BRITISH STANDARD

BS EN 1351 : 1997

Determination of flexural strength of autoclaved aerated concrete

The European Standard EN 1351 : 1997 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 September 1997

The following BSI references relate to the work on this standard:
Committee reference B/523
Draft for comment 93/110405 DC

ISBN 0 580 27462 4

Amendments issued since publication

Amd. No.	Date	Text affected

Contents

National foreword

This British Standard has been prepared under the direction of Technical Committee B/523 and is the English language version of EN 1351 : 1997 *Determination of flexural strength of autoclaved aerated concrete*, published by the European Committee for Standardization (CEN).

Cross-reference

Publication referred to	Corresponding British Standard
EN 678 : 1993	BS EN 678 : 1994 *Determination of the dry density of autoclaved aerated concrete*

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 1351

January 1997

ICS 91.100.30

Descriptors: Concrete, cellular concrete, mechanical tests, bend tests, determination, tensile strength, procedure

English version

Determination of flexural strength of autoclaved aerated concrete

Détermination de la résistance à la flexion du béton cellulaire autoclavé

Bestimmung der Biegezugfestigkeit von dampfgehärtetem Porenbeton

This European Standard was approved by CEN on 1996-12-13. 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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization

Comité Européen de Normalisation

Europäisches Komitee für Normung

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

Ref. No. EN 1351 : 1997 E

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 July 1997, and conflicting national standards shall be withdrawn at the latest by July 1997.

In order to meet the performance requirements as laid down in the product standard for prefabricated components of autoclaved aerated concrete, 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 flexural (tensile) strength of autoclaved aerated concrete (AAC) [1)] by means of prismatic test specimens taken from prefabricated components.

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*

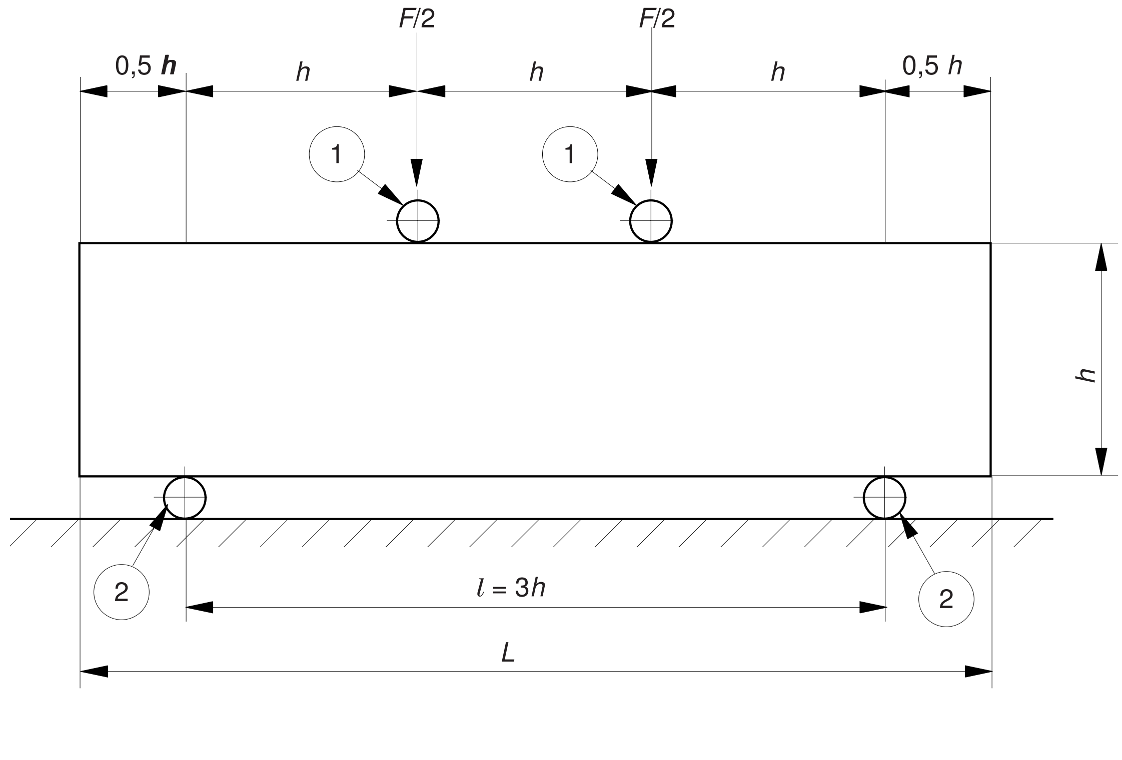
3 Principle

The flexural strength is determined by applying a uniform bending moment in the middle third of the span of a simply supported prismatic test specimen by means of two-point loading. The maximum load sustained is recorded and the flexural strength is calculated.

