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BRITISH STANDARD

BS 1881-103:
1993

Testing concrete —

Part 103: Method for determination of compacting factor

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/517, Concrete, to Subcommittee B/517/1, Concrete production and testing, upon which the following bodies were represented:

Association of Lightweight Aggregate Manufacturers
Association of Metropolitan Authorities
British Aggregate Construction Materials Industries
British Cement Association
British Civil Engineering Test Equipment Manufacturers' Association
British Precast Concrete Federation
British Ready Mixed Concrete Association
Building Emloyers' Confederation
Cement Admixtures Association
Cementitious Slag Makers' Association
Concrete Society
County Surveyors' Society
Department of the Environment (Building Research Establishment)
Department of the Environment (Property Services Agency)
Department of Transport
Department of Transport (Transport Research Laboratory)
Electricity Association
Federation of Civil Engineering Contractors
Institute of Concrete Technology
Institution of Civil Engineers
Institution of Structural Engineers
Institution of Water and Environmental Management
National House-Building Council
Quality Ash Association
Sand and Gravel Association
Society of Chemical Industry

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Foreword

This Part of BS 1881 has been prepared under the direction of Technical Committee B/517, Concrete. It is a new edition that incorporates the minor changes to equipment made in 1989, the data on the precision of the method when using the conventional (gravimetric) procedure, added by amendment in 1992, and a new annex on the volumetric procedure. This edition does not represent a full revision as test methods for concrete are currently in preparation by CEN/TC 104 "Concrete — Performance, production, placing and compliance criteria" and the UK is fully involved in this work. The resulting European Standards will be implemented as revisions of the corresponding Parts of BS 1881. This new edition of BS 1881-103 supersedes BS 1881-103:1983 and DD 90:1983, which are withdrawn.

The new annex A describes the alternative (volumetric) procedure for determining the compacting factor. This procedure was originally published in DD 90:1983. By this procedure the compacting factor is determined from the reduction in volume that occurs when a defined volume of partially compacted concrete is fully compacted. This has the advantage of not requiring the use of scales or a balance and can be carried out in less time than the gravimetric method. The volumetric procedure is similar to that described in ISO 4111.

Four methods of determining the workability of concrete are given in Parts 102 to 105 of BS 1881, these being the slump, compacting factor, Vebe time and flow methods. The methods are appropriate to concrete mixes of different workability as follows:

Workability	Method
Very low	Vebe time
Low	Vebe time, compacting factor
Medium	Compacting factor, slump
High	Compacting factor, slump, flow
Very high	Flow

There are no unique relationships between the values yielded by the four methods. Relationships depend upon such factors as the shape of the aggregate, the sand fraction and the presence of entrained air.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 1881 describes the method for determining the compacting factor of concrete of low, medium and high workability. The method applies to plain and air-entrained concrete, made with lightweight, normal weight or heavy aggregates having a nominal maximum size of 40 mm or less but not to aerated concrete, no-fines concrete and concrete which cannot be compacted by vibration alone. The measurement of compacting factor is not suitable for determining the workability of concrete when the value obtained lies outside the range 0.70 to 0.98. The method can be carried out either by using the conventional (gravimetric) procedure or by using the alternative (volumetric) procedure described in annex A.

2 References

2.1 Normative references

This Part of BS 1881 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 1881 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 1881 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 1881 the definitions given in BS 5328-1:1991 and BS 1881-101:1983 apply.

4 Apparatus

4.1 *Sampling tray,* minimum dimensions 900 mm × 900 mm × 50 mm deep, of rigid construction and made from a non-absorbent material not readily attacked by cement paste.

4.2 *Square mouthed shovel*, size 2 in accordance with BS 3388:1973.

4.3 *Scales or balance*, capable of weighing up to 25 kg and accurate to within 10 g.

The balance shall be calibrated on initial commissioning, and at least annually thereafter, using weights of which the accuracy can be traced to the national standard of mass. The balance shall be checked after relocation or disturbance. A certificate stating the accuracy of the balance shall be obtained from the organization carrying out the check.

4.4 *Compacting factor apparatus*, consisting of two conical hoppers mounted above a cylinder; its essential dimensions are shown in Table 1 and Figure 1.

