BRITISH STANDARD

BS EN
1352 : 1997

Determination of static modulus of elasticity under compression of autoclaved aerated concrete or lightweight aggregate concrete with open structure

The European Standard EN 1352 : 1996 has the status of a British Standard

ICS 91.100.30

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee B/523, Prefabricated concrete and lightweight aggregate concrete with open structure, upon which the following bodies were represented:

Aggregate Concrete Block Association
Autoclaved Aerated Concrete Association
British Masonry Society
British Precast Concrete Federation Ltd.
Department of the Environment (Building Research Establishment)
Institution of Structural Engineers
Local Authority Organizations

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 October 1997

Amendments issued since publication

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The following BSI references relate to the work on this standard:
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Contents

National foreword

This British Standard has been prepared by Technical Committee B/523 and is the English language version of EN 1352 : 1996 *Determination of static modulus of elasticity under compression of autoclaved aerated concrete or lightweight aggregate concrete with open structure*, published by the European Committee for Standardization (CEN).

Cross-references

Publication referred to	Corresponding British Standard
EN 678 : 1993	BS EN 678 : 1994 *Determination of the dry density of autoclaved aerated concrete*
EN 679 : 1993	BS EN 679 : 1994 *Determination of compressive strength of autoclaved aerated concrete*
EN 992 : 1995	BS EN 992 : 1996 *Determination of dry density of lightweight aggregate concrete with open structure*
EN 1354 : 1996	BS EN 1354 : 1997 *Determination of compressive strength of lightweight aggregate concrete with open structure*

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 8, an inside back cover and a back cover.

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1352

December 1996

ICS 91.100.30

Descriptors: Concrete, cellular concrete, aggregates, mechanical tests, compression tests, determination, modulus of elasticity

English version

Determination of static modulus of elasticity under compression of autoclaved aerated concrete or lightweight aggregate concrete with open structure

Détermination du module d'élasticité statique en compression du béton cellulaire autoclavé et du béton de granulats légers à structure ouverte

Bestimmung des statischen Elastizitätsmoduls unter Druckbeanspruchung von dampfgehärtetem Porenbeton und von haufwerksporigem Leichtbeton

This European Standard was approved by CEN on 1996-11-30. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 177, Prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure, the Secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 1997, and conflicting national standards shall be withdrawn at the latest by June 1997.

In order to meet the performance requirements as laid down in the product standards for prefabricated components of autoclaved aerated concrete and of lightweight aggregate concrete with open structure, a number of standardized test methods are necessary.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

1 Scope

This European Standard specifies a method of determining the static modulus of elasticity in compression of autoclaved aerated concrete (AAC)[1] or lightweight aggregate concrete with open structure (LAC) according to prEN 1520.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 678	*Determination of dry density of autoclaved aerated concrete*
EN 679	*Determination of compressive strength of autoclaved aerated concrete*
EN 992	*Determination of dry density of lightweight aggregate concrete with open structure*
EN 1354	*Determination of compressive strength of lightweight aggregate concrete with open structure*
prEN 1520	*Prefabricated components of lightweight aggregate concrete with open structure*
ISO 4012 : 1978	*Testing concrete — Determination of compressive strength of test specimens*

3 Principle

The modulus of elasticity (E-modulus) is determined on prismatic test specimens taken from prefabricated components. It is calculated from the difference of longitudinal compressive strains corresponding to the increase of longitudinal compressive stress from the basic test stress σ_a (approximately 5 % of the declared compressive strength of the concrete) to the upper test stress σ_b (in general one-third of the declared compressive strength of the concrete).

