table 3 - Dimensions of Container

Nominal capacity	(Litre)	10
Inside diameter	(mm)	200±1.5
Inside height	(mm)	320±1.5
Minimum thickness of metal	(mm)	4
Radius between wall and base	(mm)	20

A17 Steel straightedge

The straightedge shall be at least 300 mm long.



Note. All dimensions are in millimetres

Figure 4 - Consistometer

A18 Air content apparatus

The apparatus is shown diagrammatically in Figure 5.

A18.1 Air pump

The air pump shall be a hand pressure pump, such as a bicycle tyre pump, with a lead to facilitate connection to the non-return air inlet valve on the cover assembly.

A18.2 Calibration cylinder

The calibration cylinder shall be a hollow cylinder made of brass or other strong non-corrodible metal, having a capacity of approximately 0.3 litres. The rim of the cylinder shall be machined to a smooth plane surface at right angles to the axis of the cylinder.

A18.3 Container

The container shall be a flanged cylindrical vessel of steel or other hard metal, not readily attacked by cement paste, having a nominal capacity of at least five litres and a ratio of diameter to height of not less than 0.75 nor more than 1.25. The outer rim and upper surface of the flange and the interior surfaces of the vessel shall be machined to a smooth finish. The container shall be watertight. Together with the cover assembly it shall be suitable for an operating pressure of approximately 100kN/m^2 and be sufficiently rigid to limit the pressure expansion constant *e* (see Appendix B), to not more than 0.1% air content.

A18.4 Container with spout

This shall be a container having a capacity of two litres to five litres, fitted with a spout.

A18.5 Cover assembly

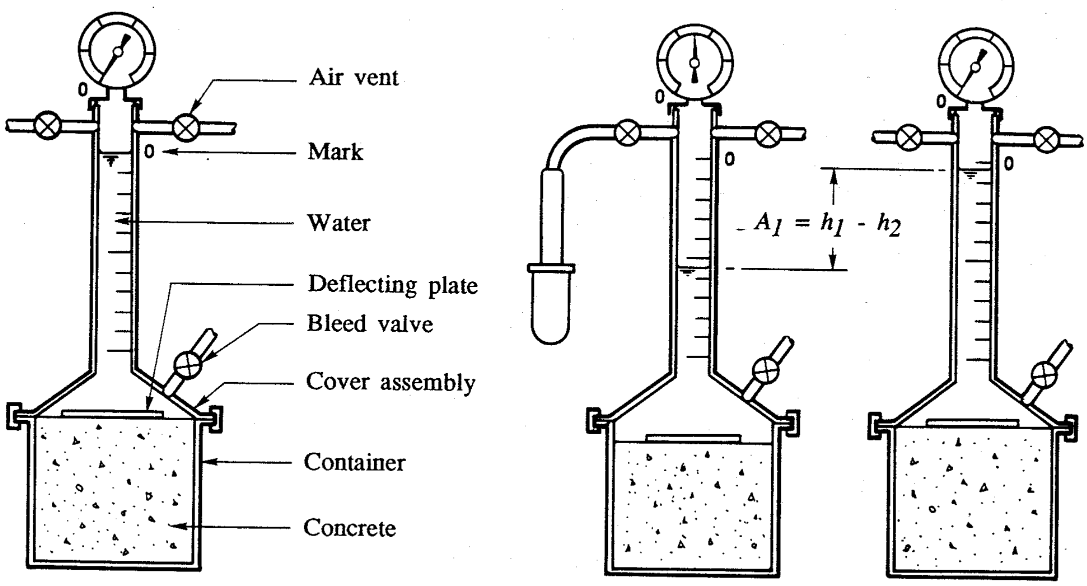
The cover assembly shall be a flanged rigid conical cover fitted with a standpipe. The cover shall be of steel or other hard metal not readily attacked by cement paste and shall have interior surfaces inclined at not less than 10° from the surface of the flange. The outer rim and lower surface of the flange and the sloping interior face shall be machined to a smooth finish. The cover shall have provision for being clamped to the container to make a pressure seal without entrapping air at the joint between the flanges of the cover and the container.

The standpipe shall consist of a graduated glass tube of uniform bore, or a metal tube of uniform bore with a glass gauge attached. The graduated scale shall indicate air content from 0% to at least 8% and preferably 10%. The scale shall be graduated with divisions every 0.1% air content, the divisions being not less than 2 mm apart. A scale in which 25 mm represents 1 % of air content is convenient.

