SLOVENSKI STANDARD
oSIST prEN 197-1:2014

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Cement - 1. del: Sestava, zahteve in merila skladnosti za običajne cemente

Cement - Part 1: Composition, specifications and conformity criteria for common cements

Zement - Teil 1: Zusammensetzung, Anforderungen und Konformitätskriterien von Normalzement

Ciment - Partie 1 : Composition, spécifications et critères des conformité des ciments courants

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Cement - Part 1: Composition, specifications and conformity criteria for common cements

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Zement - Teil 1: Zusammensetzung, Anforderungen und Konformitätskriterien von Normalzement

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 51.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (prEN 197-1:2014) has been prepared by Technical Committee CEN/TC 51 “Cement and building limes”, the secretariat of which is held by NBN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 197-1:2011.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of Regulation (EU) No. 305/2011.

For relationship with Regulation (EU) No. 305/2011, see informative Annex ZA, which is an integral part of this document.

Annexes A and ZA are informative.

The preparation of a standard for cement was initiated by the European Economic Community (EEC) in 1969 and, at the request of a member state later in 1973, the work was given to the European Committee for Standardization (CEN). The Technical Committee CEN/TC 51 was entrusted with the task of preparing a cement standard for the countries of Western Europe, comprising the EEC and EFTA members.

In the early eighties, CEN/TC 51 decided to include in the standard for cement only those cements which are intended for use in any plain and reinforced concrete and which are familiar in most countries in Western Europe because they have been produced and used in these countries for many years. The EU Construction Products Directive (89/106/EEC) required the incorporation of all traditional and well-tried cements in order to remove technical barriers to trade in the construction field. There are currently no criteria for the descriptions "traditional" and "well tried" and it was considered necessary to separate the “common cements” from special cements, i.e. those with additional or special properties.

The requirements in this standard are based on the results of tests on cement in accordance with EN 196-1, EN 196-2, EN 196-3, EN 196-5, EN 196-6, EN 196-7, EN 196-8, and EN 196-9. The scheme for the evaluation of conformity of common cements including common cements with low heat of hydration and common cements generally accepted as being sulfate resisting are specified in EN 197-2.

In 2006, CEN/TC 51 started to investigate the possible standardization of new cements produced with traditional constituent materials and manufacturing methods, but according to composition limits out of the limits defined so far in EN 197-1. Based on the results of a pre-normative study presented in 2011, new cements containing Portland cement clinker and, as other main constituents, limestone, granulated blast furnace slag or siliceous fly ash or natural pozzolana, have been standardized in this document as CEM II/C and CEM VI.

The strength attained at twenty-eight days is the important criterion in classifying cement for most uses. In order to achieve a specific strength class at twenty-eight days the early strength, at two days or at seven days, can vary and some types of cement may not attain the minimum early strengths specified in EN 197-1 for common cements.

The heat of hydration is linked to the early reactivity and lower early strengths indicate lower heat evolution and lower temperatures in concrete. For these cements additional precautions in use can be necessary to ensure adequate curing and safety in construction.

The purpose of this standard is to specify the composition requirements and conformity requirements for common cements, including common cements with low heat of hydration and common cements with adequate sulfate resistance as well as low early strength blast furnace cements and low early strength blast furnace cements with low heat of hydration.

Cement types and strength classes defined in this European Standard allow the specifier and/or the user to fulfil objectives of sustainability for cement based constructions. Cement types produced by using constituents listed and defined in Clause 5 allow the manufacturer to minimize the use of natural resources in accordance with local conditions of production.

Introduction

It is recognized that different cements have different properties and performance. Those performance tests now available (i.e. setting time, strength, soundness and heat of hydration), have been included in this standard. In addition, work is being carried out by CEN/TC 51 to identify any additional tests which are needed to specify further performance characteristics of cement. Until further performance tests are available it is necessary that the choice of cement, especially the type and/or strength class in relation to the requirements for durability depending on exposure class and type of construction in which it is incorporated, follows the appropriate standards and/or regulations for concrete or mortar valid in the place of use.

1 Scope

This European Standard defines and gives the specifications of 35 distinct common cements, 7 sulfate resisting common cements as well as 3 distinct low early strength blast furnace cements and 2 sulfate resisting low early strength blast furnace cements and their constituents. The definition of each cement includes the proportions in which the constituents are to be combined to produce these distinct products in a range of nine strength classes. The definition also includes requirements which the constituents have to meet. It also includes mechanical, physical, and chemical requirements. Furthermore, this standard states the conformity criteria and the related rules. Necessary durability requirements are also given.