4 Apparatus

a) *Any saw*, suitable for cutting reinforced AAC or LAC components;

b) *Callipers*, capable of reading the dimensions of the test specimens to an accuracy of 0,1 mm;

c) *A straight-edge* (at least as long as the longest diagonal of the test specimen surfaces, in the case of cylinders: at least as long as the generatrix), feeler gauges (0,2 mm, 0,5 mm (only for LAC), and 1,0 mm for both) and a square;

d) *A balance*, capable of determining the mass of the test specimens to an accuracy of 0,1 %;

e) *A compression testing machine*, which meets the requirements of ISO 4012 : 1978. It shall be capable of applying the required load at the specified rate and maintaining it at the required level for at least 60 s;

f) *Equalizing layers of soft fibreboard*, with a thickness of (12 ± 2) mm and a density of (250 to 400) kg/m^3 to be inserted between the loadbearing surfaces of the test specimens and the platens of the compression testing machine (not required in the case of levelling the loadbearing surfaces by grinding or capping);

g) *A ventilated drying oven*, capable of maintaining a temperature of (105 ± 5)°C (see note);

h) *Gauges*, for determining the longitudinal deformations or strains with a gauge length according to **6.1**, suitable to determine the strains to an accuracy of 5×10^{-6} (e.g. inductive displacement transducers, dial gauges, mirror extensometers, strain gauges etc.).

NOTE. In addition, a ventilated drying oven capable of maintaining a temperature of (40 to 60) °C can be helpful for conditioning of test specimens.

5 Test specimens

5.1 Sample

The sample (normally at least one prefabricated component) for the preparation of the test specimens shall be taken in such a manner that it is representative of the product to be investigated.

Test specimens may be prepared from samples which have previously been used for other tests, provided that they are cut at least 150 mm from an area where visible damage or changes of normal structure and appearance have occurred.

5.2 Shape and size of test specimens

The reference test specimens shall be prisms with square cross-section with the dimensions normally 100 mm × 100 mm × 300 mm.

Prisms of other sizes or other shape of the cross-section or cylindrical test specimens (drilled cores) may be used, provided that the smallest cross-sectional dimension is at least 75 mm (but not less than four times the maximum size of the aggregate in the concrete) and the ratio between length L and the smallest cross-sectional dimension D is in the range of $2 \leq L/D \leq 4$. If these requirements are not fulfilled, e.g. in the case of test specimens taken from hollow core components, this shall be stated in the test report.

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[1] A European Standard for prefabricated reinforced components of autoclaved aerated concrete, is in preparation at CEN.

5.3 Number of test specimens

A test set shall consist of at least three test specimens.

In the case of AAC, whenever possible, one test specimen shall be prepared from the upper third of the component, one from the middle and one from the lower third, in the direction of rise of the mass during manufacture (see figure 1). The position of the test specimens in the material relative to the rise of the mass shall be shown by the numbering, and the direction of rise shall be marked on the test specimens.

5.4 Preparation of test specimens

The specimens shall be cut not less than $2d$ after autoclaving or casting, respectively. The dust or the slurry of the process shall be removed.

They shall be taken in such a way that their longitudinal axis is:

– in the case of AAC: perpendicular to the rise of the mass during the manufacture;

– in the case of LAC: in the plane of the compression force acting in the component when used in the structure.

The test specimens shall contain no reinforcing bars within the gauge length. (If unavoidable, bars which are perpendicular to the test load can be accepted in exceptional cases. This shall be mentioned in the test report.)

The loadbearing surfaces of the test specimens (i.e. the faces in contact with the platens of the compression testing machine) shall be plane, parallel to each other and perpendicular to the longitudinal surfaces of the test specimens (in the case of cylindrical test specimens to the generatrices).

Planeness of loadbearing surfaces shall be checked across the two diagonals (in the case of cylinders across two orthogonal diameters) using a straight-edge and, if necessary, a feeler gauge. Deviations exceeding 0,2 mm shall be adjusted by cutting and/or grinding, or by capping. In the case of LAC, deviations up to 0,5 mm may be tolerated, provided that equalizing layers of soft fibreboard according to **4**f) are used. Deviations from planeness or regular shape, respectively, of the other surfaces shall not exceed 1,0 mm.

The angle between the loadbearing surfaces and the adjacent longitudinal surfaces (in the case of cylinders: the generatrices) of the test specimens shall not deviate from a right angle by more than 1 mm per 100 mm. This shall be checked along both orthogonal middle axes (in the case of cylinders along two orthogonal diameters) of the loadbearing surfaces by means of a square and a 1 mm feeler gauge or similar instrument. Larger deviations shall be corrected by cutting or grinding.

5.5 Measurement of test specimens

The dimensions of the test specimens shall be measured to an accuracy of 0,1 mm, using callipers.

