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Additions for concrete

Ajout pour béton

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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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 3, *Concrete production and execution of 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.

Introduction

Silica fume consists of mainly spherical particles of amorphous silicon dioxide smaller than 10^{-6} m and is highly pozzolanic. It is collected by filters as a by-product of the smelting process to produce silicon metal and ferro-silicon alloys. It can be supplied as collected from the filters (undensified), after treatment to increase its bulk density (densified), or as a slurry. Silica fume from more than one furnace, filter or intermediate storage silo will normally be blended in the production plant.

Many years of research and practical experience have demonstrated that silica fume which satisfies the requirements in this document has highly pozzolanic properties and can be used to produce concrete with improved properties in both the fresh and hardened states. Silica fume is normally used in combination with a plasticizer and/or superplasticizer.

The use of coal for electricity production results in the generation of large quantities of fly ash. Different types of coal and the type of boiler used in this process produce different fly ashes, such as siliceous, silico-calcareous, or calcareous fly ashes with pozzolanic and/or latent hydraulic properties. All these types of fly ash are used in concrete production in some countries, based on national experience and tradition.

Before use, fly ash can be subject to processing, for example by classification, selection, sieving, drying, blending, grinding or carbon reduction, to optimize its fineness, reduce its water demand or to improve other properties. Such processed fly ashes can conform to this document to which reference is made in such a case. If they are out of the scope of this document, their suitability for use as Type II additions in concrete according to ISO 22965-2 can also be established from national standards or provisions valid in the place of use of the concrete and which refer specifically to the use of the addition in concrete conforming to ISO 22965-2.

When using fly ashes conforming to this document, it should be noted that, apart from the effect from the pozzolanicity of the fly ash, certain properties of fresh and hardened concrete can be affected. Where relevant, such effects need to be considered in concrete mix design (see ISO 22965-2).

Blast-furnace slag is classified into two types, air-cooled blast-furnace slag and granulated blast-furnace slag, according to the cooling process after the molten slag of approximately 1 500 °C is removed from the furnace. Granulated slag is made by rapidly chilling molten slag, such as by water jet, into a granulated glassy material, which is used for ground granulated blast-furnace slag, a material for slag cement. The amorphous glassy granulated slag has hydraulicity. When finely ground into ground granulated blast-furnace slag, it also demonstrates hardening and strength-developing properties (latent hydraulicity), as the slag itself undergoes hydration, similarly to cement, in the co-presence of cement (an alkaline stimulant) and water.

Additions for concrete

1 Scope

This document specifies requirements for the properties for silica fume, siliceous fly ash and ground granulated blastfurnace slag for use as a type II addition for production of concrete conforming to ISO 22965. Additions according to this document can also be used in mortars and grouts.

This document applies to the silica fume which is a by-product of the smelting process used to produce silicon metal and ferro-silicon alloys.

Fly ash produced with other types or higher percentages of co-combustion materials than those provided for in this document is outside the scope of this document.

Ground granulated blastfurnace slag containing any added materials other than grinding aids and/or gypsum (calcium sulfate) is not within the scope of this document.

It is not within the scope of this document to specify provisions for the practical application of additions in the production of concrete, mortar or grout, i.e. requirements concerning composition, mixing, placing, curing, etc.

NOTE Some rules are given in ISO 22965-2, e.g. provisions on general suitability and use of additions. Guidance on batching, control of additions content and the use of the *k*-value concept are also given in ISO 22965-2.

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 679, *Cement — Test methods — Determination of strength*

ISO 9277, *Determination of the specific surface area of solids by gas adsorption — BET method*

ISO 9286, *Abrasive grains and crude — Chemical analysis of silicon carbide*

ISO 9597, *Cement — Test methods — Determination of setting time and soundness*

ISO 10694, *Soil quality — Determination of organic and total carbon after dry combustion (elementary analysis)*

ISO 11885, *Water quality — Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES)*

ISO 16559, *Solid biofuels — Terminology, definitions and descriptions*

ISO 19596, *Admixtures for concrete*

ISO 20290-1, *Aggregates for concrete — Test methods for mechanical and physical properties — Part 1: Determination of bulk density, particle density, particle mass-per-volume and water absorption*

ISO 22965-2, *Concrete — Part 2: Specification of constituent materials, production of concrete and compliance of concrete*