The hopper and cylinder shall be of rigid construction and 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 rim 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 in which the hoppers and cylinder are mounted shall be of rigid construction and shall firmly locate them in the relative positions indicated in Table 1. The cylinder shall be easily detachable from the frame.

4.5 *Steel floats*. Two plasterer's steel floats.

4.6 *Scoop*, as described in **3.1** of BS 1881-101:1983.

4.7 *Tamping rod*, made out of straight iron or steel bar of circular cross section, (16 ± 1) mm diameter and (600 ± 5) mm long, with both ends hemispherical.

4.8 *Compacting bar or vibrator*. Compacting bar made from iron or steel, weighing (1.8 ± 1.0) kg, at least 380 mm long and having a ramming face (25.0 ± 0.5) mm square; or a vibrating hammer or table suitable for compacting the concrete in accordance with **7.2** or **7.3**.

5 Sampling

Obtain the sample of fresh concrete by the procedure given in BS 1881-101:1983 or BS 1881-125:1986. Commence the determination of compacting factor as soon as possible after sampling.

Table 1 — Essential dimensions of the compacting factor apparatus

Detail	Dimension mm	
	Preferred apparatus	Alternative apparatus[a]
Upper hopper A:		
Top internal diameter, *D*	260 ± 2	254 ± 2
Bottom internal diameter, *E*	130 ± 2	127 ± 2
Internal height, *F*	280 ± 2	279 ± 2
Lower hopper B:		
Top internal diameter, *G*	240 ± 2	229 ± 2
Bottom internal diameter, *H*	130 ± 2	127 ± 2
Internal height, *J*	240 ± 2	229 ± 2
Distance, *K*, between bottom of upper hopper A and top of lower hopper B	200 ± 5	203 ± 5
Distance, *L*, between bottom of lower hopper B and top of cylinder C	200 ± 5	203 ± 5
Cylinder C:		
Internal diameter, *M*	150 ± 1	152 ± 1
Internal height, *N*	285 ± 1	305 ± 1
Radius between wall and base, *P*	20	—

[a] Owing to current availability, apparatus having the dimensions given in this column may be used until 31 January 1995. The column will then be deleted by amendment and the use of such apparatus will no longer comply with the standard.

6 Preparing the sample

Empty the sample from the container(s) onto the sampling tray (**4.1**). Ensure that no more than a light covering of slurry is left adhering to the container(s).

Thoroughly mix the sample by shovelling it to form a cone on the sampling tray and turning this over with the shovel (**4.2**) to form a new cone, the operation being carried out three times. When forming the cones, deposit each shovelful of the material on the apex of the cone so that the portions which slide down the sides are distributed as evenly as possible and so that the centre of the cone is not displaced. Flatten the third cone by repeated vertical insertion of the shovel across the apex of the cone, lifting the shovel clear of the concrete after each insertion.

CAUTION. When cement is mixed with water, alkali is released. Take precautions to avoid dry cement entering the eyes, mouth and nose when mixing concrete. Prevent skin contact with wet cement or concrete by wearing suitable protective clothing. If cement or concrete enters the eye, immediately wash it out thoroughly with clean water and seek medical treatment without delay. Wash wet concrete off the skin immediately.

Determine the compacting factor in accordance with clauses **7** and **8**, or in accordance with annex A.

7 Gravimetric procedure

7.1 Procedure

7.1.1 Using the scales or balance (**4.3**), weigh the empty cylinder (**4.4**) and record its mass to the nearest 10 g.

7.1.2 Ensure that the internal surfaces of the hoppers (**4.4**) and cylinder are smooth, clean and damp but free from superfluous moisture. Place the frame (**4.4**) in a position free from vibration or shock in such a manner that it is stable with the axes of the hoppers and the cylinder all lying on the same vertical line. Close the two trap doors and place the two floats (**4.5**) on the cylinder so as to cover its top.

