BS 1881 : Part 121 : 1983
UDC 666.973.017:891.32:620.1



British Standard

# Testing concrete

## Part 121. Method for determination of static modulus of elasticity in compression

Essais du béton
Partie 121. Méthode de détermination du module statique d'élasticé en compresslon

Prüfverfahren für Beton
Teil 121. Bestimmung des statischen Elastizitätsmaduls unter Druck

British Standards Institution

## 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 : Pert 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 IS0 6784, published by the International Organization for Standardization (ISO), w hich adopted a UK draft.

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

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standard

# Testing concrete

## Part 121. Method for determination of static modulus of elasticity in compression

### 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 oi elasticity in compression.** The secant modulus, which, in newtons per square millimetre, is calculated from the formula:

$$\frac{\Delta_\sigma}{\Delta_\varepsilon}$$

where $A_{,,}$ and A, are the differences in stren and strain, respectively, between a basic loading level of 0.5 N/mm$^2$ and en upper loading level of one-third of the comoressive strength of the concrete.

### 3. Apparatus

**3.1 Compression testing** machine. The machine shall comply with BS1881 : Part 115 for compression testing machines. It shall be capable of applying the load at the specified rate and maintaining it at the required level.

32 Strain measuring apparatus. The strain measuring apparatus shall have an accuracy of 4 6 micro strain.

instruments for measuring length (for exampic 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 shell he taken on opposite tides 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 prefarred.

If adhesives are used for the f ixing paints they should bc rapid setting and set hard. The specimen shall ba 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 far this purpose. Specimens shall be m-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 end tested ta obtdn the wmprenive 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 mouided specimens shell 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 at 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 snd 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 f tom the mould.

4.2.2 Specimens drilled as wres from a structure shall be drilled, stored and their ends prepared by grinding or capping in accordance wirh 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 far beams do not necessarily conform with the squareness tolerance for the end face relative to the axis.

43 **Tolerances.** The tolerances in accordance with BS 308 : Part 3 of theprepared specimens shell 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 : Part 3) for the end prepared fint with respect to the axis of the specimen as datum axis shall be 2.0 mnl wide.

(c) *Parallelism.* The parallelism tolerance (parallelism 4 of BS 308 : Part 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 : Part 120.

4.4 **Density.** Measure the as-received or saturated density of the specimens by the method described in BS 1881 : Part 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 : Part 116.

NOTE. Alternatively, the compressive strength may be estimated cm other information available, e.g. from cube strengths end 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' ($\sigma_b$), 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 ($a$, = $f_c$/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 $\sigma_a$, recentre the test specimen and repeat the tost. If it is not possible to reduce the differences to within this range, do not proceed with the test.

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

Reload the specimen to stress $\sigma_a$ at the specified rate, and at the various measurement lines record the strain reading $\epsilon_a$, taken within 30 s.

When all elasticity measurements have bean 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 $\epsilon_a$ and $\epsilon_b$ respectively.

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

$$E_c = \frac{\sigma_a - \sigma_b}{\epsilon_a - \epsilon_b}$$

where

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

$\sigma_b$, is the basic stress (i.e. 0.5 N/mm$^2$);

$\epsilon_a$ is the mean strain under the upper loading stress;

$\epsilon_b$ it the mean strain under the bask 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 !he 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 bc provided by the producer of the test specimens fnr inclusion in the test report:

(a) building project;

(b) part or component of the building;

(c) admixtures used;

(d) specified compressive strength.

7.7 Information to bs 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) rype and dimensions of the specimen:

(c) dateo f 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.

*blank*

## Publications referred to

| | |
|---|---|
| BS 308 | Engineering drawing practice |
| | Part 3 Geometrical tolerancing |
| BS 1881 | Testing concrete |
| | Part 114 Method for determination of density of hardened concrete |
| | Part 115 Specification for compression testing machines for concrete |
| | Part 116 Method for determination of compressive strength of concrete cubes |
| | Part 120 Method for determination of the compressive strength of concrete cores |
| BS 3328 | Methods for specifying concrete, including ready-mixed concrete |
| BS 5497* | Precision of test methods |
| | Part 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 |

* Roferwd to in the foreword only.

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 31 January 1993.



ISBN 0 580 12958 6

The following BSI references relate to the work on this standard:
Committee reference CAB/4 Draft for comment 80/14205 DC



## 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:

Association of Consulting Engineers
Association of County Councils
Association of District Councils
Association of Metropolitan Authorities
Autoclaved Aerated Concrete Products Association
*British Precast Concrete Federation Ltd.
*British Quarrying and Slag Federation
British Railways Board
*British Ready Mixed Concrete Association
British Steel Industry
Cement Admixtures Association
*Cement and Concrete Association
*Cement Makers' Federation
Chemical Industries Association
*Concrete Society Limited
*County Surveyors' Society
*Department of the Environment (Building Research Establishment)
*Department of the Environment (PSA)
● Department of the Environment (Transport and Road Research Laboratory)
*Department of Transport
*Federation of Civil Engineering Contractors
Gypsum Products Development Association
Institute of Quarrying
*Institution of Civil Engineers
*Institution of Highway Engineers
*Institution of Municipal Engineers
Institution of Public Health Engineers
*Institution of Structural Engineers
*Institution of Water Engineers and Scientists
*National Federation of Building Trades Employers
Natural Environment Research Council (Institute of Geological Sciences)
*Royal Institute of British Architects
*Royal Institution of Chartered Surveyors
Sand and Ballast Hauliers and Allied Trades Alliance
*Sand and Gravel Association Limited
*Society of Chemical Industry
Stone Federation

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this British Standard:

British Civil Engineering Test Equipment Manufacturers' Association
Electricity Supply Industry in England and Wales
Greater London Council
Institute of Concrete Technology
Coopted member

## Amendments issued since publication

| Amd. No. | Date of issue | Text affected |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

British Standards Institution . 2 Park Street London W1A 2BS . Telephone 01-629 9000 . Telex 266933

8711–3–0.5k–8