BRITISH STANDARD

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14488-3:2006

Testing sprayed concrete —

Part 3: Flexural strengths (first peak, ultimate and residual) of fibre reinforced beam specimens

The European Standard EN 14488-3:2006 has the status of a British Standard

ICS 91.100.30

BSI
British Standards

National foreword

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The UK participation in its preparation was entrusted by Technical Committee B/517, Concrete, to Subcommittee B/517/10, Sprayed concrete, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 12, an inside back cover and a back cover.

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Testing sprayed concrete - Part 3: Flexural strengths (first peak, ultimate and residual) of fibre reinforced beam specimens

Essais pour béton projeté - Partie 3 : Résistances à la flexion (au premier pic, ultime et résiduelle) d'éprouvettes parallélépipèdiques en béton renforcé par des fibres

Prüfung von Spritzbeton - Teil 3: Biegefestigkeiten (Erstriss-, Biegezug- und Restfestigkeit) faserverstärkten balkenförmigen Betonprüfkörpern

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Foreword

This European Standard (EN 14488-3:2006) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, 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of an identical text or by endorsement, at the latest by October 2006, and conflicting national standards shall be withdrawn at the latest by December 2007.

This European Standard is part of a series concerned with testing sprayed concrete.

This series EN 14488 Testing sprayed concrete includes the following parts:

— Part 1: Sampling fresh and hardened concrete

— Part 2: Compressive strength of young sprayed concrete

— Part 3: Flexural strengths (first peak, ultimate and residual) of fibre reinforced beam specimens

— Part 4: Bond strength of cores by direct tension

— Part 5: Determination of energy absorption capacity of fibre reinforced slab specimens

— Part 6: Thickness of concrete on a substrate

— Part 7: Fibre content of fibre reinforced concrete

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This part of European Standard specifies a method for the determination of the flexural (first peak, ultimate and residual) strength of beam specimens of hardened sprayed concrete.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12390-1:2000, *Testing hardened concrete — Part 1: Shape, dimensions and other requirements for specimens and moulds*

EN 12390-4:2000, *Testing hardened concrete — Part 4: Compressive strength — Specification for testing machines*

EN 14487-1, *Sprayed concrete — Part 1: Definitions, specifications and conformity*

EN 14488-1, *Testing sprayed concrete — Part 1: Sampling fresh and hardened concrete*

3 Principle

Prismatic beam specimens are subject to a bending moment by the application of load through upper and lower rollers. The first peak, maximum and residual loads sustained are recorded and the corresponding flexural strengths calculated.

A fibre reinforced prism specimen, sawn from a test panel in accordance with EN 14488-1 is subject to a bending moment by the application of load through upper and lower rollers under deflection control to obtain its load/deflection response (the latter exclusive of non-bending deformations). The first peak, ultimate and residual flexural strengths are determined from the load/deflection curve.

4 Apparatus

4.1 Testing machine

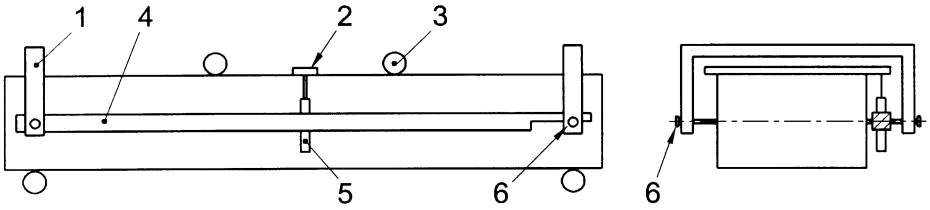
The test shall be carried out using a testing machine conforming to 4.2 and 4.3 of EN 12390-4:2000.

The stiffness and control system of the testing machine shall be such that the test can be deflection controlled. The stiffness of the load system (including frame, load cell, loading block and support frame) shall be at least 200 kN/mm.

A steel or aluminium yoke (Figure 1).

A calibrated electronic transducer with a resolution of at least 0,02 mm.

An electronic data logger or XY plotter.



Key

1 Cramp
2 Reference bar (clamped or glued)
3 Loading roller
4 Yoke
5 Transducer
6 Locating screw

NOTE A yoke/transducer may be fixed at each side of the beam, instead of at only one as it is represented in the section of the beam.