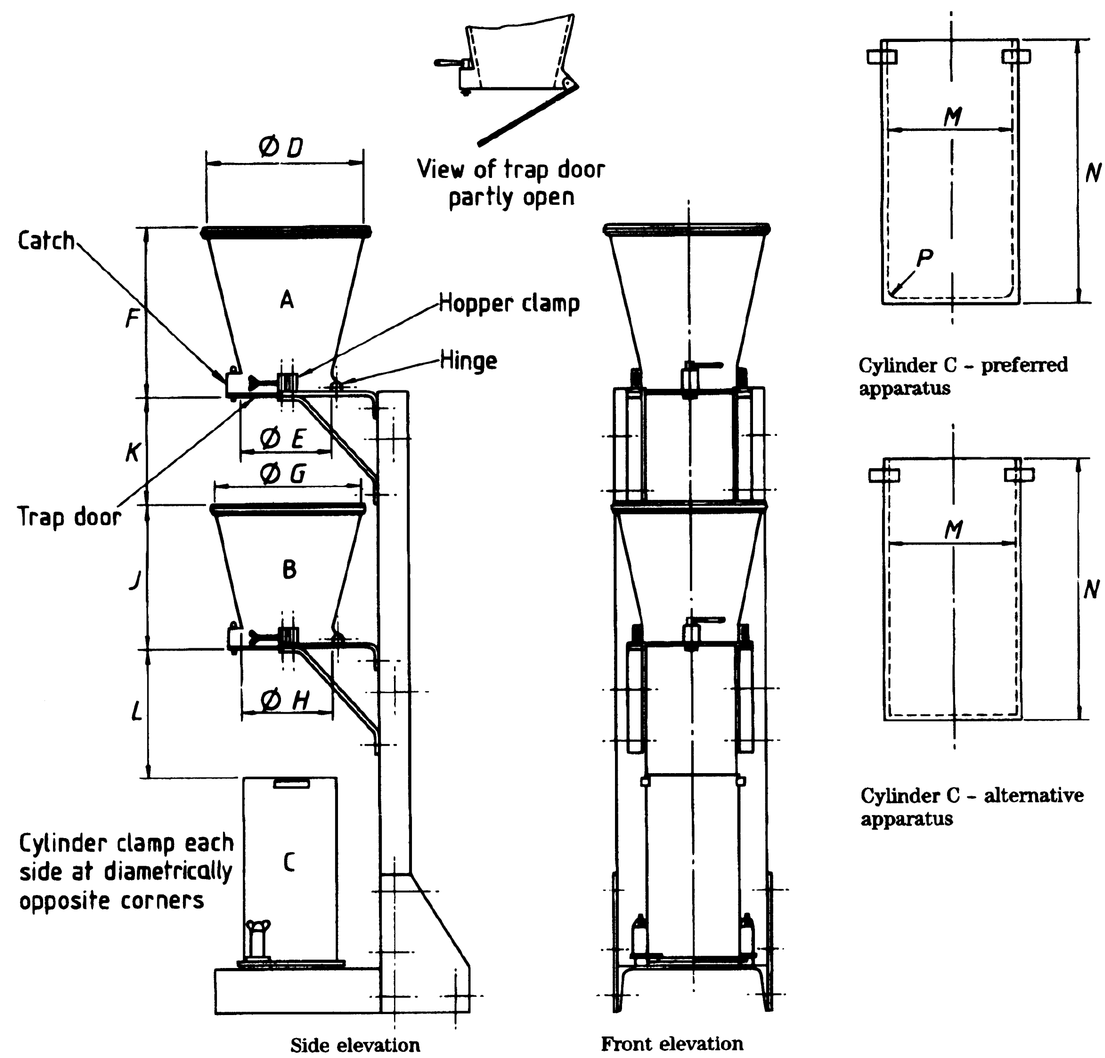

Figure 1 — Compacting factor apparatus

7.1.3 Place the sample of concrete gently in the upper hopper using the scoop (**4.6**) until the hopper is filled to the level of the rim. Open the upper trap door so that the concrete falls into the lower hopper. Immediately after the concrete has come to rest, remove the floats from the top of the cylinder, open the trap door of the lower hopper and allow the concrete to fall into the cylinder.

