BRITISH STANDARD

BS 1881-121: 1983

Testing concrete —

Part 121: Method for determination of static modulus of elasticity in compression

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Cooperating organizations

The Cement, Gypsum, Aggregates and Quarry Products Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following:

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Association of County Councils
Association of District Councils
Association of Metropolitan Authorities
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Electricity Supply Industry in England and Wales
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Coopted member

This British Standard, having been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee, was published under the authority of the Board of BSI and comes into effect on
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Amendments issued since publication

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Contents

Foreword

This Part of this standard, prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee, is a revision of clause **3** of BS 1881-5:1970 which has been deleted by Amendment No. 1 to that standard.

This static modulus of elasticity test is taken direct, with minor deviations, from ISO 6784, published by the International Organization for Standardization (ISO), which adopted a UK draft.

No estimate of repeatability or reproducibility is given in this Part of this British Standard. Reference should be made to BS 5497-1 for further information on the determination of repeatability and reproducibility.

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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.

TESTING CONCRETE

SUMMARY OF PUBLISHED BRITISH STANDARDS

Due to the present restructuring of BS1881 *Methods of testing concrete* and BS4408 *Recommendations for non-destructive methods of test for concrete*, the following information has been published, to help keep readers up-to-date, with the situation so far. (February 1983).

BS 1881-1:1970	Method of sampling fresh concrete on site
	Method of mixing and sampling fresh concrete in the laboratory
BS 1881-2:1970	Slump test
	Compacting factor test
	"V–B" consistometer test
	Method for determination of weight per cubic metre of fresh concrete
	Method for determination of air content of fresh concrete
	Analysis of fresh concrete
BS 1881-3:1970	Making and curing test cubes
	Making and curing no-fines test cubes
	Making and curing test beams
	Making and curing test cylinders
	Method for accelerating the curing of test specimens:
	1) the 55 °C method
	2) the 82 °C method
BS 1881-5:1970	Method for determination of the dynamic modulus of elasticity by an electrodynamic method
	Method for determination of changes in length of concrete prisms (initial drying shrinkage, drying shrinkage and wetting expansion)
	Method for determination of initial surface absorption
BS 1881-6:1971	Analysis of hardened concrete
BS 1881-114:1983	Method for determination of density of hardened concrete
BS 1881-115:1983	Specification for compression testing machines for concrete
BS 1881-116:1983	Method for determination of compressive strength of concrete cubes
BS 1881-117:1983	Method for determination of tensile splitting strength
BS 1881-118:1983	Method for determination of flexural strength
BS 1881-119:1983	Method for determination of compressive strength using portions of beams broken in flexure (equivalent cube method)
BS 1881-120:1983	Method for determination of the compressive strength of concrete cones
BS 1881-121:1983	Method for determination of static modulus of elasticity in compression
BS 1881-122:1983	Method for determination of water absorption
BS 4408-1:1969	Electromagnetic cover measuring devices
BS 4408-2:1969	Strain gauges for concrete investigations
BS 4408-3:1970	Gamma radiography of concrete
BS 4408-4:1971	Surface hardness methods of testing concrete
BS 4408-5:1974	Measurement of the velocity of ultrasonic pulses in concrete.

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1 Scope

This Part of this British Standard describes a method for the determination of the static modulus of elasticity in compression of hardened concrete, on test specimens which may be cast or taken from a structure.

2 Definitions

For the purposes of this Part of this standard the definitions in BS 5328 apply together with the following.

static modulus of elasticity in compression

the secant modulus, which, in newtons per square millimetre, is calculated from the formula:

$$\frac{\Delta_\sigma}{\Delta_\epsilon}$$

where Δ_σ and Δ_ϵ are the differences in stress and strain, respectively, between a basic loading level of 0.5 N/mm^2 and an upper loading level of one-third of the compressive strength of the concrete

3 Apparatus

3.1 *Compression testing machine.* The machine shall comply with BS 1881-115 for compression testing machines. It shall be capable of applying the load at the specified rate and maintaining it at the required level.

3.2 *Strain measuring apparatus.* The strain measuring apparatus shall have an accuracy of ± 5 micro strain.

Instruments for measuring length (for example mirror or dial gauge extensometers, resistance strain gauges, inductance gauges, vibrating wire strain gauges) shall have a gauge length of not less than two-thirds of the width or diameter of the test specimen (2/3*d*) and shall be attached in such a way that the gauge points are equidistant from the two ends of the specimen and at a distance not less than one-quarter of the length of the test specimen (*L*/4) from its ends.

