INTERNATIONAL STANDARD

ISO 13270

First edition
2013-01-15

Steel fibres for concrete — Definitions and specifications

Fibres d'acier pour béton — Définitions et spécifications

Reference number
ISO 13270:2013(E)

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Published in Switzerland

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13270 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 17, *Steel wire rod and wire products*.

Steel fibres for concrete — Definitions and specifications

1 Scope

This International Standard specifies definitions and symbols, classification and codes, dimensions, masses and permissible variations, inspection methods, packing, delivery and storage for steel fibres for concrete.

This International Standard covers fibres intended for use in fibre-reinforced concrete, in all types of concrete and mortar, including sprayed concrete, flooring, precast, *in situ* and repair concretes

This International Standard can also be referred to for fibres used in fibre-reinforced engineering material, such as stainless steel fibre use in reinforced refractory material.

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.

ISO 404, *Steel and steel products — General technical delivery requirements*

ISO 1920-2:2005, *Testing of concrete — Part 2: Properties of fresh concrete*

ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7989-1, *Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 1: General principles*

ISO 10474, *Metallic products — Inspection documents*

ISO 22034-1, *Steel wire and wire products — Part 1: General test methods*

EN 197-1:2011, *Cement — Part 1: Composition, specifications and conformity criteria for common cements*

EN 206-1, *Concrete — Part 1: Specification, performance,production and conformity*

EN 933-2, *Tests for geometrical properties of aggregates — Part 2: Determination of particle size distribution — Test sieves, nominal size of apertures*

EN 934-2:2009, *Admixtures for concrete. mortar and grout — Part 2: Concrete admixtures — Definitions. requirements, conformity, marking and labeling*

EN 1008, *Mixing water for concrete — Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*

EN 1766:2000, *Products and systems for the protection and repair of concrete structures — Test methods — Reference concretes for testing*

EN 1992-1-1, *Eurocode 2: Design of concrete structures — Part 1-1: General rules and rules for buildings*

EN 12350-1, *Testing fresh concrete — Part 1: Sampling*

EN 12350-3, *Testing fresh concrete — Part 3: Vebe test*

EN 12350-4, *Testing fresh concrete — Part 4: Degree of compactability*

EN 14651, *Test method for metallic fibre concrete — Measuring the flexural tensile strength (limit of proportionality (LOP). residual)*

EN 14845-2, *Test methods for fibres in concrete — Part 2: Effect on concrete*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
steel fibres
straight or deformed pieces of cold-drawn steel wire, straight or deformed cut sheet fibres, melt-extracted fibres, shaved cold-drawn wire fibres and fibres milled from steel blocks which are suitable to be homogenously mixed into concrete or mortar

Note 1 to entry: Steel fibres are suitable reinforcement material for concrete because they possess a thermal expansion coefficient equal to that of concrete, their Young's Modulus is at least 5 times higher than that of concrete and the creep of regular carbon steel fibres can only occur above 370 °C.

3.2
length
distance between the outer ends of the fibre

3.2.1
developed length
length of the deformed fibres after straightening the fibre without deforming the cross-section

3.3
equivalent diameter
diameter of a circle with an area equal to the mean cross-sectional area of the fibre

Note 1 to entry: For circular fibres, the equivalent diameter is equal to the diameter of the fibres.

3.4
aspect ratio
ratio of length (l) to equivalent diameter of the fibre

3.5
fibre shape
specific outer configuration of the fibres, both in the longitudinal direction and in the shape of the cross-section and also the possible surface coatings and/or bundling of fibres

3.6
tensile strength of fibre
stress corresponding to the maximum force that one fibre can resist

Note 1 to entry: The methods concerning how to determine the tensile strength are explained in 7.3. The tensile strength is calculated by dividing the maximum force a fibre can resist by the mean cross-sectional area of the fibre.

3.7
crack mouth opening displacement
CMOD
linear displacement measured by a transducer installed on a prism subjected to a centre-point load F

3.8
elastic modulus
initial slope of the tensile stress versus tensile strain curve

3.9
declared value
value for a product property, determined in accordance with this standard, that a manufacturer is confident of achieving within the given tolerances taking into account the variability of the manufacturing process

3.10
linear displacement
δ
displacement measured by a transducer installed on a prism subjected to a centre-point load F

3.11
residual flexural strength
notional stress at the tip of the notch which is assumed to act in an uncracked mid-span section, with linear stress distribution, of a prism subjected to the centre-point load Fj corresponding to CMODj where CMODj > CMODδ; or to δj where $\delta j > \delta F_L$ (j = 1,2,3,4)

Note 1 to entry: F_L is the load at LOP (see EN 14651).

4 Symbols

For the purposes of this document, the symbols and definitions in Table 1 apply.