7.1.4 Certain mixes have a tendency to stick in one or both of the hoppers. If this occurs, help the concrete through by pushing the tamping rod (**4.7**) 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, raise the rod and repeat the process until the concrete falls through the hopper. Count the number of times the concrete is rodded as this provides a guide to the cohesiveness of the concrete.

7.1.5 Cut off the excess concrete remaining above the level of the top of the cylinder 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, at the same time keeping them pressed on the top edge of the cylinder. Wipe clean the outside of the cylinder.

7.1.6 Within 150 s of placing the sample in the upper hopper (**7.1.3**), weigh the cylinder and its contents. By subtracting the mass of the empty cylinder, calculate and record the mass of the partially-compacted concrete to the nearest 10 g.

7.1.7 Empty the partially-compacted concrete from the cylinder and refill it 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, by means of the scoop, place the concrete in the cylinder in six layers approximately equal in depth and compact each layer by using either the compacting bar or the vibrator in the manner described in **7.2** or **7.3**. After the top layer has been compacted, smooth it level with the top of the cylinder, using one of the plasterer's floats, and wipe clean the outside of the cylinder. Weigh the cylinder and its contents to the nearest 10 g, and by subtracting the mass of the empty cylinder, calculate and record the mass of the fully-compacted concrete to the nearest 10 g.

7.2 Compacting with compacting bar

When compacting each layer with the compacting bar (**4.8**), distribute the strokes of the compacting bar in a uniform manner over the cross section of the cylinder, and ensure that the compacting bar does not penetrate significantly any previous layer nor forcibly strike the bottom of the cylinder when compacting the first layer. The number of strokes per layer required to produce full compaction will depend upon the consistence of the concrete but in no case shall the concrete be subjected to fewer than 30 strokes per layer. Record the number of strokes.

7.3 Compacting with vibrator

When compacting each layer by means of the vibrating hammer or table (**4.8**), use applied vibration of the minimum duration necessary to achieve full compaction of the concrete. Over-vibration may cause excessive segregation and laitance or loss of entrained air, if present. The required duration of vibration will depend upon the workability of the concrete and the effectiveness of the vibrator. Vibration shall cease as soon as the surface of the concrete becomes relatively smooth and has a glazed appearance. Record the duration of vibration.

NOTE Workability of a concrete mix 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.

8 Expression of results

8.1 Calculation

Calculate the compacting factor from the formula:

$$\text{compacting factor} = \frac{m_p}{m_f}$$

where

m_p is the mass of the partially-compacted concrete (in g);

m_f is the mass of the fully-compacted concrete (in g).

Express the result to two decimal places.

8.2 Precision

Precision data are given in Table 2. These apply to compacting factor measurements made on concrete taken from the same sample and when each test result is obtained from a single compacting factor determination.

Table 2 — Precision data for compacting factor measurements

Range of compacting factor	Repeatability conditions		Reproducibility conditions	
	S_r	r	S_R	R
0.82 to 0.95	0.011	0.03	0.014	0.04

NOTE 1 The precision data were determined as part of an experiment carried out in 1987 in which precision data were obtained for several of the tests described in BS 1881. The experiment involved 16 operators. The concretes were made using an ordinary Portland cement, Thames Valley sand, and Thames Valley 10 mm and 20 mm coarse aggregates.

NOTE 2 The difference between two test results from the same sample by one operator using the same apparatus within the shortest feasible time interval will exceed the repeatability value r on average not more than once in 20 cases in the normal and correct operation of the method.

NOTE 3 Test results on the same sample obtained within the shortest feasible time interval by two operators each using their own apparatus will differ by the reproducibility value R on average not more than once in 20 cases in the normal and correct operation of the method.

NOTE 4 For further information on precision, and for definitions of the statistical terms used in connection with precision, see BS 5497-1:1987.

9 Report

9.1 General

The report shall affirm that the compacting factor was determined in accordance with this Part of BS 1881. The report shall state whether or not a certificate of sampling is available. If available, a copy of the certificate shall be provided.

