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Quality control for batching and mixing steel fibre-reinforced concretes

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Foreword

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 6, *Non-traditional reinforcing materials for concrete structures*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Quality control for batching and mixing steel fibre-reinforced concretes

1 Scope

This document specifies the principles and procedures to secure quality control of steel fibre-reinforced concretes (SFRC) during batching and mixing procedures to deliver to a purchaser with the ingredients uniformly mixed, and that can be sampled and tested at the point of delivery.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 13270, *Steel fibres for concrete — Definitions and specifications*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13270 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
slump
distance from the top of the slumped concrete to the level of the top of the slump cone.

3.2
workability
property measure of the ease of moulding or shaping an unshaped concrete.

3.3
segregation
separation of aggregate and fines during fabrication of a concrete to leave a honeycomb appearance and/or a layer of excess fines.

3.4
fibre balling
bunch of fibres sticking together during fibre integration in the concrete mix.

3.5
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.

4 Materials

4.1 Steel fibres

4.1.1 Classification

Five general groups of steel fibres in accordance with ISO 13270 are identified in this document based on the product or process used as a source of the steel fibre material.

a) Group I: cold-drawn wire

b) Group II: cut sheet

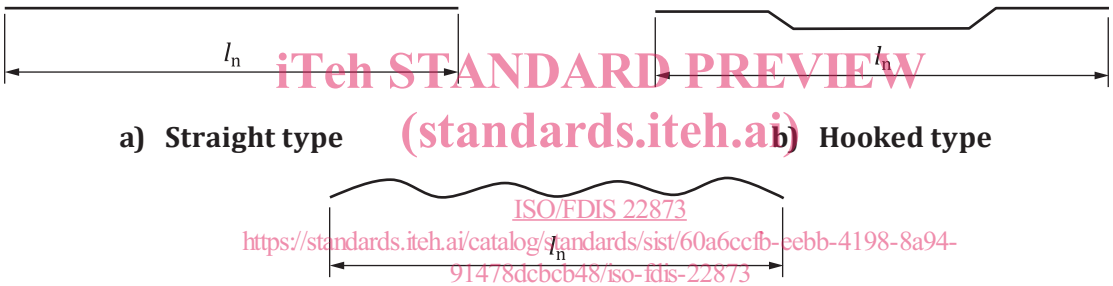
c) Group III: melt-extracted

d) Group IV: shaved cold-drawn wire

e) Group V: milled from blocks

4.1.2 Shape

Fibres shall be straight or deformed.



a) Straight type **b) Hooked type**

c) Crimped type

Key

l_n nominal length of fibre

Figure 1 — Steel fibre types

4.2 Admixture

a) Calcium chloride and chlorides from other sources should be limited to lower than 0,3 kg/m^3. The amounts should be lower than 0,6 kg/m^3 when permitted by purchaser approval.

b) Both chemical and mineral admixtures are suitable in steel fibre-reinforced concretes (SFRC) and are commonly used.

c) Air-entraining admixtures are recommended for SFRC exposed to freezing and thawing conditions.

4.3 Storage of fibres

Care should be taken to see that steel fibres are stored in a manner that prevents their deterioration or the intrusion of moisture or foreign matter. If fibres deteriorate or become contaminated, they should not be used.

5 Mixture proportioning

5.1 General

As with conventional concrete, SFRC mixtures employ a variety of mixture proportions depending on the end use. Because of the unique properties of SFRC, slump requirements are somewhat different from those of conventional concrete. Some modifications for mixture proportions of SFRC compared to the conventional concrete are required.

5.2 Proportioning methods

Steel fibres shall be added without any changes to the conventional mixture proportions used by ready-mix suppliers for the required concrete compressive strength. Where very large numbers of fibres per unit volume are used, some adjustments can be required. To provide better workability of the concrete, more paste is needed in the mixture. Therefore, the ratio of fine-to-coarse aggregate is adjusted upward accordingly. To prevent wet fibre balls, avoid overmixing and using a mixture with too much coarse aggregate (more than about 55 % of the total combined aggregate by absolute volume).

Another method of improving SFRC workability has been to use pozzolans such as fly ash, slag or silica fume in addition to or as a partial replacement of hydraulic cement.

6 Batching

6.1 Measuring materials

a) Hydraulic cement, aggregate, water, mineral and chemical admixtures shall be measured with each scale. Water weighed with chemical admixture in advance shall be measured together.

b) Fibres shall be batched by mass or volume with an accuracy of –3 % and +5 % of the amount required per batch.

c) When fibres are to be measured by mass, bags, boxes or like containers provided that such like containers are sealed by the fibre manufacturer and have the mass contained therein clearly marked. No fraction of a container delivered unsealed, or left over from previous work, shall be used unless weighed.

6.2 Batching plant

a) Bins with adequate separate compartments shall be provided in the batching plant for fine and for each required size of coarse aggregate. Each bin shall be designed and operated so as to discharge efficiently and freely, with minimum segregation, into the weighing hooper.

b) Scales shall be considered accurate if load indicated relative to applied test load is within ±0,15 % of the total capacity of the scale or 0,4 % of the net applied load.

c) Indicating devices shall be in full view and near enough to be read accurately by the operator while charging the hopper. The operator shall have convenient access to all controls.

d) All exposed fulcrums, clevises and similar working parts of scales shall be kept clean.