Length and width (in the case of cylindrical test specimens the diameter) of the cross-sectional area, A_c, shall be measured at mid height at two opposite longitudinal sides. The cross-sectional area shall be calculated using the mean values of the results of the measurements.

The height of the test specimens shall be measured in the middle of two opposite longitudinal sides (in the case of cylinders along two opposite generatrices).

The volume V of the test specimens shall be calculated by multiplying A_c by the mean value of the results of the height measurements.

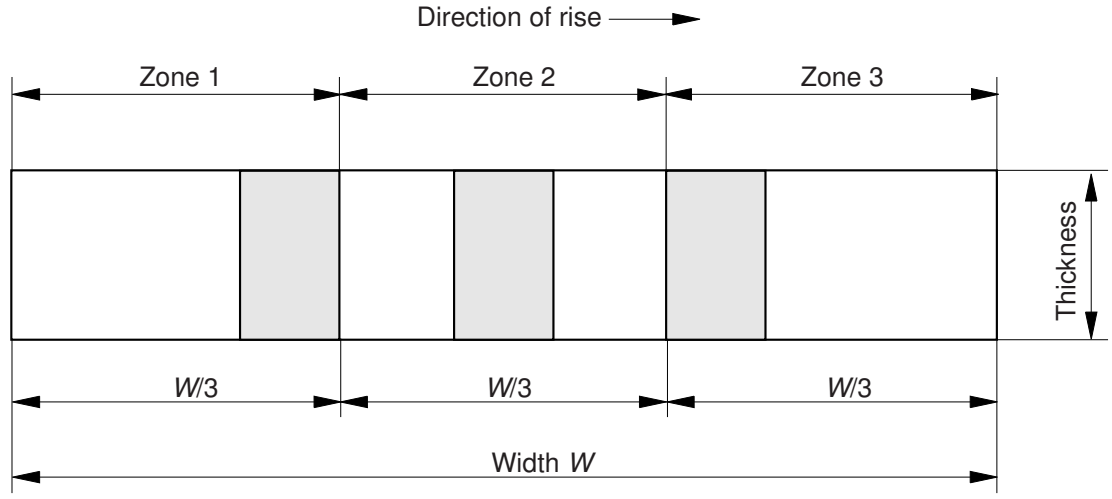


Figure 1. Sampling scheme for AAC-test specimens

5.6 Conditioning of test specimens

In the case of AAC the test specimens shall be dried till their mass related moisture content is (6 ± 2) % (see note). In doing so the temperature shall not exceed 60 °C.

In the case of LAC the mass related moisture content shall be at least 4 %.

After reaching the specified moisture content, the test specimens shall be stored, protected against moisture changes, for at least 24 h prior to the test at (20 ± 5)°C for ensuring uniform moisture distribution within the test specimen and thermal equilibrium with the temperature in the laboratory.

Immediately before testing and before applying any of the devices for measurement of deformations the moist mass, m_{hum}, of the test specimens shall be determined to an accuracy of 0,1 % in order to enable calculation of the density and the actual moisture content of the specimen when tested.

Prior to the test, attainment of the specified moisture content may be estimated by comparing the moist density of the test specimens with the dry density determined in accordance with EN 678 (for AAC) and EN 992 (for LAC) on companion specimens extracted from the same area of the same component.

NOTE. The expected moisture content of a test specimen can be calculated from equation (1):

$$\mu_{m,\,exp} = \frac{\rho_{hum,t} - \rho_{comp}}{\rho_{comp}} \times 100 \qquad (1)$$

where

$\mu_{m,exp}$ is the expected mass related moisture content, in per cent;

$\rho_{hum,t}$ $= m_{hum}/V$ is the moist density of the test specimen, calculated by dividing its moist mass m_{hum} by its volume V determined according to **5.5**, in kilograms per cubic metre;

ρ_{comp} is the dry density of the companion specimen determined according to EN 678 for AAC) or EN 992 (for LAC),in kilograms per cubic metre.