In addition to those sulfate resisting cements defined in the present document, other cements conforming either to this standard or to other standards, European or national, have been nationally demonstrated to have sulfate resisting properties. These cements which are listed in Annex A, are considered by different CEN Member countries as sulfate resisting within the limits of their territory.

NOTE 1 In addition to the specified requirements, an exchange of additional information between the cement manufacturer and user can be helpful. The procedures for such an exchange are not within the scope of this standard but should be dealt with in accordance with national standards or regulations or can be agreed between the parties concerned.

NOTE 2 The word “cement” in EN 197-1 is used to refer only to common cements unless otherwise specified.

This European Standard does not cover:

— very low heat special cement covered by EN 14216;
— supersulfated cement covered by EN 15743;
— calcium aluminate cement covered by EN 14647;
— masonry cement covered by EN 413-1.

2 Normative references

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

EN 196-1, *Methods of testing cement — Part 1: Determination of strength*

EN 196-2, *Methods of testing cement — Part 2: Chemical analysis of cement*

EN 196-3, *Methods of testing cement — Part 3: Determination of setting times and soundness*

EN 196-5, *Methods of testing cement — Part 5: Pozzolanicity test for pozzolanic cement*

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 196-8, *Methods of testing cement — Part 8: Heat of hydration — Solution method*

EN 196-9, *Methods of testing cement — Part 9: Heat of hydration — Semi-adiabatic method*

EN 197-2:2014, *Cement — Part 2: Conformity evaluation*

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

EN 933-9, *Tests for geometrical properties of aggregates — Part 9: Assessment of fines — Methylene blue test*

EN 13639, *Determination of total organic carbon in limestone*

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*

3 Terms and definitions

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

3.1
reactive calcium oxide (CaO)
fraction of the calcium oxide which, under normal hardening conditions, can form calcium silicate hydrates or calcium aluminate hydrates

Note 1 to entry: To evaluate this fraction, the total calcium oxide content (see EN 196-2) is reduced by the fraction corresponding to calcium carbonate ($CaCO_3$), based on the measured carbon dioxide (CO_2) content (see EN 196-2), and the fraction corresponding to calcium sulfate ($CaSO_4$), based on the measured sulfate (SO_3) content (see EN 196-2) after subtraction of the SO_3 taken up by alkalis.

3.2
reactive silicon dioxide (SiO_2)
fraction of the silicon dioxide which is soluble after treatment with hydrochloric acid (HCl) and with boiling potassium hydroxide (KOH) solution

Note 1 to entry: The quantity of reactive silicon dioxide is determined by subtracting from the total silicon dioxide content (see EN 196-2) the fraction contained in the residue insoluble in hydrochloric acid and potassium hydroxide (see EN 196-2), both on a dry basis.

3.3
main constituent
specially selected inorganic material in a proportion exceeding 5 % by mass related to the sum of all main and minor additional constituents

3.4
minor additional constituent
specially selected inorganic material used in a proportion not exceeding a total of 5 % by mass related to the sum of all main and minor additional constituents

3.5
type of common cement
one of the 35 products (see Table 1) in the family of common cements

3.6
strength class of cement
class of compressive strength

3.7
autocontrol testing
continual testing by the manufacturer of cement spot samples taken at the point(s) of release from the factory/depot

3.8
control period
period of production and dispatch identified for the evaluation of the autocontrol test results

3.9
characteristic value
value of a required property outside of which lies a specified percentage, the percentile P_k, of all the values of the population

3.10
specified characteristic value
characteristic value of a mechanical, physical or chemical property which in the case of an upper limit is not to be exceeded or in the case of a lower limit is, as a minimum, to be reached

3.11
single result limit value
value of a mechanical, physical or chemical property which – for any single test result – in the case of an upper limit is not to be exceeded or in the case of a lower limit is, as a minimum, to be reached

3.12
allowable probability of acceptance CR
for a given sampling plan, allowed probability of acceptance of cement with a characteristic value outside the specified characteristic value

3.13
sampling plan
specific plan which states the (statistical) sample size(s) to be used, the percentile P_k and the allowable probability of acceptance CR

3.14
spot sample
sample which is taken at the same time and from one and the same place, relating to the intended tests, and which can be obtained by combining one or more immediately consecutive increments

Note 1 to entry: See EN 196-7.

