SLOVENSKI STANDARD
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Cement - 1. del: Sestava, zahteve in merila skladnosti za obiļajne cemente

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

Zement - Teil 1: Zusammensetzung, Anforderungen und Konformitätskriterien für 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

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

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

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

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (prEN 197-1:2009) 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 197-1:2000.

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 EC Directive(s).

For relationship with EC Directive(s), see informative Annex ZA, which is an integral part of this document.

Annexes A and B 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 Standardisation (CEN). The Technical Committee TC 51 was entrusted with the task of preparing a cement standard for the countries of Western Europe, comprising the EEC and EFTA members.

A first enquiry initiated by CEN/TC 51 in the mid-seventies identified at that time nearly 20 different kinds of cement, which had all been standardised on a national basis and which had proved satisfactory in common or special fields of application under local conditions. The evaluation of the enquiry showed that different sources of raw materials, different climatic conditions and different social/cultural attitudes have established a typical architecture with different building techniques in the different regions of Western Europe which led to the great variety of kinds of cement. The same or similar cement may be used in very different structures with different types of application and with substantially different requirements regarding its performance under the respective climatic conditions.

When CEN/TC 51 became aware of this situation, it decided in the early eighties 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 view of CEN/TC 51 was then that the more regional cements should continue to be standardised at the national level. The 1989 draft for the standard for cement followed this approach, but did not achieve the majority necessary for acceptance because a few countries wanted to incorporate all their nationally standardised cements and because the EU Construction Products Directive (89/106/EEC) requires the incorporation of all traditional and well tried cements in order to remove technical barriers to trade in the construction field.

There are as yet no criteria for the descriptions "traditional" and "well tried". A second enquiry initiated by CEN/TC 51 in 1990 revealed a further 50 cements standardised nationally. It became obvious that some of the cements described as traditional by the respective national standardisation bodies have been produced and used for decades so that their durability performance has been proved in practice. In contrast, there are some cements, also regarded as traditional and well tried which have been produced only for a few years and have been standardised nationally for only one or two years.

In view of the large number of different cements involved, it was considered necessary to separate the “common cements” from special cements i.e. those with additional or special properties. The purpose of EN 197-1 is to specify the composition, requirements and conformity criteria for the common cements. This includes all common cements and common cements generally accepted as being sulfate resisting which are described by the respective national standardisation bodies within CEN as traditional and well tried. Types based on composition and a classification based on strength have been introduced in order to take into account the different cements included. The hardening of these cements mainly depends on the hydration of calcium silicates. Common cements with special properties as well as cements with different hardening processes will be included in further parts of this European Standard or in further European Standards respectively.

The requirements in EN 197-1 are based on the results of tests on cement in accordance with EN 196-1, -2, -3, -5, -6, -7 -8, and -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 order to find out which common cements are generally accepted as being sulfate resisting and should be taken into account in EN 197-1, there was an investigation within CEN/TC 51 comprising all national specifications and recommendations in the European Union. The review of these investigations led to the following results:

— A wide variety of cements have been classified in the EU Member States as sulfate resisting. This is due to the different geographical and climatic conditions under which sulfate attacks on mortar and concrete occur at the place of use and the traditionally different rules governing the production and use of sulfate resistant mortars and concretes;

— sulfate resistance is an additional property and therefore sulfate resisting cements have first to conform to the requirements of the standards which define the product, e. g. EN 197-1 for common cements;

— the additional requirements to be met by the nationally specified sulfate resisting cements refer to selected characteristics for which the required limit values are more stringent than those for common cements;

— having satisfied the local requirements for various cement types many countries apply further restrictions to the production of concrete to be used in a sulfate environment, such as minimum cement contents and/or maximum water/cement ratio that vary depending on the cement type and the type and intensity of the sulfate conditions.

Based on the above results common cement types to be harmonized at the European level have been chosen. Most of the common cements on the market which are generally accepted as being sulfate resisting are covered by this selection. It was not possible to take into account national particularities the use of which is laid down within national standards, national application rules and regulations/provisions.

The strength attained at 28 days is the important criterion in classifying cement for most uses. In order to achieve a specific strength class at 28 days the early strength, at 2 days or at 7 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 EN 197-1 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 blastfurnace cements and low early strength blastfurnace cements with low heat of hydration.

Introduction

It is recognised that different cements have different properties and performance. Those performance tests now available (i.e. setting time, strength and soundness and heat of hydration), have been included in EN 197-1. 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

EN 197-1 defines and gives the specifications of 27 distinct common cements, 7 sulfate resisting common cements as well as 3 distinct low early strength blastfurnace cements and 2 sulfate resisting low early strength blastfurnace 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 EN 197-1 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 EN 197-1 or to other standards, European or national, have been nationally demonstrated to have sulfate resisting properties. These cements which are listed in Annex B, 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 EN 197-1 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.

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 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 time and soundness*

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

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, *Cement — Part 2: Conformity evaluation*

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

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 934-2, *Admixtures for concrete, mortar and grout — Part 2: Concrete admixtures - Definitions and requirements*

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

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

3 Definitions

For the purposes of this standard, the following definitions apply:

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

NOTE 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 substraction of the SO_3 taken up by alkalis.

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

NOTE The quantity of reactive silicon dioxide is determined by subtracting from the total silicon dioxide content (see EN 196-2) that 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 27 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, the 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 taken at the same time and from one and the same place, relating to the intended tests. It can be obtained by combining one or more immediately consecutive increments (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 blastfurnace cement
low early strength blastfurnace cement with a limited heat of hydration

3.19
sulfate resisting low early strength blastfurnace cement
low early strength blastfurnace 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 EN 197-1, 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 EN 197-1 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 pozzolanic cements (CEM IV) shall fulfill additional requirements for tricalcium aluminate content. The tricalcium aluminate content of the clinker shall be calculated by equation (1) as follows:

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

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 noted. 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 case of CEM I alone, it is permissible to calculate the C_3A content of clinker from the chemical analysis of the cement. The minimum frequency of testing and possible use of indirect methods of evaluation should be included in the factory production control (see EN 197-2). A typical frequency of testing is two per month in routine situation.

Sulfate resisting Portland cements and 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 blastfurnace slag (S)

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

Granulated blastfurnace 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 clauses (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, homogenised, 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

(1) Fly ash is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases from furnaces fired with pulverised coal. Ash obtained by other methods shall not be used in cement that conforms to EN 197-1.

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

(2) 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, in % by mass.

a) 0 up to 5,0

b) 2,0 up to 7,0

c) 4,0 up to 9,0

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

(3) The use of fly ash with loss on ignition up to 7,0 % or up to 9,0 % by mass may have an influence on the effect of air entraining admixture used for the manufacture of concrete resistant to freezing and thawing. According to the declared limit of the loss on ignition of the fly ash used as main constituent for the production of cement, the user could make the necessary evaluations in order to guarantee the durability of concrete following the standards and/or regulations for concrete valid in the place of use.