9.2 Information to be included in the test report

9.2.1 *Obligatory information*

The following information shall be included in the test report:

a) date, time and place of sampling and sample identity number;

b) time and place of test;

c) type of apparatus (see Table 1);

d) number of times concrete was rodded whilst in each hopper;

e) compacting factor and whether measured by using the gravimetric or volumetric procedure;

f) method of compaction (hand or vibration) including type of equipment used, the number of strokes of the compacting bar or the duration of vibration;

g) name of person carrying out the test.

9.2.2 ***Optional information***

If requested, the following information shall be included in the test report:

a) name of project and place where concrete was used;

b) name of supplier and source of concrete;

c) date and time of production of concrete or delivery to site;

d) specification of the concrete mix (e.g. strength grade).

Annex A (normative) Volumetric procedure

A.1 General

In this method, the compacting factor is calculated from the change in volume of fresh concrete when compacted. The procedure is similar to that described in ISO 4111 but is preceded by a partial compaction caused by allowing the sampled concrete to fall through the two hoppers of the apparatus.

A.2 Apparatus

A.2.1 *General*. Use the apparatus described in **4.1**, **4.2** and **4.4** to **4.8**, together with the following item.

A.2.2 *Rule*, graduated in one of the following ways:

a) from 0 mm to 300 mm at 1 mm intervals, the zero point being at one end of the rule;

b) for use with the preferred form of apparatus (see Table 1), expressing the compacting factor directly from 1.00 to 0.65, in increments of 0.005, by means of graduation marks spaced at intervals of 1.425 mm, the value of 1.00 being flush with one end of the rule, the total length of the rule being about 300 mm and clearly marked "preferred apparatus";

c) for use the with the alternative form of apparatus (see Table 1), expressing the compacting factor directly from 1.0 to 0.65, in increments of 0.005, by means of graduation marks spaced at intervals of 1.525 mm, the value of 1.00 being flush with one end of the rule, the total length of the rule being about 300 mm and clearly marked "alternative apparatus".

A.3 Procedure

Take the sample of fresh concrete as in clause **5** and prepare it as in clause **6**.

Follow the procedure described in **7.1.2** to **7.1.5**. Compact the concrete by hand or vibration as appropriate, as described in **7.2** or **7.3**, to produce full compaction with neither excessive segregation nor laitance.

Then measure the distance of the concrete surface from the top of the cylinder using the rule described in **A.2.2** a), taking measurements at four positions equally spaced around the circumference. Alternatively, the rules described in **A.2.2** b) or **A.2.2** c) may be used, as appropriate. Complete the entire procedure within 5 min of placing the sample in the upper hopper (**7.1.3**).

A.4 Calculation and expression of results

Record the compacting factor directly from the rules described in **A.2.2** b) or **A.2.2** c) as appropriate to the apparatus used. Alternatively, if using the rule described in **A.2.2** a), calculate the compacting factor from equation (1) if the preferred apparatus is used, or from equation (2) if the alternative apparatus is used:

$$\text{Compacting factor} = \left(1 - \frac{h}{285}\right) \qquad (1)$$

$$\text{Compacting factor} = \left(1 - \frac{h}{305}\right) \qquad (2)$$

where

h is the mean distance of the concrete surface from the top of the cylinder (in mm).

Express the result to two decimal places.

A.5 Report

Report the results of the test in accordance with clause **9**.

List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 1881, *Testing concrete*.

BS 1881-101:1983, *Method of sampling fresh concrete on site*.

BS 1881-125:1986, *Methods for mixing and sampling fresh concrete in the laboratory*.

BS 3388:1973, *Specification for forks, shovels and spades*.

BS 5328, *Concrete*.

BS 5328-1:1991, *Guide to specifying concrete*.

Informative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 1881, *Testing concrete*.

BS 1881-102:1983, *Method for determination of slump*[1].

BS 1881-104:1983, *Method for determination of Vebe time*[1].

BS 1881-105:1984, *Method for determination of flow*[1].

BS 5497, *Precision of test methods*.

BS 5497-1:1987, *Guide for the determination of repeatability and reproducibility for a standard test method by inter-laboratory tests*.

ISO standards publications

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO), Geneva. (All publications are available from BSI Sales.)

ISO 4111:1979, *Fresh concrete — Determination of consistency — Degree of compactability (compaction index)*.

[1] Referred to in the foreword only.

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