ISO 29581-1, *Cement — Test methods — Part 1: Analysis by wet chemistry*

ISO 29581-2, *Cement — Test methods — Part 2: Chemical analysis by X-ray fluorescence*

EN 196-6, *Methods of testing cement — Part 6: Determination of fineness*

EN 196-7, *Methods of testing cement — Part 7: Methods of taking and preparing samples of cement*

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

EN 413-2:2005, *Masonry cement — Part 2: Test methods*

EN 451-1, *Method of testing fly ash — Part 1: Determination of free calcium oxide content*

EN 451-2, *Method of testing fly ash — Part 2: Determination of fineness by wet sieving*

EN 933-10, *Tests for geometrical properties of aggregates — Part 10: Assessment of fines — Grading of filler aggregates (air jet sieving)*

EN 1015-3:1999, *Methods of test for mortar for masonry — Part 3: Determination of consistence of fresh mortar (by flow table)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
activity index
ratio (in percent) of the compressive strength of a mortar where a specific percentage of the cement is replaced with the addition, relative to the compressive strength of the reference mortar specimens made from the test cement, tested at the same age

3.2
characteristic value
value having a prescribed probability of not being attained in a hypothetical unlimited test series

Note 1 to entry: Equivalent to "fractile" which is defined in ISO 3534-1:1993.

[SOURCE: ISO 8930:1987]

3.3
densified
state of silica fume that has been treated to increase the bulk density by particle agglomeration, the bulk density typically being above 450 kg/m^3

3.4
fly ash
fine powder of mainly spherical, glassy particles, derived from burning of pulverised coal, with or without co-combustion materials, which has pozzolanic properties and consists essentially of SiO_2 and Al_2O_3 and which:

— is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases of the power stations;

— can be processed, for example by classification, selection, sieving, drying, blending, grinding or carbon reduction, or by combination of these processes, in adequate production plants, in which case it can consist of fly ashes from different sources, each conforming to the definition given in this document

Note 1 to entry: Municipal and industrial waste incineration ashes do not conform to this definition.

3.5
granulated blastfurnace slag
vitrified material made by rapid cooling of a slag melt of suitable composition, obtained by smelting iron ore in a blastfurnace, consisting of at least two thirds by mass of glassy slag and possessing hydraulic properties when suitably activated

Note 1 to entry: Rapid cooling includes quenching in water (granulation) and projecting through water and air (pelletization).

3.6
green wood
wood originating from trees, bushes and shrubs that is created when processing wood as cross-cut ends, planings, saw dust and shavings used in the form of dust, chips and pellets

3.7
ground granulated blastfurnace slag
fine powder made by drying and grinding granulated blastfurnace slag where gypsum can be added and sulphur trioxide (SO_3) can be added up to 4,0 % of mass

3.8
particle density
average density of addition particles, including voids inside the particles

3.9
production plant
facility used by a manufacturer for the production and processing of addition

Note 1 to entry: Processing of addition includes selection, slurrifying, blending or densifying of addition.

3.10
silica fume
set of very fine particles of amorphous silicon dioxide collected as a by-product of the smelting process used to produce silicon metal and ferro-silicon alloys

Note 1 to entry: Silica fume can be processed, for example by classification, selection, blending, densifying, or slurrifying, or by a combination of these processes, in adequate production plants. Such processed silica fume can consist of silica fumes from different sources, each conforming to the definition given in this document.

Note 2 to entry: Other names used for silica fume are condensed silica fume and microsilica.

3.11
silica fume slurry
slurry
homogeneous, pH-regulated liquid suspension of silica fume in water, typically with a dry content of 50 % by mass, corresponding to about 700 kg of silica fume per cubic metre of slurry

3.12
spot sample
sample taken within a short period of time and at a fixed point from within a larger quantity, relating to the intended tests

Note 1 to entry: It can be obtained by combining one or more immediately consecutive increments.

3.13
test cement
Portland cement, conforming to ISO 22965, to be used for carrying out the tests needed to evaluate conformity

Note 1 to entry: Test cement is selected by the manufacturer and is further characterized by its fineness and contents of tricalcium aluminate and alkalis as follows:

— Fineness (Blaine): at least 300 m^2/kg when determined in accordance with EN 196-6 (or equivalent);

— Tricalcium aluminate: 6 % to 12 % when determined in accordance with EN 196-2 (or equivalent);

— Alkalis (Na_2O eqv): 0,4 % to 1,2 % when determined in accordance with ISO 29581-1 or ISO 29581-2 (or equivalent);

— Cement 28-day strength: 42,5 or higher.

