BRITISH STANDARD

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Precast concrete products — Test method for strength retention of glass fibres in cement and concrete (SIC TEST)

The European Standard EN 14649:2005 has the status of a British Standard

ICS 91.100.30

National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/524, Precast concrete products, which has the responsibility to:

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English version

Precast concrete products - Test method for strength retention of glass fibres in cement and concrete (SIC TEST)

Produits préfabriqués en béton - Méthode d'essai de la conservation de la résistance des fibres de verre en contact avec le ciment et le béton (SIC-TEST)

Vorgefertigte Betonerzeugnisse - Prüfverfahren zur Bestimmung der Beständigkeit von Glasfasern in Beton (SIC-Prüfung)

This European Standard was approved by CEN on 3 March 2005.

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Contents

Foreword

This document (EN 14649:2005) has been prepared by Technical Committee CEN/TC 229 “Precast concrete products”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by October 2005, and conflicting national standards shall be withdrawn at the latest by October 2005.

This document includes a Bibliography.

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Introduction

The Strand in Cement (SIC) test measures the tensile strength of a glass fibre strand in a specified hardened cement or mortar environment. The test enables an assessment to be made of the strength durability of strands of glass fibre after accelerated ageing, under conditions which approximate to those in a cement or concrete precast product.

This test may be used to ensure that an AR glass fibre complies with the specified minimum value of retained strength as defined in the related standard *Precast Concrete products - classification of GRC performances* when tested in standard conditions. The test is a type test, and is appropriate to determine whether the fibre is suitable to use in a standard current matrix, or if necessary using different types of cement or modified cement matrices. The method utilises a strand of glass fibre as used in the commercial glass fibre reinforcement product. In the test the middle section of a length of glass fibre strand is encased within a block of cement paste. The block is cured and aged under defined conditions for a given time and the strength of the encased part of the strand is determined by applying a tensile load at each end of the strand. The test may be performed on strands extracted from a roving or on strands from a cake prior to making up into rovings or chopped strands. Strands of different tex may be assessed.

1 Scope

This document provides details of equipment, materials and procedure for performing the Strand in Cement test on a sample of glass fibre strand in a hardened cement environment.

Requirements for glass fibres used as reinforcement in cements and concrete are defined in the European Standard *Precast Concrete products - classification of GRC performances*. It applies to continuous filament glass fibre products in the form of rovings, strands, or chopped strands and related products such as nets or chopped strand mats based on these products.

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 1169:1999, *Precast Concrete Products – General rules for factory production control of glass-fibre reinforced cement.*

EN ISO 1889, *Reinforcement yarns – Determination of linear density (ISO 1889:1997)*.

EN ISO 3344, *Reinforcement products – Determination of moisture content (ISO 3344:1997)*.

EN ISO 7500-1, *Metallic materials – Verification of static uniaxial testing machines – Part 1: Tension/compression testing machines – Verification and calibration of the force-measuring system (ISO 7500-1:2004)*.

ISO 1887, *Textile glass – Determination of combustible-matter content*.

ISO 1888, *Textile glass – Staple fibres or filaments – Determination of average diameter*.

ISO 3341, *Textile glass – Yarns – Determination of breaking force and breaking elongation*.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1169:1999 and the following apply.

3.1
Alkali Resistant (AR) Glass Fibre
glass fibre product resistant to the alkaline environment of matrices made from hydraulic cement, and manufactured and sold for the reinforcement of cement and concrete products

The resistance is due particularly to a specific composition of the glass.

3.2
filament
single glass fibre as obtained from the manufacturing process

NOTE Adapted from EN ISO 472.

3.3
strand
number of approximately parallel filaments of 10 µm–30 µm individual filament diameter, held together with a size

NOTE Adapted from EN ISO 472 and ISO 1888.

3.4
cake
number of strands wound together on a former; an intermediate stage in the manufacturing process, prior to the conversion to "rovings" or "chopped strands"

3.5
roving
number of parallel strands wound together on a mandrel to form a uniform cylindrical package size

NOTE Adapted from EN ISO 472.

3.6
chopped strands
number of filaments bonded together with size to form strands in cake form, and then chopped into discrete lengths generally between 3 mm and 50 mm by the glass fibre manufacturer

NOTE Adapted from EN ISO 472.

3.7
size
coating materials applied to the strand during manufacture to facilitate or improve processing, use and performance of the glass fibres

NOTE Adapted from EN ISO 472.