3.15
heat of hydration
quantity of heat developed by the hydration of a cement within a given period of time

3.16
low heat common cement
common cement with a limited heat of hydration

3.17
sulfate resisting common cement
common cement which fulfils the requirements for sulfate resisting properties

3.18
low heat low early strength blast furnace cement
low early strength blast furnace cement with a limited heat of hydration

3.19
sulfate resisting low early strength blast furnace cement
low early strength blast furnace cement which fulfils the requirements for sulfate resisting properties

4 Cement

Cement is a hydraulic binder, i.e. a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water.

Cement conforming to this standard, termed CEM cement, shall, when appropriately batched and mixed with aggregate and water, be capable of producing concrete or mortar which retains its workability for a sufficient time and shall after defined periods attain specified strength levels and also possess long-term volume stability.

Hydraulic hardening of CEM cement is primarily due to the hydration of calcium silicates but other chemical compounds may also participate in the hardening process, e.g. aluminates. The sum of the proportions of reactive calcium oxide (CaO) and reactive silicon dioxide (SiO_2) in CEM cement shall be at least 50 % by mass when the proportions are determined in accordance with EN 196-2.

CEM cements consist of different materials and are statistically homogeneous in composition resulting from quality assured production and material handling processes. The link between these production and material handling processes and the conformity of cement to this standard is elaborated in EN 197-2.

NOTE There are also cements whose hardening is mainly due to other compounds, e.g. calcium aluminate in calcium aluminate cement.

5 Constituents

5.1 General

The requirements for the constituents specified in 5.2 to 5.5 shall be determined in principle in accordance with the test methods described in EN 196 unless otherwise specified.

5.2 Main constituents

5.2.1 Portland cement clinker (K)

Portland cement clinker is made by sintering a precisely specified mixture of raw materials (raw meal, paste or slurry) containing elements, usually expressed as oxides, CaO, SiO_2, Al_2O_3, Fe_2O_3 and small quantities of other materials. The raw meal, paste or slurry is finely divided, intimately mixed and therefore homogeneous.

Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates ($3CaO \cdot SiO_2$ and $2CaO \cdot SiO_2$), the remainder consisting of aluminium and iron containing clinker phases and other compounds. The ratio by mass $(CaO)/(SiO_2)$ shall be not less than 2,0. The content of magnesium oxide (MgO) shall not exceed 5,0 % by mass.

Portland cement clinker incorporated in sulfate resisting Portland cement (CEM I) and sulfate resisting pozzolanic cements (CEM IV) shall fulfil additional requirements for tricalcium aluminate content (C_3A). The tricalcium aluminate content of the clinker shall be calculated by Equation (1) as follows:

$$C_3A = 2{,}65\ A - 1{,}69\ F \quad (1)$$

where

A is the percentage of aluminium oxide (Al_2O_3) by mass of the clinker as determined in accordance with EN 196-2

F is the percentage of iron (III) oxide (Fe_2O_3) by mass of the clinker as determined in accordance with EN 196-2.

NOTE It may happen that a negative C_3A value is obtained from the calculation. In this case, the value 0 % should be recorded. A test method to determine the C_3A content of clinker from the analysis of a spot sample of cement is currently under development by CEN/TC 51. Until this method is available, the C_3A content should be directly measured on the clinker. In the specific case of CEM I, it is permissible to calculate the C_3A content of clinker from the chemical analysis of the cement. The minimum frequency of testing and the use of alternative methods for the direct or indirect evaluation of C_3A should be included in the factory production control (see EN 197-2). A typical frequency of testing is two per month in routine situations.

Sulfate resisting Portland cements and sulfate resisting pozzolanic cements are made with Portland cement clinker in which the C_3A content does not exceed:

- For CEM I: 0 %, 3 % or 5 % as appropriate (see 6.2)
- For CEM IV/A and CEM IV/B: 9 %.

5.2.2 Granulated blast furnace slag (S)

Granulated blast furnace slag is made by rapid cooling of a slag melt of suitable composition, as obtained by smelting iron ore in a blast furnace and contains at least two-thirds by mass of glassy slag and possesses hydraulic properties when suitably activated.

Granulated blast furnace slag shall consist of at least two-thirds by mass of the sum of calcium oxide (CaO), magnesium oxide (MgO) and silicon dioxide (SiO_2). The remainder contains aluminium oxide (Al_2O_3) together with small amounts of other compounds. The ratio by mass (CaO + MgO)/(SiO_2) shall exceed 1,0.

5.2.3 Pozzolanic materials (P, Q)

5.2.3.1 General

Pozzolanic materials are natural substances of siliceous or silico-aluminous composition or a combination thereof. Although fly ash and silica fume have pozzolanic properties, they are specified in separate subclauses (see 5.2.4 and 5.2.7).