The cover shall be fitted with a suitable device for venting the air chamber, a non-return air inlet valve and a small valve for bleeding off water. The applied pressure shall be indicated by a pressure gauge connected to the air chamber above the water column. The gauge shall be graduated with divisions every 5 kN/m^2, the divisions being not less than 2 mm apart. The gauge shall read up to 200 kN/m^2.

A18.6 Deflecting plate or tube

The deflecting plate shall be a thin non-corrodible disc of not less than 100 mm diameter which will minimize disturbance of the concrete when water is added to the apparatus. Alternatively a brass tube of appropriate diameter, which may be an integral part of the cover assembly or provided separately, can be used. The tube shall be constructed so that when water is added to the container it is sprayed onto the walls of the cover in such a manner as to flow down the sides causing minimum disturbance to the concrete.



(a)
Zero Reading at Zero Pressure

(b)
Reading at Pressure P

(c)
Reading at Zero Pressure after Release of Pressure P

Note 1. In (b), the operating pressure lowers the level of concrete and water in tube.

Note 2. In (b) and (c), $A_1 = h_1 - h_2$ when the container holds concrete as shown in this figure. When the container holds only aggregate and water:

$h_1 - h_2 = G$ (aggregate correction factor)
$A_1 - G = A_c$ (air content of concrete)

Figure 5 - Air Content Apparatus

A18.7 Support

The support for the calibration cylinder shall be made of non-corrodible material and shall allow free flow of water into and out of the cylinder in the inverted position.

A18.8 Spring

The spring shall be a non-corrodible coil spring or equivalent for retaining the calibration cylinder in place.

A18.9 Transparent plates

Two rigid transparent plates are required, one suitable for use as a closure for the calibration cylinder and one as a closure for the container.

A19 Mallet

This shall be a soft-faced mallet with a mass of approximately 250g.

A20 Thermometer

The thermometer shall be suitable for measuring temperature within the intended range to an accuracy of 0.5°C. The thermometer for the mist room shall in addition be suitable for measuring the maximum and minimum air temperatures.

A21 Mould for making test cubes

A21.1 Construction and assembly

The sides of the mould shall be of ferrous metal, preferably cast steel. The mould shall include a removable steel base plate at least 10 mm thick. All parts of the mould shall be robust enough to prevent distortion. Before assembly for use, the joints between the sides of the mould and between them and the base plate shall be thinly coated with oil or grease to prevent loss of water. The parts of the mould when assembled shall be positively located and rigidly held together in such a manner as to prevent leakage from the mould. The internal faces of the assembled mould shall be thinly coated with release agent to prevent adhesion of the concrete.

The sides of the mould shall be clearly marked with a reference number or code to enable each concrete specimen to be identified when it is demoulded and the mould to be correctly reassembled.

A21.2 Tolerances

The use of a mould manufactured to the following tolerances will, if it is correctly assembled and handled with reasonable care, enable consistent production of cubes complying with the dimensional tolerances specified in Section 7 of the Standard.

(a) **Dimensions.** The depth of the mould and the distance between the two pairs of opposite internal side faces, each based on the average of four symmetrically placed measurements, shall be the nominal size of 100 ± 0.15 mm or 150 ± 0.15 mm.

(b) **Flatness.** The flatness tolerance for each internal side face shall be 0.03 mm. That for the joint faces, for the bottom surface of the assembled mould sides and for the top surface of the base plate shall be 0.06 mm.

(c) **Squareness.** The squareness tolerance for each internal side face with respect to the bottom surface of the mould and the adjacent internal side faces as datum faces shall be 0.5 mm.

(d) **Parallelism.** The parallelism tolerance for the top surface of the mould with respect to the bottom surface of the mould as datum face shall be 1 mm.

(e) **Surface texture.** The surface texture of each internal side face shall not exceed 3.2 μm R_a, when determined in accordance with BS1134.