3.8
tex
mass in grams per kilometre length of roving or strand, in units of TEX

NOTE Adapted from EN ISO 1889.

3.9
glass fibre reinforced cement (or concrete)
GRC
composite material consisting of a matrix of hydraulic binder reinforced with glass fibres, these materials being compatible

3.10
matrix
part of glass-fibre reinforced cement including the mixture of sand, cement, water and if necessary additives and admixtures

It is made up of the mixture of sand, cement, water and any additives and admixtures.

3.11
category
A: strength retention by strand (SIC) test ≥ 250 MPa
B: strength retention by strand (SIC) test ≥ 350 MPa

4 Material requirements

The material shall include:

— a frame to hold the strands and to form ten moulds 30 mm x 10 mm x 10 mm into which cement is cast (Figure 1);

— a scale capable of weighing to 0,1 g;

— a scale capable of weighing to 0,1 mg;

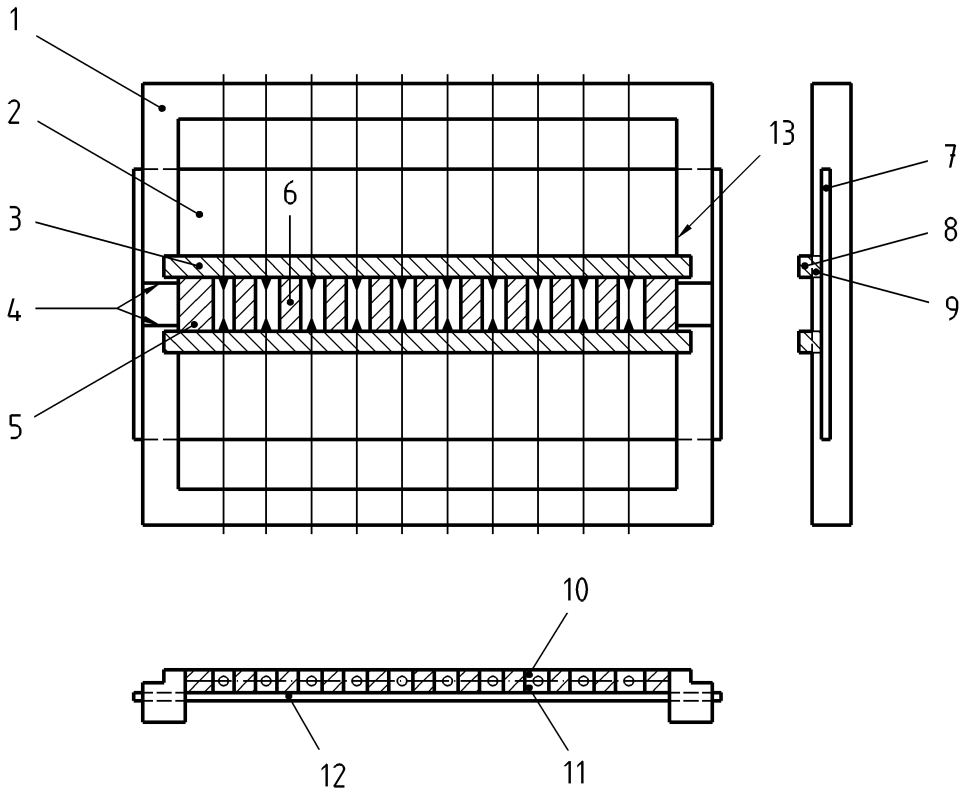
— a curing chamber capable of maintaining the frame assembly at (20 ± 2) °C and at 100 % Relative Humidity;

— a water bath or container, with a ratio: volume 1 dm^3 per 10 specimens, capable of maintaining moulded specimens at the required temperature ± 1 °C;

— a testing machine of accuracy meeting the class 2 requirements specified in EN ISO 7500-1 with a load cell of 200 Newton full-scale deflection and a cross head speed of 1 mm/min;

— an oven capable of maintaining a temperature of (30 – 100) °C ± 1 °C;

— storage containers and mixing vessels, spatula etc.