Figure 1 — Arrangement of yoke for bending deflection measurement

4.2 Force application

The device for applying loads (see Figure 2) shall consist of:

— two supporting rollers;

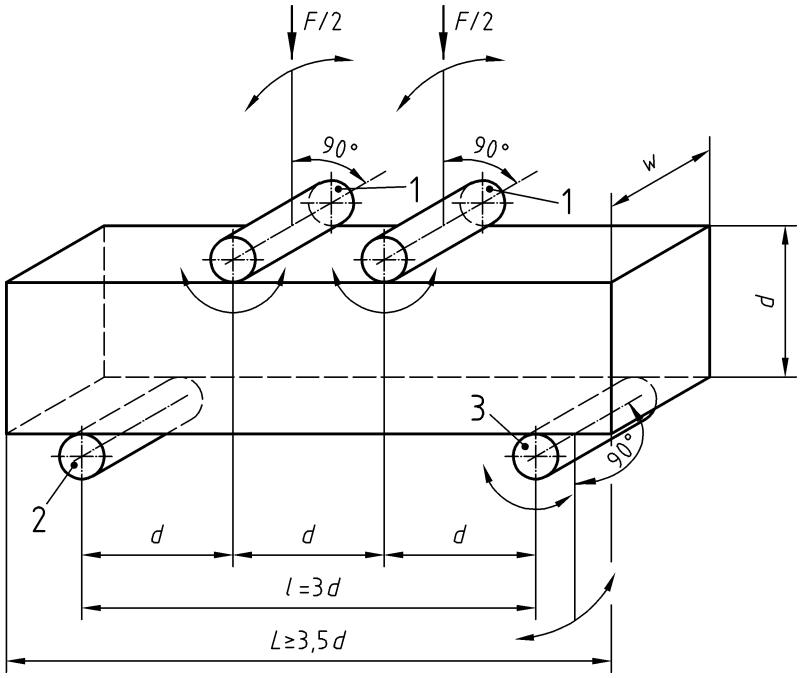
— two upper rollers carried by an articulated cross member, which divides the load applied by the machine equally between the two rollers.

All rollers shall be manufactured from steel and shall have a circular cross-section with a diameter of 20 mm to 40 mm. They shall be at least 10 mm longer than the width of the test specimen.

Three rollers, including the two upper ones, shall be capable of rotating freely around their axes and of being inclined in a plane normal to the longitudinal axis of the test specimen.

The distance, l, between the outer rollers (i.e. the span) shall be equal to $3\,d$, where d is 150 mm. The distance between the inner rollers shall be equal to d. The inner rollers shall be equally spaced between the outer rollers as shown in Figure 2. All rollers shall be adjusted to the positions illustrated in Figure 2 to an accuracy of ± 2,0 mm.

Dimensions in millimetres



Key

1 Loading roller (capable of rotation and of being inclined)
2 Supporting roller
3 Supporting roller (capable of rotation and of being inclined)
F is the load (P_{fp} or P_{ult}) defined above in newtons
l is the span
w is the average beam width
d is the beam height
L is the beam length

Figure 2 — Arrangement of loading of test specimen

4.3 Deflection measurement and control

Bending deflection, excluding any support deformations and twist, shall be measured by means of an electronic transducer mounted at mid-span to a yoke that is held to the beam at mid-height of the beam (the neutral axis) and directly over the supports. A suitable yoke arrangement is shown in Figure 1. It is preferable to use two transducers, one mounted on each side of the beam.

The testing machine shall be controlled from the transducer in order to load the specimen at a constant rate of deflection at the midspan of the beam. The load-deflection curve shall be continuously recorded or logged. Where two transducers are used the average midspan deflection shall be determined.

5 Test specimen

5.1 General

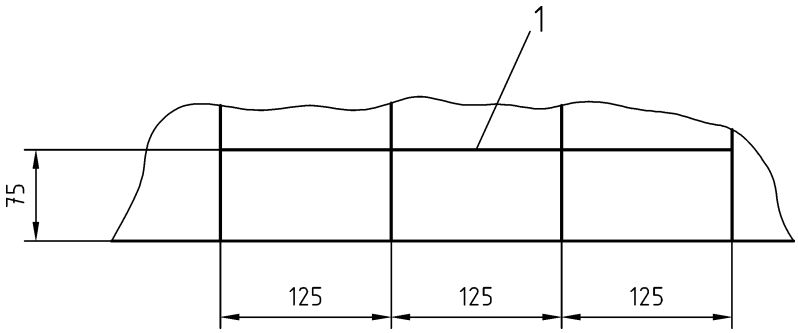
Each test specimen shall be a sawn prism with dimensions of 75 mm depth × 125 mm width and a length of at least 500 mm length cut from a sprayed panel as shown in Figure 3 and prepared to meet the requirements of EN 12390-1. The bottom uncut mould face shall be identified on the specimen (indicating the direction of spraying).