A22 Mould for making test beams

A22.1 Construction and assembly

The sides and ends of the mould shall be of ferrous metal, preferably cast steel. The mould shall include a removable steel base plate at least 10 mm thick. All parts of the mould shall be robust enough to prevent distortion. Before assembly for use, the joints between the sides and ends of the mould and between them and the base plate shall be thinly coated with oil or grease to prevent loss of water. The parts of the mould when assembled shall be positively located and rigidly held together in such a manner as to prevent leakage from the mould. The internal faces of the assembled mould shall be thinly coated with release agent to prevent adhesion of the concrete.

The sides and ends of the mould shall be clearly marked with a reference number or code to enable each concrete specimen to be identified when it is demoulded and the mould to be correctly reassembled.

A22.2 Tolerances

The use of a mould manufactured to the following tolerances will, if it is correctly assembled and handled with reasonable care, enable consistent production of beams complying with the dimensional tolerances specified in Section 8 of this Standard.

(a) **Dimensions.** The depth and internal width of the mould, each based on the average of six measurements symmetrically placed along the axis of the mould, shall be the nominal size of 150 ± 0.15 mm.

(b) **Flatness.** The flatness tolerance for each internal side face shall be 0.03 mm per 150 mm length and 0.15 mm for the entire surface. That for the joint faces, for the bottom surface of the mould and for the top surface of the base plate shall be 0.06 mm per 150 mm length and 0.25 mm for the entire surface.

(c) **Squareness.** The squareness tolerance of each internal side face with respect to the bottom surface of the mould as datum face shall be 0.5 mm.

(d) **Parallelism.** The parallelism tolerance for the top surface of the mould with respect to the bottom surface of the mould as datum face, and for one internal side face with respect to the other internal side face as datum face, shall be 1 mm.

(e) **Surface texture.** The surface texture of each internal face shall not exceed 3.2 μm R_a, when determined in accordance with BS1134.

A23 Mould for making test cylinders

A23.1 Construction and assembly

The steel mould shall comprise a cylindrical former and a base plate. The cylindrical former shall be capable of being split longitudinally to facilitate removal of the cylinder. All parts of the mould shall be robust enough to prevent distortion. Before assembly for use, the joints between the two sections of the cylindrical former and between them and the base plate shall be thinly coated with oil or grease to prevent loss of water. When the mould is assembled, the sections of the cylindrical former shall be positively located and the whole assembly including the base plate rigidly held together in such a manner as to prevent leakage from the mould. The internal faces of the assembled mould shall be thinly coated with release agent to prevent adhesion of the concrete.

The sections of the cylindrical former shall be clearly marked with a reference number or code to enable each cylinder to be identified when it is demoulded and the mould to be correctly reassembled.

A23.2 Tolerances

The use of a mould manufactured to the following tolerances will, if it is correctly assembled and handled with reasonable care, enable consistent production of cylinders complying with the dimensional tolerances specified in Section 9 of the Standard.

(a) **Dimensions.** The internal diameter of the mould, based on the average of three pairs of measurements at right angles to each other symmetrically placed along the axis of the mould, shall be 150 ± 0.15 mm. The length, based on the average of four symmetrically placed measurements, shall be 300 ± 0.5 mm.

(b) **Flatness.** The flatness tolerance for the top surface of the base plate shall be 0.03 mm. That for the top and bottom surfaces of the cylindrical former shall be 0.06 mm and that for the joint faces shall be 0.06 mm per 150 mm length and 0.15 mm for the entire surface.

(c) **Squareness.** The squareness tolerance for the axis of the mould with respect to the bottom surface of the mould as datum face shall be a cylinder of diameter 1.0 mm perpendicular to the datum face.

(d) **Parallelism.** The parallelism tolerance for the top surface of the mould with respect to the bottom surface of the mould as datum face shall be 1 mm.

(e) **Cylindricity.** The cylindricity tolerance for the inner cylindrical surface shall be 0.5 mm.

(f) **Surface texture.** The surface texture of the top surface of the base plate shall not exceed 3.2 µm R_a , when determined in accordance with BS1134.

A24 Curing tank

The curing tank shall be constructed from corrosion-resistant material of adequate strength. The internal dimensions of the tank shall be appropriate for the number and size of the specimens to be accommodated, shall permit adequate circulation of water and shall enable specimens to be easily removed. The tank shall contain clean water which shall be replaced at least once a month. The tank shall be fitted with a device to circulate the water so that at any point in the tank where specimens are stored the temperature shall be 27 ± 3°C.