Key

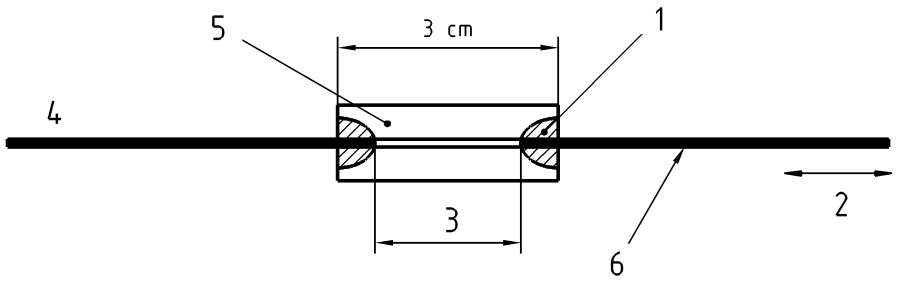
1 Wooden frame
2 Plywood base
3 Cross piece
4 Gauge length markers
5 End block
6 Glassfibre Reinforced Plastic (GRP) or similar mould block
7 Slot for plywood base
8 Top cross piece
9 Bottom cross piece
10 Top cross piece
11 Bottom cross piece
12 Plywood base
13 Frame

Figure 1 — Frame for SIC specimen manufacture

5 Test methods

5.1 Specimen manufacture

Ten individual specimens of the type shown in Figure 2 are needed for each determination.



Key

1 Modelling clay
2 Grip length
3 "Bare" strand test length of 20 mm
4 Resin impregnated strand
5 Cement block L = 30 mm; width = 10 mm; thickness = 10 mm
6 30 mm

Figure 2 — Strand in cement (SIC) specimen

The test is typically performed on strands (separated from a roving or cake) of between 19 tex and 150 tex. Experience has shown that the test is suitable for strands of 320 tex at maximum. Using the test frame, lengths of glass fibre strand are laid across the frame and held under slight tension by means of adhesive tape. At this stage, from the immediately adjacent portion of each length of strand a 1 m (to $\pm$ 2 mm) length is cut off and weighed to the nearest 0,1 mg in order to determine the strand tex. The weight measured for each length is corrected for size content. Subtracting the percentage size content of the glass fibre product as determined by ISO 1887 does this.

The central 20 mm test lengths of the glass fibre strands are defined by a marking system, for example by cotton or glass threads laid transversely across the centre portion of the frame. The epoxy resin, dyed with a colour to make more visible, is then applied as a coating to the test strands from a position 10 mm inside the frame edge up to the markers, leaving the central test length uncoated. The guide system is then removed and the glass strands straightened and tensioned before allowing the resin to cure.

After the resin is cured, a small quantity of modelling clay or silicone sealant is placed around the strand, in the form of a grommet, at the point where the resin impregnated portion ends and the test length begins, and the moulds for the cement mortar blocks are positioned around the test lengths. The purpose of the clay grommet is to prevent any adherence between the resin-coated part of the strand and the cement mortar block. Any strands that have become loose are re-tensioned.

The cement mortar is mixed thoroughly by hand or with an automatic device in a beaker for 3 min to 4 min when the water is added. The cement used should be a Standard cement from a consistent source to ensure repeatability and is preferably a type with defined alkali content of Na_2O-equivalent of 0,60 % ± 0,05 %. For standard evaluation of glass fibres, the mix proportions to be used are:

— Standard Rapid Hardening Portland cement (CEM I) as above: 75 parts by weight;

— sand (see specification Annex A): 25 parts by weight;

— water 32 parts by weight.

The moulds around the fibre strand test pieces are filled with the cement slurry and the frame tapped to ensure the mould is completely filled and level. Care shall be taken to avoid abrasion of the test fibre strands.

Immediately after filling the moulds with cement, the frame is placed for 24 h in a curing chamber with a temperature of (20 – 25) °C and a RH of (90 – 100) %. After this period, the moulds are dismantled from around the test pieces and identifying marks are applied to individual specimens.

5.2 Accelerated ageing

Groups of ten specimens, manufactured as in 5.1, are subjected to an accelerated ageing by controlled immersion in hot water. For the purpose of this document, the ageing regime is:

— immersion in deionised water maintained at 80 °C (± 1 °C) for 96 h (± 1 h).

NOTE For a full assessment of a new alkali resistant glass fibre or modified cement mixture, it is useful in addition to adopt testing points of immediately after the 24 h setting period and then after 36 h, 64 h and finally 96 h of hot water immersion. This will require a greater number of samples.

After ageing, samples are immersed in water at (20 – 25) °C for at least 15 min to cool prior to testing. They are then removed from the cooling water, placed carefully on a tray lined with paper tissue to absorb excess water and covered with a damp cloth until testing.