7 Mixing

7.1 General

There are some important differences in mixing SFRC in a transit mixer or revolving drum mixer compared to conventional concrete. One of these is that, to obtain good dispersion of the fibres and to prevent fibre balling, the fibres should be added to a fluid mix.

7.2 Mixer equipment

a) Mixers include stationary mixers or truck mixers. Agitators include truck mixers or truck agitators.

b) Stationary mixers shall be equipped with a metal plate or plates on which are plainly marked the mixing speed of the drum or paddles, and the maximum capacity in terms of the volume of mixed concrete. If used for the complete mixing of concrete, stationary mixers shall be equipped with an acceptable timing device that does not permit the batch to be discharged until the specified mixing time has elapsed.

c) Each truck mixer or agitator shall have attached thereto in a prominent place a metal plate or plates on which are plainly marked the gross volume of the drum, the capacity of the drum or container in terms of the volume of mixed concrete, and the minimum and maximum mixing speeds of rotation of the drum, blades or paddles.

d) Stationary and truck mixers shall be capable of producing uniformly mixed concrete within the specified time or the specified number of revolutions.

e) The agitator shall be capable of maintaining the mixed concrete in a uniformly mixed condition.

f) Mixers and agitators shall be examined, or their mass determined, as frequently as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examined to detect wear of blades.

7.3 Mixing method

7.3.1 Add fibres to transit mix truck

a) The wet mixture to be used is prepared first without the fibres. The slump of the concrete before fibre addition should be 50 mm to 75 mm greater than the final slump desired. Normally, the mixture would be prepared using the water-hydraulic cement ratio found to give the best results and meeting the specifications for the job. The use of a high-range water-reducing admixture can be advantageous, but is not essential.

b) Adding the individual fibres, ball-free, with the mixes operating at normal charging speed to the mixer. Mechanical or pneumatic systems that prevent fibres balling are recommended for insertion fibres into the concrete mixer. A conventional way to do this is to dump the fibres through a 100 mm mesh screen into a hopper which opens onto a moving conveyor belt going to the mixer. It is important that no clumps be introduced; once a clump is introduced into the mixture, it remains a clump. The drum shall rotate fast enough to carry away the fibres as they enter the mixture. After all the fibres have been introduced into the mixer, the mixer should be slowed to the rated mixing speed and mixed for approximately 30 to 40 revolutions.

c) For small jobs, this method has been used successfully by a number of ready-mix concrete producers.

7.3.2 Add fibres to aggregate on a conveyor belt

a) In a plant set up to charge a central mixer or transit mixers, add the fibres to the aggregates on a conveyor belt during aggregate addition and mix in the normal manner. Fibres should not be allowed to pile up and form balls on their way to the mixer.

b) Operator should stretch out the addition of aggregate so that fibres go in with the aggregate and not by themselves.

c) A fibre feeder or shaker is useful in reducing the time for fibres handing and addition.

d) This method has been used for the majority of fibrous concrete projects where larger quantities of concrete were mixed using bulk individual fibres.

NOTE Most fibres balling occurs somewhere before the fibres get into the mixture when the fibres are added too fast at some point in the procedure (in the mixer, on the belt, on the vanes, on the loading chute, etc.). Other causes of balling are adding fibres to a mixture (more than about 2 % by volume or even 1 % of a fibre with a high aspect ratio, too fast addition to a harsh mixture, adding fibres first to the mixer, using equipment with worn-out mixing blades, overmixing, a mixture with too much coarse aggregate).

8 Quality

8.1 Slump and air content

a) Slump, air-content, and temperature tests shall be made at the time of placement at the option of the inspector as often as is necessary for control checks. In addition, these tests shall be made when specified and always when strength specimens are made.

b) If the measured slump, temperature, or air-content falls outside the specified limits, a check test shall be made immediately on another portion of the same sample. In the event of a second failure, the concrete shall be considered to have failed the requirements of the specification.

8.2 Tolerances in slump

a) When the project specifications for slump are written as a "maximum" or "not to exceed" requirement, then the concrete shall be supplied to the slump class for the maximum likely upper limit (see Table 1); and

Table 1 — Tolerances for specified slump (I)

Dimensions in millimetres

Specified slump	Tolerance
75 or less	−25
More than 75	−30

b) When the project specifications for slump are not written as a "maximum" or "not to exceed" requirement, Table 2 applies.

Table 2 — Tolerances for specified slump (II)

Dimensions in millimetres

Specified slump	Tolerance
50 and less	±15
50 to 100	±25
More than 100	±40

c) Fibre-reinforced concrete shall be available within the permissible range of slump for a period of 30 min starting either on arrival at the job site or after the permitted slump adjustment, whichever is later. The first and last 0,25 m^3 discharged are exempt from this requirement.

d) If the user is unprepared for discharge of the material at the job site, the manufacturer shall not be responsible for failure to meet slump requirement after 30 min have elapsed beyond either the actual arrival time at the job site or the requested delivery time, whichever is later.

8.3 Tolerances in air content

When air-entrainment is specified, the total air content measured shall be within a tolerance of ±1,5 % of the specified value.

The air content of air-entrained concrete when sampled from the transportation unit at the point of discharge shall be within a tolerance of ±1,5 % of the specified value.