NOTE. *In order to achieve this temperature control it may be necessary to provide the tank with a lid and/or insulation and/or a water cooling system in addition to the water heating system.*

A25 Mist room

Temperature and humidity controls shall be installed in the mist room such that the temperature is maintained at 27 ± 3°C and the atmosphere shall have a relative humidity of not less than 95%. All surfaces of the specimens in storage shall both look moist and feel moist at all times.

APPENDIX B

CALIBRATION TESTS

CONTENTS

APPENDIX B - CALIBRATION TESTS

B1 Calibration of the container for the determination of the density of compacted fresh concrete

The empty container shall be weighed and placed on a horizontal surface and filled with water at a temperature of 25 ± 5°C so that no meniscus is above the rim. If necessary, a sufficient known volume of water may be removed with a pipette, to allow the container to be lifted and placed on the platform of the weighing equipment without loss of water. The mass of the water required to fill the container shall be determined. The volumetric capacity of the container shall be calculated to the nearest 0.01 kg by dividing the mass of water required to fill the container by 1000kg/m^3. The volumetric capacity shall be expressed to the nearest 0.00001 m^3.

The calibration method described shall be made as frequently as necessary to check the volume of the container.

B2 Calibration tests for the determination of the air content of fresh concrete

The calibration tests described in Cl. B2.1 to B2.4 shall be made at the time of the initial calibration of the apparatus and at any time when it is necessary to check whether the capacity of the calibration cylinder or container may have changed. The calibration test described in Cl. B2.5 and B2.6 shall be made as frequently as necessary to check the pressure gauge so as to ensure that the proper gauge pressure P is being used. Recalibration of the apparatus will also be required when the location at which it is to be used varies in elevation by more than 200m from that at which it was last calibrated.

B2.1 Capacity of the calibration cylinder

Using Type 3 weighing equipment, the capacity of the calibration cylinder shall be obtained by determining the mass of water required to fill it. For this purpose, the weighed cylinder shall be filled with water at ambient temperature (20°C to 30°C) and carefully covered with the previously weighed transparent plate. Air bubbles shall not be allowed to be trapped under the plate and surplus water shall be wiped away before weighing the assembly. By repeating this procedure, a total of three weighings of the covered cylinder filled with water shall be obtained. The average mass of water $\boldsymbol{m_1}$ contained in the full cylinder shall be calculated and recorded to the nearest 0.5 g.

B2.2 Capacity of the container

Using Type 2 weighing equipment, the capacity of the container shall be obtained by determining the mass of water required to fill it. For this purpose, a thin film of grease shall be smeared on the flange of the container, and after weighing it empty, it shall be filled with water at ambient temperature (20°C to 30°C) and a water-tight joint made by sliding the weighed transparent plate over the top of the container. Air bubbles shall not be allowed to be trapped under the plate and surplus water shall be wiped away before weighing the assembly. By repeating this procedure, a total of three weighings of the covered cylinder filled with water shall be obtained. The average mass of water $\boldsymbol{m_2}$ contained in the full cylinder shall be calculated and recorded to the nearest 5 g.

B2.3 Pressure expansion constant, *e*

The pressure expansion constant shall be determined by filling the apparatus with water, making sure that all entrapped air has been removed and the water level is exactly on the zero mark, and applying an air pressure equal to the operating pressure determined by the routine calibration test (see Cl. B2.5).

The reading of the water column (in percent air content) will be the pressure expansion constant *e* for the apparatus.

B2.4 Calibration constant, *K*

The calibration constant is the reading needed on the air content scale during the routine calibration procedure to obtain the gauge pressure required to make the graduations on the air content scale correspond directly to the percentage of air introduced into the container by the calibration cylinder when the container is full of water.

The constant K is generally calculated as follows (see Note):

$$K = 0.98\,R + e \qquad \textbf{(B-1)}$$

where

- e is the pressure expansion constant
- R is the capacity of the calibration cylinder expressed relative to the capacity of the container and is calculated as follows:

$$R = \frac{m_1}{m_2} \cdot 100\% \qquad \textbf{(see Cl. B2.1 and B2.2)}$$

NOTE. *The factor 0.98 is used to correct for the reduction in the volume of air in the calibration vessel when it is compressed by a depth of water equal to the depth of the container. This factor is approximately 0.98 for a 200 mm deep container at sea level. Its value decreases to approximately 0.975 at 1500 m above sea level and 0.97 at 4000 m above sea level. The value of the constant will decrease by about 0.01 for each 100 mm increase in bowl depth. Hence the term 0.98R represents the effective volume of the calibration vessel expressed as a percentage of the container under normal operating conditions.*

B2.5 Required operating pressure

The calibration cylinder support shall be placed centrally on the bottom of the clean container. The cylinder shall then be placed on the support with its open end downward. The coil spring shall be placed on the cylinder and the cover assembly carefully clamped in place.