5.3 Mechanical testing

The tensile test machine, equipped with suitable grips having rubber faces, should be configured with a load cell of 200 Newton full-scale deflection capacity and be set at a crosshead speed of 1 mm per min.

For testing, the resin coated ends of the strand are gripped in the jaws of the tensile test machine according to ISO 3341 and the specimens loaded to failure. The maximum load for each sample in Newtons is noted against its reference number on a suitable record sheet (Annex B).

The strand should fail within the cement block. Any sample result where failure is outside the cement block should be ignored. If there are more than two failures outside the cement block in any group of ten samples, then the cause of such failure should be determined and remedied, and a repeat evaluation carried out.

6 Calculation of results

The breaking stress (σ, in MPa) (Formula 1) of each individual SIC specimen is calculated from the observed failure load (F, in Newtons) and the weight (M, in grams) of the adjacent 1 m length of strand, corrected for size content, by the formula:

$$\text{Breaking Stress}\,(\sigma) = \frac{F}{M} \times \rho \qquad (1)$$

Where

ρ is the density of glass fibre in g/cm^3 (measured in accordance with ISO 1888 and EN ISO 1889).

The Strand-in-Cement Strength for any one evaluation is the mean of the 10 individual SIC specimen strengths for the group of 10 specimens used. The Standard Deviation (s) (Formula 2) and Coefficient of Variation (CV) (Formula 3) are calculated by the following formulas:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2}\ \text{, standard deviation} \qquad (2)$$

$$CV(\%) = \frac{s}{\bar{x}} \times 100 \qquad (3)$$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i\ \text{, arithmetic mean value} \qquad (4)$$

In the case of assessment of a new type of glass fibre, or new cement system, tests shall be made immediately after the 24 h setting period and then after 36 h, 64 h and finally 96 h of hot water immersion and to plot the change in measured SIC value with time. The form of the graph will indicate if the SIC value has approached an equilibrium level after 96 h or is reducing in a linear manner.

NOTE Experience has shown that the coefficient of variation (CV) of the results from 10 individual specimens lies in the range (7–14) %. If the CV of a set of results exceeds 14 %, then the set of results should be discarded and the test repeated on fresh samples.

Annex A
(normative)

Sand specification - SIC test

A.1 Composition

The sand used in sample preparation should comply with the following:

— the sand should be from a proprietary source, bagged, washed and dried. This ensures that it will contain less soluble matter and fine particles, and permits more accurate control of water/cement ratio;

— the particle shape should be round or irregular, without elongated or flaky particles, and the surface texture should smooth without honeycombing.

A suitable chemical composition is as follows:

— silica > 96 %;

— moisture[1] < 2 %;

— soluble salts (i.e. alkalis) < 1 %;

— loss on Ignition < 0,5 %;

— organic matter shall not affect the setting of the cement;

— acid soluble sulphate content 0,4 (4 000 ppm) max;

— water-soluble chloride content 0,06 (600 ppm) max.

A.2 Grading

a) Particle size.

The grading should allow for 1,2 mm maximum particle size, as for sprayed GRC.

b) Fine fraction.

The fine fraction, that is sand passing a 0,15 mm sieve, should be less than 10 % of the total sand weight.

[1] According to EN ISO 334.

The distribution of particle size should ideally be well-distributed between these limits. A typical grading is as below:

Sieve size (mm)	% of residue on sieve
1,00	Nil
0,70	0,5
0,50	2,7
0,35	19,0
0,25	40,5
0,21	21,6
0,15	12,8
0,104	2,6
0,076	0,2
Pan	Trace

Annex B
(informative)

Strand in cement test results sheet

Date:.....

Fibre/strand identification: .....

Glass fibre density: (ρ) in g/cm^3 .....

Size pick-up: .....

Cement slurry formulation: .....

Ageing conditions: .....

Specimen number	Weight M (g)	M corrected for size content (g)	Load F (N)	Breaking Stress σ (MPa) $\sigma = \frac{F \times \rho}{M}$	Location at which the fibre fails
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Mean					
Standard Deviation					
Coefficient of variation (%)					

SIC strength value = MPa from this determination

Bibliography

[1] EN 197-1, *Cement – Part 1: Composition, specifications and conformity criteria for common cements*.

[2] EN 197-2, *Cement – Part 2: Conformity evaluation*.

[3] EN ISO 472, *Plastics – Vocabulary (ISO 472:1999)*.

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