At least one pair of measurements shall be taken on opposite sides of the specimen. With rectangular specimens cast in a horizontal position, the gauge lengths should be arranged on the vertical sides as cast.

NOTE Where fixing points for extensometers are required, threaded inserts cast into the specimen are preferred.

If adhesives are used for the fixing points they should be rapid setting and set hard. The specimen shall be removed from the curing tank for as short a time as possible to allow the surface to be dried for the application of adhesive. Specimens shall not be less than 7 days old when removed for this purpose. Specimens shall be re-immersed in water for a minimum of 12 h before testing.

4 Test specimens

4.1 General. A minimum of four moulded specimens shall be made. Three of these shall be used to determine the mean compressive strength or alternatively, three extra cubes may be made at the same time as the specimens for this test and tested to obtain the compressive strength of the concrete. For specimens taken from a structure the compressive strength may be estimated from other information available.

NOTE Moulded test specimens should preferably be cylinders 150 mm in diameter and 300 mm in height. Alternatively, other test specimens may be used, provided that the length to diameter ratio, *l*/*d* is not less than 2 nor more than 5, where *l* is the length and *d* the diameter, or, for a square cross-section, *d* is the width of one face of the specimen.

The minimum dimensions of moulded specimens shall be 100 mm or at least four times the nominal maximum size of aggregate in the concrete whichever is the larger. In the case of specimens drilled or cut out of a structure or other sample of concrete these dimensions shall be not less than three times the nominal maximum size of aggregate in the concrete nor less than 100 mm.

4.2 Preparation of test specimens

4.2.1 Moulded test specimens (beams or cylinders) shall be made, cured and stored in accordance with the relevant Parts of this standard. In addition, for cylindrical specimens, whilst the concrete is still plastic first finish the surface of the concrete level with the top of the mould and then press the top plate, coated with a thin film of mould oil, down on to the concrete with a rotary motion until it makes complete contact with the rim of the mould. Attach the top plate rigidly to the top of the mould and lay the mould, with top and base plates, with its axis horizontal on supports which prevent any movement. Lightly tap the capping plate to ensure good contact with the trowelled surface of the concrete. Allow the cylinder to harden in a horizontal position until it is removed from the mould.

4.2.2 Specimens drilled as cores from a structure shall be drilled, stored and their ends prepared by grinding or capping in accordance with Part 120 of this standard.

4.2.3 Unless rectangular moulded specimens comply with the dimensional tolerances in **4.3**, their ends and those of other sawn specimens shall be ground to conform with the tolerances.

NOTE Moulds for beams do not necessarily conform with the squareness tolerance for the end face relative to the axis.

4.3 Tolerances. The tolerances in accordance with BS 308-3 of the prepared specimens shall be as follows.

a) *Flatness.* The flatness tolerance for the prepared end surfaces shall be 0.06 mm wide.

b) *Squareness.* The squareness tolerance (squareness 3 of BS 308-3) for the end prepared first with respect to the axis of the specimen as datum axis shall be 2.0 mm wide.

c) *Parallelism.* The parallelism tolerance (parallelism 4 of BS 308-3) for the prepared surface with respect to the opposite surface of the specimen as datum face shall be 2.0 mm wide for all specimens. For rectangular specimens, the parallelism tolerance of opposite sides of the specimen shall also be 2.0 mm wide.

d) *Cylindricity.* The cylindricity tolerance for moulded cylindrical specimens shall be 2.0 mm or as given in BS 1881-120.

4.4 Density. Measure the as-received or saturated density of the specimens by the method described in BS 1881-114.

5 Procedure

5.1 Determination of compressive strength. All specimens shall be tested in a moist condition.

Determine the compressive strength of the concrete on three companion specimens, from the same batch as those to be used for the determination of the static modulus of elasticity, and made and cured under similar conditions, by the compression test carried out in accordance with BS 1881-116.

NOTE Alternatively, the compressive strength may be estimated on other information available, e.g. from cube strengths and the basis of the estimate reported.

The mean value of the compressive strength, f_c, determines the stress applied in the determination of static modulus of elasticity.

5.2 Determination of static modulus of elasticity. Place the test specimen, with the measuring instruments or fixing points attached axially, centrally in the machine. Apply the basic stress of 0.5 N/mm^2 (σ_b), and record the strain gauge readings taken at each measurement line.