6 Determination of static modulus of elasticity

6.1 Position of gauge points and gauge length

The gauges for determining the longitudinal deformations or compressive strains shall be attached to at least two (better four) opposite longitudinal surfaces of the test specimen. If measurements are performed at two surfaces only, these surfaces should be parallel to the direction of rise in the case of AAC and parallel to the direction of casting in the case of LAC. The middle of the gauge length shall coincide with the middle of the specimen length. The distance of the gauge points to the adjacent end face of the test specimen shall be at least equal to the largest cross-sectional dimension (for prisms) or to half of the diameter of the test specimen (for cylinders). The gauge length should normally be at least 100 mm, but not less than the smallest cross-sectional dimension or two thirds of the diameter, respectively, of the test specimen, and, in the case of LAC, not less than five times the nominal maximum particle size of the aggregate.

6.2 Testing procedure

The platens of the compression testing machine shall be wiped clean, and the test specimen shall be positioned in the compression testing machine. In the case of LAC test specimens where the loadbearing surfaces have not been capped or levelled by grinding and depart from planeness by more than 0,2 mm, equalizing layers of soft fibreboard, as specified in **4f**), shall be inserted between the loadbearing surfaces of the test specimen and the platens of the compression testing machine. In this case, for each test a new set of fibreboard equalizing layers shall be used.

The test specimen shall be seated centrally in the compression testing machine, the deformation measuring devices attached (see note).

Loading shall be applied according to the loading scheme shown in figure 2.

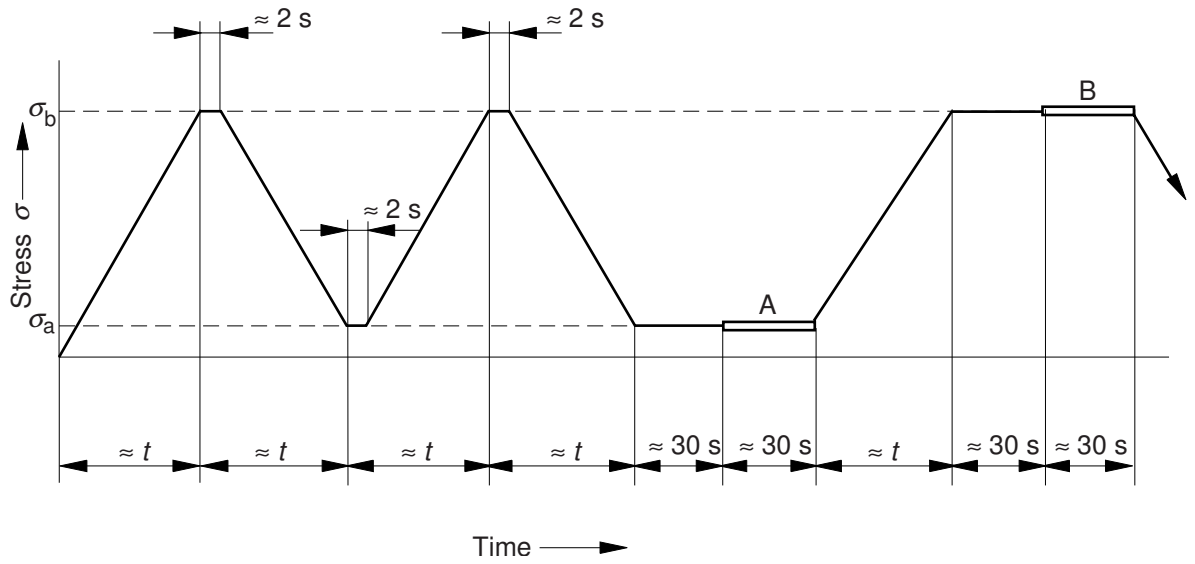
The test stress is calculated from the applied load and the cross-sectional area at mid-height of the test specimen.

The basic test stress σ_a shall be approximately 5 % and the upper test stress σ_b shall normally be one-third of the declared mean value of the compressive strength of the concrete.

If the declared compressive strength of the concrete is not known, the actual compressive strength shall be determined by testing in accordance with EN 679 (for AAC) or EN 1354 (for LAC), respectively. The basic and the upper test stresses shall be calculated from the mean value of the compressive strength according to paragraph 5 of **6.2**.

If another upper test stress is chosen, this shall be indicated in the test report.