Table 1 — Symbols and definitions

Symbols	Definitions	Unit
w^a	width of the fibre	mm
t^a	thickness of the fibre	mm
d	diameter or equivalent diameter of the fibre	mm
R_m	tensile strength of the fibre	MPa
l	length of the fibre	mm
λ	aspect ratio of the fibre ($\lambda = l/d$)	
l_d	developed length of the fibre	mm
m	mass of the fibre	g
ρ	density of steel	kg/m^3

[a] Description for rectangular fibres.

5 Classification

The steel fibres shall conform to one of the groups and one of the shapes listed below:

a) Group

Steel fibres shall be classified into one of the following groups, in accordance with the basic material used for the production of the fibres.

Group I: cold-drawn wire

Group II: cut sheet

Group III: melt extracted

Group IV: shaved cold-drawn wire

Group V: milled from blocks

b) Shape

Fibres shall be either straight or deformed. The manufacturer shall declare the shape of the fibre. The control and tolerances on the shape shall be specified for each different shape separately.

When applicable, the type of bundling shall be declared.

c) Coating

When steel fibres are supplied with a coating (e.g. zinc coating), the type and characteristic quantity in g/m^2 shall be declared. The control of the quantity shall be a function of the type of coating and shall be declared by the manufacturer. In the case of a zinc coating, the determination of the coating thickness shall be performed according to ISO 7989-1. In the case of a Zn or Zn/Al coating, a protection against the alkaline environment is recommended (passivation).

6 Ordering information

The purchaser shall clearly provide the following information concerning the product in his enquiry or order:

a) the desired quantity;

b) the number of this International Standard;

c) group, shape, coating if any, class A, class B for Group I and nominal tensile strength ;

d) diameter or equivalent diameter;

e) length;

f) the type of inspection document;

g) for stainless steel fibres, the steel grade shall be agreed at the time of ordering.

7 Requirements

7.1 Dimensions and tolerances

7.1.1 General

For fibres of group I and II, the length, equivalent diameter, the class (A or B), and the aspect ratio shall be declared. The tolerances shall be as given in Table 2.

Specimens of fibres, when sampled in accordance with 8.2 and 8.3, and measured in accordance with 7.1.2 and 7.1.3, shall not deviate from the declared value by more than the tolerances given in Table 2. At least 95 % of the individual specimens shall meet the specified tolerances.

For fibres of group III, IV and V, the range of lengths, equivalent diameters and aspect ratios shall be declared. Specimens of fibres, when sampled in accordance with 8.2 and measured in accordance with 7.1.2 e 7.1.3 shall be within the specified range. At least 90 % of the individual specimen fibres shall meet the specified tolerances in both cases.

Table 2 — Tolerances on fibre length and diameter

Property	Range	Deviation of the individual value relative to the declared value		Deviation of the average value relative to the declared value	
		Class A	Class B	Class A	Class B
Length and developed length l (or l_d)	>30 mm ≤30 mm	±3 mm ±10 %	±10 %	±5 % ±1,5 mm	
(Equivalent) diameter d	>0,30 mm ≤0,30 mm	±0,02 mm	±10 %	±0,015	±5 % ±0,015 mm
Length/diameter ratio λ		±15 %		±7,5 %	

7.1.2 Determination of length

The length shall be measured with a marking gauge (callipers) with an accuracy of 0,1 mm.

In the case of an irregular cross-section, the developed length of the fibre shall also be determined to calculate the equivalent diameter. If straightening of the fibre is necessary, it shall be done by hand or, if this is not possible, by hammering on a level of wood, plastic material or copper using a hammer of similar material. During the straightening, the cross-section should not be changed.

7.1.3 Determination of (equivalent) diameter

7.1.3.1 Round wire fibres

The diameter of the fibre shall be measured with a micrometer, in two directions, approximately at right angles, to an accuracy of 0,01 mm. The fibre diameter shall be the mean of the two diameters.

7.1.3.2 Rectangular fibres

The width (w) and thickness (t) of the fibres shall be measured with a micrometer with an accuracy of 0,01 mm.

The equivalent diameter (d) is calculated using the following formula:

$$d = \sqrt{\frac{4wt}{\pi}}$$

7.1.3.3 Fibres with irregular cross-section

The mass (m) and the developed length (l_d) of the fibre shall be determined. The mass shall be determined to an accuracy of 0,001 g. The equivalent diameter is computed from the mass and the developed length using the following formula:

$$d = \sqrt{\frac{4m \times 10^6}{\pi l_d \rho}}$$

Where ρ is the nominal density: for all steels except stainless steel, it may be taken as 7850 kg/m^3; for stainless steel, it may be taken as 7950 kg/m^3."

7.2 Surface condition

The surface of fibre should be kept dry and clean, with no greasy dirt substances and inclusions existing which may effect the consistence behaviour of steel-fibre concrete.