Steadily increase the stress at a constant rate within the range 0.6 ± 0.4 N/(mm^2 s) until the stress equal to one-third of the compressive strength of the concrete ($\sigma_a = f_c/3$) is reached.

NOTE The preferred rate is 0.6 N/(mm^2 s).

Maintain the stress for 60 s and record the strain readings taken during the succeeding 30 s at each measurement line. If the individual strains are not within a range of ± 10 % of their mean value at σ_a, recentre the test specimen and repeat the test. If it is not possible to reduce the differences to within this range, do not proceed with the test.

When the centring is sufficiently accurate reduce the load, at the same rate as during loading, to the level of the basic stress. Carry out at least two additional preloading cycles, using the same loading and unloading rate, and maintaining the stress (σ_a and σ_b) constant for a period of 60 s. After completion of the last preloading cycle and a waiting period of 60 s under the stress σ_b = 0.5 N/mm^2, at the various measurement lines record the strain reading, ϵ_b, taken during the succeeding 30 s.

Reload the specimen to stress σ_a at the specified rate, and at the various measurement lines record the strain reading ϵ_a, taken within 30 s.

When all elasticity measurements have been completed, increase the load on the test specimen, at the specified rate, until failure of the specimen occurs. If the compressive strength of the specimen differs from f_c by more than 20 %, this shall be noted in the test report.

6 Calculation and expression of results

Calculate the mean strain ϵ_a and ϵ_b respectively.

The static modulus of elasticity in compression E_c (in N/mm^2) is given by the formula

$$\frac{\Delta_\sigma}{\Delta_\epsilon} = \frac{\sigma_a - \sigma_b}{\epsilon_a - \epsilon_b}$$

where

σ_a is the upper loading stress (in N/mm^2) ($\sigma_a = f_c/3$);

σ_b is the basic stress (i.e. 0.5 N/mm^2);

ϵ_a is the mean strain under the upper loading stress;

ϵ_b is the mean strain under the basic stress.

Express the result to the nearest 500 N/mm^2 for values over 10 000 N/mm^2, and to the nearest 100 N/mm^2 for values below 10 000 N/mm^2.

7 Test report

7.1 General. The test report shall affirm that the tests were carried out in accordance with this Part of this standard. The report shall also state whether or not certificates of sampling, specimen preparation and curing are available. If available, a copy of each certificate shall be provided.

7.2 Information to be provided by the producer of the test specimens for inclusion in the test report

7.2.1 *Mandatory information.* The following information shall be provided by the producer of the test specimens for inclusion in the test report:

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

b) identification of the specimen;

c) time and place of making specimens;

d) date of production of the concrete;

e) number and nominal size of specimens;

f) conditions of curing and storage;

g) name of person making specimens;

h) required age of the specimen at the time of testing, or date of testing if the age is not known.

7.2.2 *Optional information.* If requested the following information shall be provided by the producer of the test specimens for inclusion in the test report:

a) building project;

b) part or component of the building;

c) admixtures used;

d) specified compressive strength.

7.3 Information to be provided by the test laboratory for inclusion in the test report. The following information shall be provided by the test laboratory for inclusion in the test report:

a) condition of the specimen when received, and any surface treatment;

b) type and dimensions of the specimen;

c) date of receipt of the specimen;

d) conditions of curing and storage;

e) date of test;

f) age of the specimen at the time of testing;

g) density (as-received or saturated and method of determining volume);

h) type and number of measuring instruments and the gauge length;

i) mean compressive strength of the companion specimens or, if estimated, the basis of the estimate;

j) compressive strength of the specimen used for the determination of the static modulus of elasticity;

k) static modulus of elasticity;

l) appearance of the concrete and type of fracture, if unusual;

m) certificate that the test has been carried out in accordance with this Part of this standard;

n) other remarks.

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Publications referred to

BS 308, Engineering drawing practice.
BS 308-3, Geometrical tolerancing.
BS 1881, Testing concrete.
BS 1881-114, Method for determination of density of hardened concrete.
BS 1881-115, Specification for compression testing machines for concrete.
BS 1881-116, Method for determination of compressive strength of concrete cubes.
BS 1881-120, Method for determination of the compressive strength of concrete cores.
BS 5328, Methods for specifying concrete, Including ready-mixed concrete.
BS 5497, Precision of test methods[1)].
BS 5497-1, Guide for the determination of repeatability and reproducibility for a standard test method.
ISO 6784, Concrete — Determination of static modulus of elasticity in compression[1)].

[1)] Referred to in the foreword only.

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