The method of centre-point loading may also be used and is specified in annex A.

The procedure using two-point loading shall be the reference test method.

NOTE. In general, the method of centre-point loading as described in annex A gives higher values of the flexural strength than the method of two-point loading.



1. Loading rollers (capable of rotation and of being inclined independently of each other)
2. Supporting rollers (one fixed and the other capable of rotation and of being inclined)

Figure 1. Loading arrangement for two-point loading

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

4 Apparatus

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

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

c) *A straight-edge with a length of approximately 300 mm*, a 0,5 mm feeler gauge, a 0,1 mm feeler gauge, and a square, for checking the planeness and the squareness of test specimens;

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

e) *A testing machine*, capable of applying a vertical compressive load at the required uniform rate without shock or interruption. The precision of the machine and the load indication shall be such that the ultimate load can be determined with an accuracy of ± 2 %. The measuring range shall be such that the ultimate load is higher than one tenth of the range used.

f) *A loading device*, according to figure 1, for transmitting the load of the testing machine to the test specimen.

The device for applying the loads shall consist of two supporting rollers and two loading rollers. The rollers shall be manufactured from steel and shall have a circular cross-section with a diameter between 15 mm and 40 mm; they shall be at least 10 mm longer than the width of the test specimen. The axes of all rollers shall be parallel to each other. Each roller, except one of the supporting ones, shall be capable of rotating around its longitudinal axis and of being inclined in a plane normal to the longitudinal axis of the test specimen. After correct centring in the testing machine, the axes of the hinges of the three inclinable rollers shall be situated on a vertical plane which shall not deviate by more than ± 1 mm from the axis of the compression force of the testing machine.

The middle axis between the loading rollers or the supporting rollers, respectively, shall not deviate from the axis of the testing machine (axis of the vertical compression force) by more than ± 1 mm.

The centre distance, l, between the supporting rollers (i.e. the span length) shall be equal to $3h$ where h is the nominal height of the test specimen (normally 50 mm). The loading rollers shall be equally spaced between the supporting rollers as shown in figure 1.

All rollers shall be adjusted in their correct position with all distances having an accuracy of ± 0,5 mm.

g) *A ventilated drying oven* , capable of maintaining a temperature of (105 ± 5) °C (see 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 for the preparation of the test specimens shall be taken in such a manner that it is representative of the product to be investigated.

NOTE. The test specimens may be prepared from prefabricated reinforced components. Alternatively, they may be taken from prefabricated unreinforced components of the same mould.

5.2 Shape and size of test specimens

The reference test specimens shall be prisms cut from prefabricated components, with a height h = 50 mm, a width b = 50 mm, and a length of L = 200 mm.

Test specimens of other sizes may be used, provided that the flexural strength determined on such test specimens can be directly related to the flexural strength determined on prisms 50 mm × 50 mm × 200 mm.

5.3 Number of test specimens

A test set shall consist of three test specimens.

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 2).

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 test specimens shall be taken from that zone of the prefabricated component which is adjacent to the surface with the maximum tensile stresses under service conditions (see figure 2). The longitudinal axis of the test specimens shall be perpendicular to the direction of rise (see figure 2).

They shall be cut from the component, not before $2d$ after removal from the autoclave. They shall not contain any reinforcement within the span length l. The surfaces shall be plane and perpendicular to each other.

The planeness of the surfaces shall be checked along both of their diagonals and along the lines where the loading forces and the support reactions will be applied, by means of a straight-edge and, if necessary, by means of feeler gauges. Deviations by more than 0,5 mm along the diagonals and by more than 0,1 mm along the lines where the loading forces and the support reactions will be applied shall be corrected by grinding.

The angle between adjacent faces of the test specimens shall also be checked, using a square and, if necessary, a 0,5 mm feeler gauge. Deviations from squareness by more than 0,5 mm per 50 mm (≈ 0,6°) shall be corrected by grinding.