The apparatus shall be filled with water at ambient temperature to a level above the zero mark on the air content scale. The air vent shall be closed and the air pumped into the apparatus approximately to the operating pressure. The sides and cover shall be lightly tapped with the mallet to remove as much as possible of the entrapped air adhering to the interior surfaces of the apparatus and the pressure shall be gradually reduced by opening the vent. The water shall be brought exactly to the zero mark by bleeding water through the small valve in the conical cover and the air vent shall then be closed. Pressure shall be applied by means of the pump until the reading of the water level equals the calibration constant K. The pressure P indicated on the pressure gauge shall be recorded. The vent shall be opened and the pressure gradually released until zero reading is indicated. If the water level returns to a reading less than 0.05% air content, the pressure P shall be taken as the operating pressure. If the water pressure fails to return to a reading below 0.05% air content, the apparatus shall be checked for leakage and the procedure repeated.

B2.6 Alternative operating pressure

The range of air contents which can be measured with a particular apparatus can be extended by determining an appropriate alternative operating pressure, e.g. if the range is to be doubled, the alternative operating pressure P_1 is that for which the apparatus indicates half of the calibration reading K (see Cl. B2.4).

Exact calibration will require the determination of the pressure expansion constant e (see Cl. B2.3) for the reduced operating pressure. For most purposes the change in pressure expansion constant can be disregarded and the alternative operating pressure can be determined during the determination of the normal operating pressure.

B2.7 Aggregate correction factor

The aggregate correction factor will vary with different aggregates and although it will remain reasonably constant for a particular aggregate an occasional check should be carried out. The aggregate correction factor can be determined only by test as it is not directly related to the water absorption of the particles.

B2.7.1 Aggregate sample size

The aggregate correction factor shall be determined by applying the operating pressure on a combined sample of the coarse and fine aggregates in the approximate proportions and moisture conditions that exist in the concrete sample. The sample of aggregates shall be obtained either by washing the cement from the concrete sample tested for air content through a 150µm sieve, or by using a combined fine and coarse aggregate similar to that used in the concrete. In the latter case, the masses of fine and coarse aggregates to be used shall be calculated as follows:

$$m_f = V_o D p_f \quad \textbf{(B-2)}$$

$$m_c = V_o D p_c \quad \textbf{(B-3)}$$

where

p_f and p_c are the proportions of fine and coarse aggregates respectively, expressed as fractions by mass of the total concrete mix (aggregates, cement and water)

V_o is the capacity of the container(in m^3)

D is the density of the concrete to be tested in (kg/m^3), determined in accordance with this Standard or calculated from the known proportions and densities of the materials and the nominal air content

B2.7.2 Filling the container

The container shall be partially filled with water and the combined sample of aggregate introduced in small quantities. This shall be done in such a manner as to entrap as little air as possible and if necessary additional water shall be added to inundate all of the aggregate. After the addition of each quantity of aggregate, any foam formed shall be promptly removed. Any entrapped air shall be released by stirring the aggregate with the tamping rod and tapping the container with the mallet.

B2.7.3 Determination of aggregate correction factor

When all the aggregate has been placed in the container, the flanges of the container shall be wiped clean and the cover clamped in position. The apparatus shall be filled with water and lightly tapped with the mallet to remove air adhering to the interior surfaces of the cover.

The water level in the standpipe shall be brought to zero by bleeding through the small valve with the air vent open. The operating pressure P shall be applied after closing the air vent.

The reading of the gauge tube h_1 shall be recorded, the pressure shall then be released and a further reading h_2 shall be taken. The entire procedure shall be repeated and a second pair of readings obtained. The average value of h_1-h_2 shall be taken as the aggregate correction factor G. Should the two values of h_1-h_2 differ by more than 0.1% air content, further determinations shall be made until consistent results are obtained.