The rate of loading and unloading should be approximately the same as specified in the relevant European Standard for the determination of the compressive strength (for AAC (0,1 ± 0,05) N/mm^2 per s according to EN 679; for LAC the loading time from σ_a to σ_b and vice versa shall be approximately 30 s according to EN 1354). The initial loading shall be applied cautiously, paying attention that the contact face of the hinged upper bearing block of the compression testing machine is aligned parallel to the upper bearing face of the test specimen to ensure centric transmission of the load.



A reading and recording of the basic test stress σ_a and of the corresponding strain ε_a;

B reading and recording of the upper test stress σ_b and of the corresponding strain ε_b;

t time for loading or unloading, respectively, according to EN 679 or EN 1354.

Figure 2. Loading scheme for the determination of the static modulus of elasticity

Before and after the third loading the stress shall be maintained constant for a period of 30 s at the levels σ_a and σ_b, respectively, and the corresponding strain readings ε_a and ε_b shall be taken during the succeeding 30 s of constant stress. Subsequently, the load shall be removed from the test specimen and the strain differences $\varepsilon_b - \varepsilon_a$ shall be calculated for the individual gauge lines. If these differ by more than 40 % from their mean value, the test specimen shall be recentered in order to get a more uniform strain distribution, and the test shall be repeated. If it is not possible to reduce the differences in strains to below 40 %, the test results should be disregarded.

When the centering has been sufficiently accurate, the test specimen shall be reloaded until failure, to determine its compressive strength, at the rate specified in the relevant European Standard for the determination of the compressive strength.

If the compressive strength of the test specimen differs by more than 30 % from the declared mean strength used for the determination of the upper test stress σ_b, this shall be noted in the test report.

After the compression test the fragments of the test specimens or parts thereof (at least 80 % by mass) shall be weighed and dried at $(105 \pm 5)^{\circ}C$ until constant mass has been attained, according to the procedure described in EN 678 or EN 992, respectively, in order to determine the dry density and the moisture content.

NOTE. In order to obtain uniform load transmission, it may be necessary to adjust the spherically seated upper platen of the compression testing machine by hand so that it is parallel to the upper loadbearing surface of the test specimen before it is brought to contact with it.

7 Test results

The modulus of elasticity is calculated according to equation (2):

$$E_c = \frac{\sigma_b - \sigma_a}{\varepsilon_b - \varepsilon_a} \qquad (2)$$

where

E_c is the modulus of elasticity, in newtons per square millimetre;

σ_b is the upper test stress in the last loading cycle, in newtons per square millimetre;

σ_a is the basic test stress before the last loading cycle, in newtons per square millimetre;

ε_b is the mean strain under the upper test stress σ_b in the last loading cycle;

ε_a is the mean strain under the basic test stress σ_a before the last loading cycle;

and where ε_a and ε_b are either measured directly (when strain gauges are used) or calculated by dividing the measured length changes by the initial gauge length (e.g. when dial gauges or displacement transducers are used).

The static modulus of elasticity of each individual test specimen and the mean value shall be rounded to the nearest 100 N/mm^2.

8 Test report

The test report shall include the following:

a) identification of the product;

b) date of manufacture or other code;

c) date of sampling;

d) place and date of testing, testing institute and person responsible for testing;

e) number and date of issue of this European Standard;

f) conditions of curing (only for LAC) and storage;

g) shape, size, and (only for AAC) relative position of the test specimens with regard to the direction of rise;

h) mode of levelling of the loadbearing surfaces of the test specimens (grinding, capping or use of equalizing layers);

j) type and number of gauges and gauge length;

k) declared mean compressive strength of the concrete;

l) upper test stress σ_b;

m) static modulus of elasticity of individual test specimens and mean value;

n) compressive strength of individual test specimens and mean value;

p) average moisture content of the test specimens;

q) dry density of the individual test specimens and mean value;

r) remarks when sufficient centering has not been achieved or when the compressive strength of a test specimen differs by more than 30 % from the declared mean strength of the concrete;

s) (if unusual) observations on the appearance of the test specimens;

t) (if appropriate) deviations from the standard method of testing;

u) a declaration that the testing has been carried out in accordance with this European Standard, except as detailed in **8**t.

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List of references

See national foreword.

BSI — British Standards Institution

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