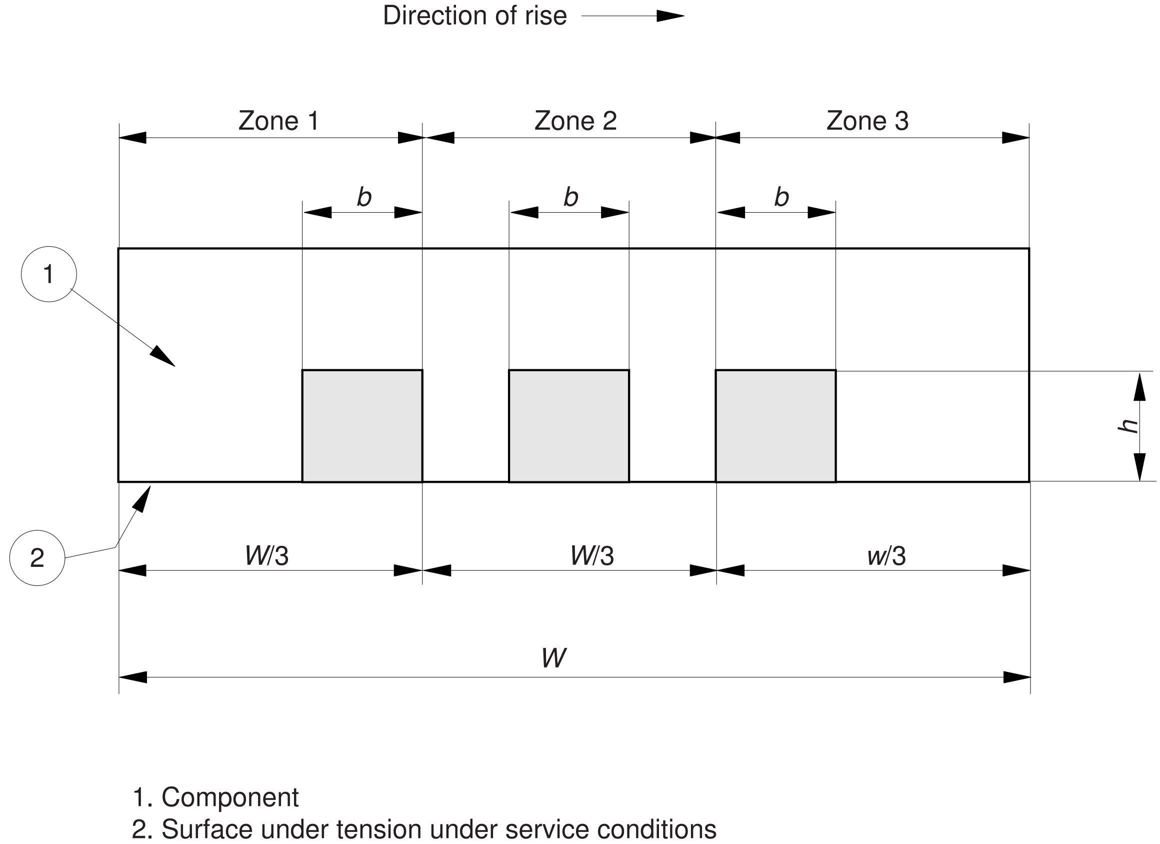


Figure 2. Sampling scheme

Alternatively, if the surfaces in contact with the loading rollers or support rollers depart from a plane by not more than 0,5 mm, rubber or leather strips may be used as a load distributing an intermediate layer between the rollers and the bearing surfaces, instead of grinding these areas.

The rubber or leather strips shall be of uniform thickness (approximately 5 mm), 25 mm in width, and shall extend over the full width of the test specimen.

5.5 Examination of test specimens and determination of their dimensions and volume

The test specimens shall be examined visually, and any abnormalities shall be reported.

The dimensions of the test specimens shall be measured to an accuracy of 0,1 mm, using callipers. Measurements may be taken before or after conditioning according to **5.6**.

The width b and the height h shall be measured at both ends (b_1 and b_3 or h_1 and h_3, respectively) and at midspan (b_2 or h_2, respectively), each value being the mean value of a total of two individual measurements, taken at two opposite longitudinal faces.

The total length L shall be measured along the middle axes of two opposite longitudinal surfaces.

The volume V of the individual test specimens shall be calculated by multiplying the arithmetic mean value of length measurements by the geometric mean value of width measurements $(b_1 + 2b_2 + b_3)/4$ and the geometric mean value of height measurements $(h_1 + 2h_2 + h_3)/4$.

5.6 Conditioning of test specimens

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.

After reaching the specified moisture content, the test specimens shall be stored, protected against moisture changes, for at least 24 h at room temperature for ensuring internal moisture equilibrium and thermal equilibrium with the laboratory at (20 ± 5) °C prior to the flexural test. Immediately before the flexural test the moist mass, m_{hum}, of the test specimens shall be determined again, to an accuracy of 0,1 %.

The actual moisture content shall be determined after the test (see last paragraph of **6.2**). 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 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).