Seams and surface irregularities shall not be the cause for rejection, provided that tensile properties are not less than the requirements of this specification and mixing performance in concrete is not adversely affected.

Rust, mill scale, or other coatings shall not be the cause for rejection provided that the individual fibres separate when mixed in concrete, and tensile and bending properties are not less than the requirements of this specification.

7.3 Tensile strength of fibres

The tensile strength (R_m) shall be determined in accordance with ISO 6892-1, except as indicated below, and shall be declared.

For Group I (cold-drawn wire), the tensile strength shall be determined from the source wire before deformation. The acceptable tolerance on the declared value of R_m shall be 15 % for individual values and 7,5 % for the mean value. At least 95 % of the individual specimens shall meet the specified tolerance.

For Group II (cut sheet), the tensile strength shall be determined from the source plate before deformation.

The acceptable tolerance on the declared value of R_m shall be 15 % for individual values and 7,5 % for the mean value. At least 95 % of the individual specimens shall meet the specified tolerance.

For Group III (melt-extracted fibres), Group IV (shaved cold-drawn wire) and Group V (milled from steel blocks) the tensile strength shall be determined from fibres with a minimum length of 20 mm clamped within the jaws of the testing machine. These fibre types have an irregular cross-section and therefore the fibres will break at the minimum cross-section. The nominal tensile strength shall be determined by dividing the maximum load during the tensile test by the cross-section calculated from the equivalent diameter. The manufacturer may determine the cross-section at the break by an optical method, in which case the tensile strength, obtained by dividing the maximum tensile load during the tensile test by the fracture cross-section, may also be declared, giving the precision of the area measurement.

For Groups III, IV and V, the manufacturer may instead declare a minimum tensile strength and at least 90 % of the individual specimens of fibres shall then comply with this value.

7.4 Modulus of elasticity

The manufacturer shall declare the modulus of elasticity of the fibres.

The modulus of elasticity may be determined for Groups I and II fibres using the tensile test as described in ISO 6892-1. The test shall be done on the basic material before deformation of the fibre and the modulus of elasticity shall be calculated using the stress and the deformation at 10 % and 30 % of R_m.

7.5 Bending requirements

Fibres shall withstand being bent, according to ISO 22034-1, around a 3,0 mm diameter pin to an angle of 90° at temperatures not less than 16 °C. At least no less than 90 % of the fibres being tested should be without breaking.

7.6 Mixing

Mixing instructions shall be supplied by the manufacturer which recommend the mixing sequence to be adopted when introducing the fibre into both a centrally mixed concrete plant and for a dry-batch truck mixed plant.

7.7 Reinforcing effect of the steel fibres in concrete

The minimum reinforcing effect of the steel fibres in concrete shall be determined according to Annex A, The unit volume of fibres in kg/m^3 shall be declared by the manufacturer that achieves a residual flexural

strength of 1,5 MPa at 0,5 mm CMOD (equivalent to 0,47 mm central deflection) and a residual flexural strength of 1 MPa at 3,5 mm CMOD (equivalent to 3,02 mm central deflection).

7.8 Effect on consistency of concrete

The effect of fibres on the consistency of a reference concrete conforming to Annex A (Clause A.1) shall be determined.

The consistence according to ISO 1920-2:2005, subclause 4.4 shall be determined on the reference concrete without fibres and then on an identical mix with fibres. The effect on consistency shall be declared.

The amount of fibres added shall be declared by the manufacturer and shall be the minimum amount of fibres needed to obtain the required strength specified in 7.7. If a plasticiser or superplasticer is needed in order to meet the consistence requirements when determining the required addition level of fibres, the amount and type shall also be declared by the manufacturer.

The fibre manufacturer may additionally declare the consistency for the reference concrete with a range of dosages of fibres.

7.9 Effect on air of concrete

Steel fibres, dosed at 30 kg/m^3, in a reference concrete, conforming with Annex A, but without the use of a water reducing agent or highly water reducing agent, should not increase the air content by more than 2 % versus the air content of the plain reference concrete. The air content of the reference concrete with or without steel fibres shall be measured in accordance to ISO 1920-2:2005, subclause 6.4.

8 Testing and Inspection

8.1 General

Products conforming to this International Standard shall be delivered with specific testing (see ISO 404) and the relevant inspection document, in accordance with ISO 10474, specified by the purchaser at the time of enquiry or order.

All steel fibres are intended to structurally reinforce the concrete. The conformity of the steel fibres with the requirements of this International Standard and with the declared values shall be demonstrated as ITT (Initial Type Test) + a continuous production control (FPC), both under the surveillance of a Certifying Body.

8.2 ITT (Initial Type Test)

Initial type testing, according to Table 3, shall be performed to show conformity with this International Standard.

The tests shall be repeated whenever a change in the basic materials or manufacturing procedure occurs, or a new product type is being produced.