Beams shall be tested with the bottom uncut moulded face in tension, unless otherwise specified. If the top face of the beam is to be put in tension it shall not be sawn (to avoid cutting end anchorages of the steel fibres).

The prisms should be stored in water at (20 +/- 2)°C for a minimum of 3 days after sawing until no more than 3 hours before testing (leaving sufficient time for preparation including the attachment of any location devices for the yoke or transducer).

Testing shall normally be performed at 28 days.

The specimens shall be examined and any abnormalities observed shall be reported.



Key

1 Top of beam

Figure 3 — Cutting arrangement for beams

5.2 Adjustment of test specimens

Where the dimensions or shapes of test specimens do not conform to 4.3 of EN 12390-1:2000 because they exceed the respective tolerances, they shall be rejected or adjusted as follows:

— uneven surfaces shall be levelled by grinding;

— the deviation of angles shall be corrected by cutting and/or grinding.

NOTE The tolerances specified in EN 12390-3 will usually be too demanding for specimens sawn from sprayed concrete test panels and should normally be relaxed by prior agreement of the parties.

6 Procedures

6.1 Preparation and positioning of specimens

For specimens stored in water, wipe excess moisture from the surface of the specimen before placing in the testing machine.

Wipe clean all testing machine bearing surfaces and remove any loose grit or other extraneous material from the surfaces of the specimen that will be in contact with the rollers.

Mount the yoke and transducer(s) on the specimen, ensuring the yoke is held directly over the supporting rollers and at mid-depth of the specimen and that the transducer(s) are located at midspan and bear against a reference plate attached or clamped to the beam.

Place the test specimen in the machine, correctly centred and orientated (uncut mould face normally in tension) and with the longitudinal axis of the specimen at right angles to the longitudinal axis of the upper and lower rollers.

NOTE The test result may be affected by the direction of loading with respect to the direction of spraying.

6.2 Loading

Do not apply the load until all loading and supporting rollers are resting evenly against the test specimen.

The testing machine shall be controlled from the transducer in order to load the specimen at a constant rate of deflection at the mid-span of the beam of (0,25 ± 0,05) mm per minute until a deflection of 0,5 mm. After this point the rate of deflection may be increased to 1,0 mm/min.

The test shall be finished when the mid-span deformation exceeds 4 mm or the specimen fractures.

Record the load and deflection continuously with the data logger or XY plotter, and also record the maximum load and corresponding deflection indicated.

Measure the distance from the centre of the crack on the tensile face to the nearest support and report a fracture outside the loading rollers (see Figure 2).

7 Expression of results

7.1 First peak and ultimate flexural strengths

The first peak flexural strength shall be calculated from the load-deflection curve (Figure 4) as follows. The initial straight line portion of the curve shall be determined, based on data up to 50 % of the peak load, and a line drawn parallel at a horizontal offset of 0,1 mm mid-span beam defection. The first peak flexural strength (f_{fp}) shall be calculated from the first peak load (P_{fp}) achieved up to and including the point at which the 0,1 mm offset line intercepts the load/deflection curve (see Figure 4).

The ultimate flexural strength (f_{ult}) shall be calculated from the maximum load (P_{ult}) recorded.

Two measurements shall be made of the beam width and depth at the fracture plane, to the nearest 0,1 mm and the average calculated to the nearest 1 mm. A note shall be made if the fracture plane is outside loading rollers and the results discarded.

Each flexural strength shall be calculated as an equivalent elastic tensile strength:

$$\text{flexural strength in MPa} = P \times l / (w \times d^2) \quad (1)$$

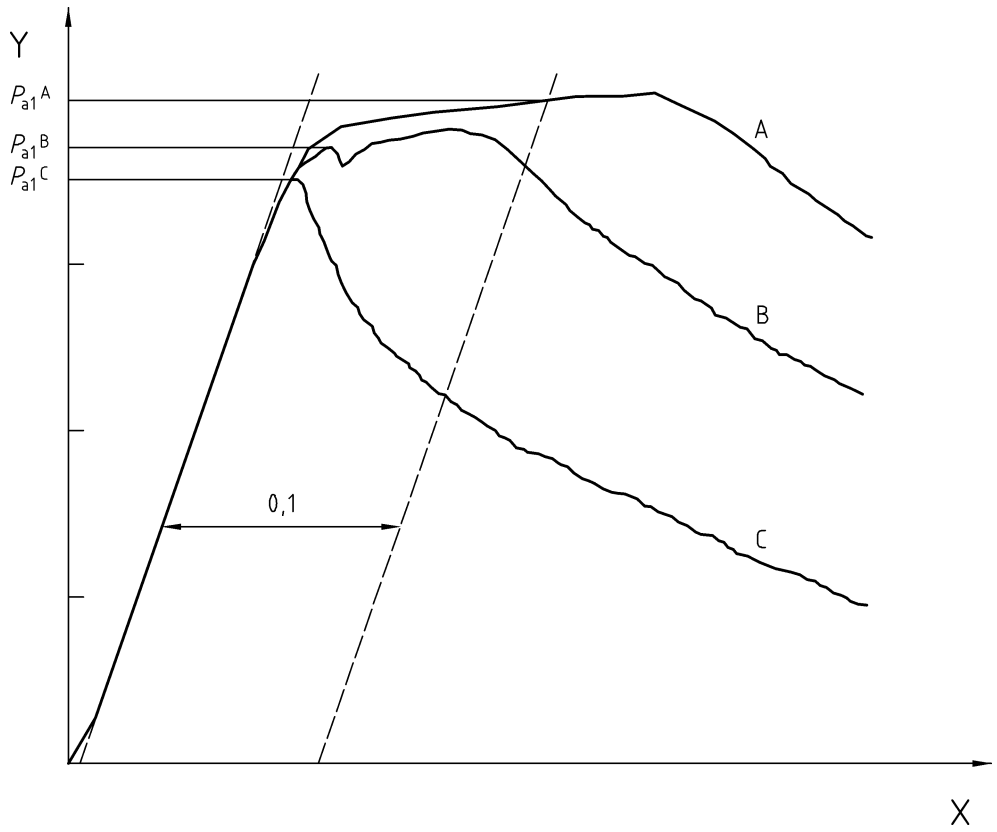
where

P is the load (P_{fp} or P_{ult}) defined above in newtons

l is the span (450 mm)

w is the average beam width at the fracture plane (nominally 125 mm)

d is the average beam depth at the fracture plane (nominally 75 mm)



Key

X Central deflection in mm

Y Load in kN

$P_{a1}{}^{A}$ is the first peak load (P_{fp}) for curve A

$P_{a1}{}^{B}$ is the first peak load (P_{fp}) for curve B

$P_{a1}{}^{C}$ is the first peak load (P_{fp}) for curve C

NOTE Curves A, B and C are three different examples.

Figure 4 — Examples of load/deflection curves for the determination of first peak load P_{fp}

7.2 Residual flexural strengths

The residual strengths shall be calculated from the minimum loads on the flexural stress (or load)/deflection curve between 0,5 mm and 1 mm, 2 mm and 4 mm (corresponding to the low, normal and high deformation classes D_1, D_2 and D_3 defined in EN 14487-1).

The residual flexural strength (f_{r1}) shall be calculated from the minimum load (P_{r1}) recorded between midspan deflections of 0,5 mm and 1,0 mm.

The residual flexural strength (f_{r2}) shall be calculated from the minimum load (P_{r2}) recorded between midspan deflections of 0,5 mm and 2,0 mm.

The residual flexural strength (f_{r4}) shall be calculated from the minimum load (P_{r4}) recorded between midspan deflections of 0,5 mm and 4,0 mm.

Each residual flexural strength shall be calculated as an equivalent elastic tensile strength using equation (1) in 7.1.

8 Test report

The report shall include:

a) identification of the test specimen;

b) average depth, d, and width, b, of the specimen at the fracture plane to nearest 1 mm;

c) details of adjustment by grinding (if appropriate);

d) type of testing machine;

e) surface moisture condition of specimen at time of test (saturated/moist);

f) date of test;

g) load (or stress) -deflection curve including load to nearest 0,1 kilonewtons;

h) first peak (P_{fp}), maximum (P_{ult}) and residual (P_{r1}, P_{r2} and P_{r4}) loads, to nearest 0,1 kilonewtons;

i) first peak (f_{fp}), maximum (f_{ult}) and residual (f_{r1}, f_{r2} and f_{r4}) flexural strengths to nearest 0,1 MPa;

j) distance of centre of crack to nearest support to nearest 1 mm and note if outside upper rollers;

k) appearance of the concrete (if unusual);

l) any deviation from the standard test method;

m) a declaration from the person technically responsible for the test that the testing was carried out in accordance with this standard, except as detailed in item (l).

NOTE The report may also include, if known:

n) condition of specimen at receipt for storage;

o) curing conditions;

p) age of specimen at time of test.

9 Accuracy

There are currently no accuracy data for this test.

Bibliography

[1] EN 12390-3, *Testing hardened concrete - Part 3: Compressive strength of test specimens*

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