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

where

μ_{mexp}	is the expected mass related moisture content, in per cent;
$\rho_{hum,}$	$= m_{hum} / V$ 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, in kilograms per cubic metre;

6 Testing procedure

6.1 Flexural test

All testing machine bearing surfaces shall be wiped clean and any loose material shall be removed from the surfaces of the test specimen that will be in contact with the rollers.

The loading device shall be correctly centred in the testing machine (see 4 f)).

The test specimen shall be placed on the support rollers of the loading device in the testing machine, correctly centred and aligned perpendicular to the rollers. The longitudinal axis shall not deviate by more than ± 1 mm from the (theoretical) plane of the hinges of the inclinable rollers (see 4 f)).

If possible, the test specimen shall be supported on that surface corresponding to the surface of the component with the maximum tensile stresses under service conditions (see figure 2).

The load shall not be applied before all loading and supporting rollers are resting evenly against the test specimen.

Subsequently, the load may be applied rapidly, but without shock, up to approximately 50 % of the anticipated breaking load. Thereafter, without halt, the load shall be increased continuously until rupture occurs, at a uniform rate which constantly increases the stress in the extreme fibres at approximately 0,02 N/mm^2 per s, when calculated in accordance with clause **7** (see note).

When using a manually controlled testing machine, any tendency for the selected rate of loading to decrease, as test specimen failure is approached, shall be corrected by appropriate adjustment of the controls.

When using an automatically controlled testing machine, the rate of loading shall be periodically checked to ensure that the rate is constant and at the required level.

The maximum load indicated shall be recorded.

NOTE. The required loading rate of the testing machine for test specimens with square cross-section under two-point loading according to figure 1 is given by the equation (2).

$$R = sh^2/3 \quad (2)$$

where

R	is the required loading rate, in newtons per second;
s	is the specified stress rate (normally s = 0,02), in newtons per square millimetre, per second;
h	is the nominal height of the test specimen, in millimetres.

For reference test specimens, with nominal square section 50 mm × 50 mm and a span length of l = 150 mm, the specified stress rate is achieved by increasing the testing machine load by approximately 20 N/s.

6.2 Examination and measurement of test specimens after the test

The fractured test specimen shall be examined and the appearance of the AAC and type of fracture shall be recorded if these are unusual.

Height h_{fr} and width b_{fr} of the cross-section at the location of fracture shall be measured to the nearest 0,1 mm, each value being the mean value of a total of two individual measurements, taken at two opposite longitudinal faces. Subsequently, the test specimens shall be dried at (105 ± 5) °C in order to check the actual moisture content of the AAC and to determine the dry density on the basis of EN 678.

7 Test results

The flexural strength of the test specimen shall be calculated from equation (3) (see note).

$$f_{cf} = \frac{Fl}{b_{fr}\, h_{fr}^2} \quad (3)$$

where

f_{cf}	is the flexural strength, in newtons per millimetre;
F	is the maximum load (see note), in newtons;
l	is the span length, in millimetres;
b_{fr} and h_{fr}	are the cross-sectional dimensions of the test specimen at the location of fracture, in millimetres (see figure 1);

The flexural strength of each individual test specimen and the mean value shall be expressed to the nearest 0,01 N/mm^2.

The dry density of the AAC shall be calculated from equation (4).

$$\rho = \frac{m_d}{V} \quad (4)$$

where

ρ is the dry density in kilograms per cubic metre;

m_d is the dry mass of the broken test specimen according to **6.2**, in kilograms;

V is the volume of the test specimen according to **5.5** in cubic metres.

The dry density of each individual test specimen and the mean value shall be indicated to the nearest 10 kg/m^3.

The moisture content of the AAC shall be calculated from equation (5).

$$\mu_m = 100 \frac{m_{hum} - m_d}{m_d} \quad (5)$$

where

μ_m is the mass related moisture content, in per cent;

m_{hum} is the mass of the test specimen in the moist state according to **5.6**, in kilograms;

m_d is the dry mass of the broken test specimen according to **6.2**, in kilograms.

The mass related moisture content of each individual test specimen and the mean value shall be indicated to the nearest 0,1 %.

NOTE. The weight of the test specimen is not included. Depending on the testing machine and the loading device, the weight of the latter parts thereof is not always included in the maximum load. It may be necessary, therefore, to take this into account when calculating the flexural strength.

8 Test report

The test report shall include the following:

a) identification of the product;

b) date of manufacture or other code;

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

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

e) dimensions (actual or checked nominal) and relative position of the test specimens with regard to the direction of rise;

f) method of loading (two-point loading or centre-point loading);

g) flexural strength of each individual test specimen and mean value;

h) dry density of each individual test specimen and mean value;

j) moisture content of each individual test specimen and mean value;

k) (if unusual) observations on the appearance of the test specimens before and after the flexural test, appearance of the fracture surface, location of fracture outside the loading rollers;

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

m) a declaration that the testing has been carried out in accordance with this Eurpean Standard, except as detailed in **8** l.