Pozzolanic materials do not harden in themselves when mixed with water but, when finely ground and in the presence of water, they react at normal ambient temperature with dissolved calcium hydroxide ($Ca(OH)_2$) to form strength-developing calcium silicate and calcium aluminate compounds. These compounds are similar to those which are formed in the hardening of hydraulic materials. Pozzolanas consist essentially of reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other oxides. The proportion of reactive calcium oxide for hardening is negligible. The reactive silicon dioxide content shall be not less than 25,0 % by mass.

Pozzolanic materials shall be correctly prepared, i.e. selected, homogenized, dried, or heat-treated and comminuted, depending on their state of production or delivery.

5.2.3.2 Natural pozzolana (P)

Natural pozzolanas are usually materials of volcanic origin or sedimentary rocks with suitable chemical and mineralogical composition and shall conform to 5.2.3.1.

5.2.3.3 Natural calcined pozzolana (Q)

Natural calcined pozzolanas are materials of volcanic origin, clays, shales or sedimentary rocks, activated by thermal treatment and shall conform to 5.2.3.1.

5.2.4 Fly ashes (V, W)

5.2.4.1 General

Fly ash is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases from furnaces fired with pulverized coal.

NOTE 1 For definition of fly ash see EN 450-1.

Ash obtained by other methods shall not be used in cement that conforms to this standard.

Fly ash may be siliceous or calcareous in nature. The former has pozzolanic properties; the latter may have, in addition, hydraulic properties. The loss on ignition of fly ash determined in accordance with EN 196-2, but using an ignition time of 1 h, shall be within one of the following limits:

a) 0 % to 5,0 % by mass

b) 2,0 % to 7,0 % by mass

c) 4,0 % to 9,0 % by mass

The upper limit of loss on ignition of the fly ash used as a main constituent for the production of a cement shall be stated on its packaging and/or delivery note.

NOTE 2 The purpose of the requirement for the loss on ignition is to limit the residue of unburnt carbon in the fly ash. It is therefore sufficient to show, through direct measurement of unburnt carbon residue, that the content of unburnt carbon falls within the limits of the categories specified above. The content of unburnt carbon is determined in accordance with ISO 10694.

5.2.4.2 Siliceous fly ash (V)

Siliceous fly ash is a fine powder of mostly spherical particles having pozzolanic properties. It consists essentially of reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other compounds.

The proportion of reactive calcium oxide (CaO) shall be less than 10,0 % by mass, the content of free calcium oxide, as determined by the method described in EN 451-1 shall not exceed 1,0 % by mass. Fly ash having a free calcium oxide content higher than 1,0 % by mass but less than 2,5 % by mass is also acceptable, provided that the requirement on expansion (soundness) does not exceed 10 mm when tested in accordance with EN 196-3 using a mixture of 30 % by mass of siliceous fly ash and 70 % by mass of a CEM I cement conforming to EN 197-1.

The reactive silicon dioxide content shall not be less than 25,0 % by mass.

5.2.4.3 Calcareous fly ash (W)

Calcareous fly ash is a fine powder, having hydraulic and/or pozzolanic properties. It consists essentially of reactive calcium oxide (CaO), reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other compounds. The proportion of reactive calcium oxide shall not be less than 10,0 % by mass. Calcareous fly ash containing between 10,0 % and 15,0 % by mass of reactive calcium oxide shall contain not less than 25,0 % by mass of reactive silicon dioxide.

Adequately ground calcareous fly ash containing more than 15,0 % by mass of reactive calcium oxide shall have a compressive strength of at least 10,0 MPa at 28 days when tested in accordance with EN 196-1. Before testing, the fly ash shall be ground and the fineness, expressed as the proportion by mass of the ash retained when wet sieved on a 40 µm mesh sieve, shall be between 10 % and 30 % by mass. The test mortar shall be prepared with ground calcareous fly ash only instead of cement. The mortar specimens shall be demoulded 48 h after preparation and then cured in a moist atmosphere of relative humidity of at least 90 % until tested.

The expansion (soundness) of calcareous fly ash shall not exceed 10 mm when tested in accordance with EN 196-3 using a mixture of 30 % by mass of calcareous fly ash ground as described above and 70 % by mass of a CEM I cement conforming to EN 197-1.

NOTE If the sulfate (SO_3) content of the fly ash exceeds the permissible upper limit for the sulfate content of the cement then this has to be taken into account for the manufacture of the cement by appropriately reducing the calcium sulfate-containing constituents.