3.14
type II addition
finely divided inorganic, pozzolanic or latent hydraulic material that may be added to concrete in order to improve certain properties or to achieve special properties

Note 1 to entry: See ISO 22965.

3.15
undensified
state of silica fume taken directly from the collection filter, the bulk density typically being in the range 150 kg/m^3 to 350 kg/m^3

4 Specifications

4.1 General

The chemical and physical requirements are specified as characteristic values. Conformity to a characteristic value is assessed by means of statistical control procedures (see Clause 6).

The test methods prescribed in this document are reference methods. In factory production control, other methods may be used provided they give results equivalent to those obtained with the reference method. In case of dispute, only the reference method shall be used.

4.2 Silica fume

4.2.1 General

The properties in 4.2.2.1 to 4.2.3.1 are specified as proportions by mass of dry silica fume. The laboratory samples shall be dried in a ventilated oven at (105 ± 5) °C to constant mass and then cooled in a dry atmosphere.

4.2.2 Chemical requirements

4.2.2.1 Silicon dioxide

The content of silicon dioxide, SiO_2, as determined by the method described as reference method in ISO 29581-1 or ISO 29581-2 shall be not less than 85 % by mass.

4.2.2.2 Elemental silicon

The content of elemental silicon, Si, determined according to ISO 9286, shall not be greater than 0,4 % by mass.

4.2.2.3 Free calcium oxide

The content of free calcium oxide, free CaO, as determined by the method described in EN 451-1 (or equivalent), shall not be greater than 1,0 % by mass.

4.2.2.4 Sulfate

The sulfate content, as determined by the method described in ISO 29581-1 or ISO 29581-2 (or equivalent) and expressed as total content of SO_3, shall not be greater than 3,0 % by mass.

4.2.2.5 Total content of alkalis

The total content of alkalis determined by the method described in ISO 29581-1 or ISO 29581-2 and calculated as "Na_2O equivalent" shall be declared.

NOTE Different national provisions adopt different principles but, in general, only a small proportion of alkalis in silica fume are considered to contribute to alkali silica reaction (see CEN Report CR 1901).

4.2.2.6 Chloride

The total content of chloride, calculated in accordance with the method described in ISO 29581-1 or ISO 29581-2, shall not be greater than 0,3 % by mass. If the Cl^- content is above 0,10 % by mass, the upper limit for its characteristic value shall be declared by the manufacturer.

4.2.2.7 Loss on ignition

The loss on ignition, as determined in accordance with the method described in ISO 29581-1 or ISO 29581-2, but using an ignition time of 1 h, shall not be greater than 5,0 % by mass.

4.2.3 Physical requirements

4.2.3.1 Specific surface area

The specific surface area, as determined by nitrogen adsorption according to the method given in ISO 9277, shall not be less than 15 000 m^2/kg, nor more than 35 000 m^2/kg.

4.2.3.2 Dry mass content in slurry

The dry mass content shall not deviate from the value declared by the supplier by more than ±2 % by mass of the slurry when determined by drying a representative sample of at least 5 g of slurry in a well ventilated oven at (105 ± 5) °C to constant mass. Constant mass is considered to be reached when successive weightings at least 1 h apart during drying at (105 ± 5) °C do not differ by more than 0,2 %.

4.2.3.3 Activity index

The activity index is determined as the ratio (in percent) of the compressive strength of standard mortar bars, prepared with 90 % test cement plus 10 % silica fume per mass of total binder, to the compressive strength of standard mortar bars prepared with 100 % test cement, when tested at the same age.

Preparation of standard mortar bars and determination of the compressive strength shall be carried out in accordance with the method described in ISO 679. The mortar containing silica fume shall be mixed with an amount of superplasticizer (conforming to ISO 19596) so that the mortar has a consistency equivalent to the reference mortar when tested by the flow table method given in EN 413-2 (or equivalent).

The activity index shall be at least 100 % when tested at a mortar age of 28 days.

NOTE The result of the activity index tests gives no direct information on the strength contribution of silica fume in concrete, nor is the use of silica fume limited to mixing ratio used in these tests.