Annex A (normative)

Determination of flexural strength using the method of centre-point loading

If the method of centre-point loading is used (see note in clause **3**), the test procedure differs from the procedure with two- point loading as specified in this European Standard in the following respects:

The loading arrangement shall conform to that shown in figure A.1.

The load shall be applied in accordance with **6.1**, except that the loading rate shall be determined in accordance with equation (A.1)

$$R = \frac{2s \times h^2}{9} \qquad \text{(A.1)}$$

where

- R is the required loading rate, in newtons per second;
- s is the specified stress rate (normally 0,02 N/mm^2), in newtons per square millimetre per second;
- h is the nominal height of the test specimen, in millimetres.

For the reference test specimens with nominal square section 50 mm x 50 mm and a span length of l = 150 mm the specified stress rate is achieved by increasing the testing machine load by approximately 10 N/s.

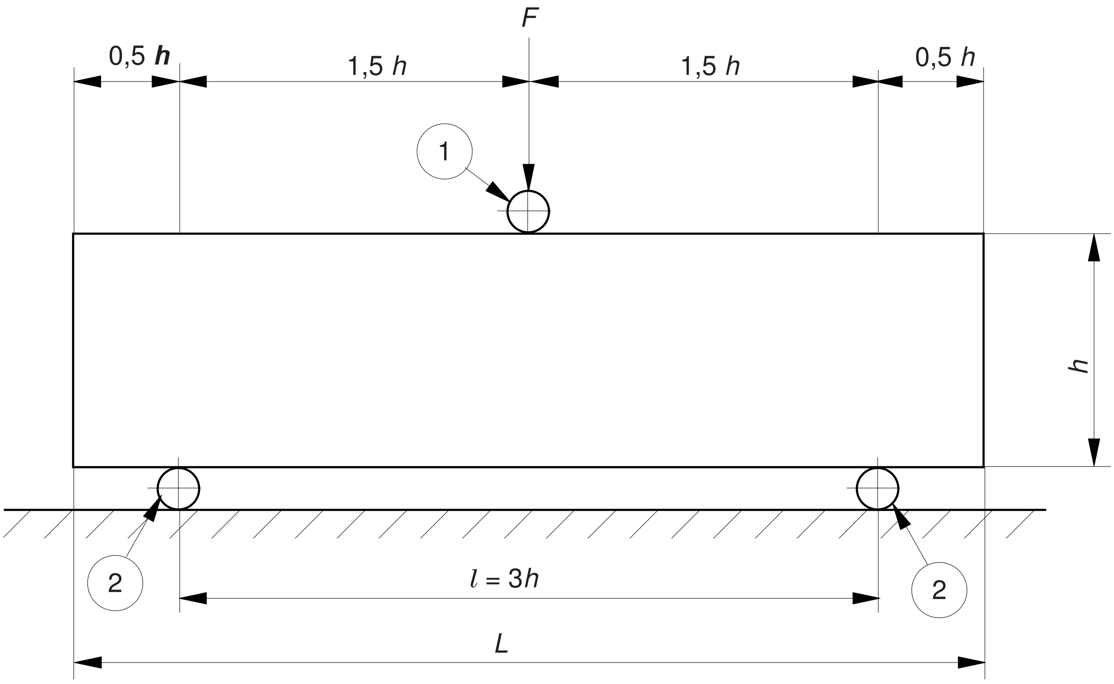
The flexural strength of the test specimen shall be calculated from equation (A.2):

$$f_{cf} = \frac{1{,}5\,F\,l}{b_{fr}\,h_{fr}^2} \qquad \text{(A.2)}$$

where

- f_{cf} is the flexural strength, in newtons per square millimetre;
- F is the maximum load (see note to clause **7**), in newtons;
- l is the span length (centre distance between the supporting rollers, see figure A.1), in millimetres;
- b_{fr} and h_{fr} are the cross- sectional dimensions of the test specimen at the location of fracture, in millimetres (see figure A.1).

In the test report it shall be clearly indicated that the centre-point loading method has been used.



1. Loading roller at midspan (capable of rotation and of being inclined)
2. Supporting rollers (one fixed and the other capable of rotation and of being inclined)

Figure A.1 Loading arrangement for centre-point loading

(With respect to the diameter of the rollers and other details see 4f))

List of references

See national foreword.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL