SLOVENSKI STANDARD

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Kalcijev aluminatni cement – Sestava, zahteve in merila skladnosti

Calcium aluminate cement - Composition, specifications and conformity criteria

Tonerdezement - Zusammensetzung, Anforderungen und Konformitätskriterien

Ciment d'aluminates de calcium - Composition, spécifications et criteres de conformité

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Calcium aluminate cement - Composition, specifications and conformity criteria

Ciment d'aluminates de calcium - Composition, spécifications et critères de conformité

Tonerdezement - Zusammensetzung, Anforderungen und Konformitätskriterien

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Management Centre: rue de Stassart, 36 B-1050 Brussels

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Foreword

This European Standard (EN 14647:2005) has been prepared by Technical Committee CEN/TC 51 “Cement and building limes”, the secretariat of which is held by IBN/BIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2006, and conflicting national standards shall be withdrawn at the latest by July 2007.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

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

The requirements in this European Standard are based on the results of tests on cement in accordance with EN 196-1, -2, -3, -5, -6, and –7. The scheme for the evaluation of conformity of calcium aluminate cement is specified in EN 197-2.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

Calcium aluminate cement was developed during the latter stages of the nineteenth century as an alternative to calcium silicate cement (Portland cement) to prevent structural elements from serious sulfate attack.

Whilst it is suitable for sulfate resistance it was also found to be exceptionally rapid hardening and resistant to high temperatures. It was this rapid hardening property that led to more general use particularly in precast applications.

The hydration of calcium aluminate cement is substantially different from that of Portland cement in that the calcium aluminate hydrates formed depend upon the temperature at which hydration takes place. At low and normal temperatures (less than 40 °C) the hydration process leads to a temporarily high strength. This situation can last for several days or many years, depending mainly upon temperature and humidity, before stable long term hydrates develop. This process, known as conversion, is inevitable. It is the result of a phase transition in the hardened paste of cement and is accompanied by a decrease in strength to a minimum stable level.

Misunderstanding of this conversion process and unsuccessful attempts to maintain the temporary high strength led to failures in several countries during the 1960's and 1970's. In one of the reported failures, the strength of concrete, made with calcium aluminate cement, was reduced even further as a result of chemical attack. Chemical resistance is reduced when porosity of concrete is increased by a high water/cement ratio and conversion. As a result, calcium aluminate cement has been, and remains, excluded from the list of cements permitted in structural concretes in some countries.

Guidance for the correct use of this cement is given in Annex A. It includes a method which allows the long term strength, i.e. after conversion, to be predicted.

NOTE 1 Calcium aluminate cement can be produced in a blastfurnace, using a process of reductive fusion (a method used in Germany until the 1980's) but the cement will have a high level of sulfides which would exclude it from this European Standard.

NOTE 2 Calcium aluminate cement has previously been known by several alternative names in different countries, e.g.

— high alumina cement;

— aluminous cement;

— high alumina melted cement.

1 Scope

This European Standard gives a general definition of calcium aluminate cement and its composition. It includes requirements for the mechanical, physical and chemical properties and also states the conformity criteria and the related rules.

Calcium aluminate cement used as a constituent material of formulated mixes for specific applications (e.g. dry mixes) is outside the scope of this European Standard.

NOTE Guidance for the correct use of calcium aluminate cement in concrete and mortars is given in Annex A.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 197-2:2000, *Cement — Part 2: Conformity evaluation*

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

3 Terms and definitions

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

3.1
autocontrol testing
continual testing by the manufacturer of cement spot samples taken at the point(s) of release from the factory/depot

3.2
control period
period of production and dispatch identified for the evaluation of the autocontrol test results

3.3
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

3.4
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

3.5
single result limit values
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

3.6
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

3.7
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*

3.8
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)

4 Calcium aluminate cement (CAC)

Calcium aluminate cement is a hydraulic binder i.e. it is 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 the hydration process has produced stable hydrated phases after conversion, retains its strength and stability.

Cement conforming to this European Standard 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.

The main component is monocalcium aluminate ($CaO \cdot Al_2O_3$). Other mineralogical compounds include calcium alumino-ferrites, dicalcium silicate, and calcium silico-aluminate or gehlenite.

Hydraulic hardening of calcium aluminate cement is primarily due to the hydration of monocalcium aluminate, but other chemical compounds may also participate in the hardening process.

Calcium aluminate cement consists of individual small grains of calcium aluminate clinker 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 calcium aluminate cement to this European Standard is elaborated in EN 197-2.

5 Constituents

5.1 Calcium aluminate cement clinker

Calcium aluminate cement clinker is produced by fusing or sintering a precisely specified mixture of aluminous and calcareous material.

5.2 Grinding aids

Grinding aids are chemical substances or proprietary products added to the calcium aluminate cement clinker during the grinding process to enhance the efficiency of the process. The total quantity of grinding aid on a dry basis shall not exceed 0,2 % by mass of the cement. Grinding aids shall not promote corrosion of reinforcement or impair the properties of the cement or of concrete and mortar made with the cement.

6 Cement type and composition

Except for grinding aids that may be used in manufacture, as stated in 5.2, calcium aluminate cement shall be composed of only calcium aluminate cement clinker.

7 Mechanical, physical and chemical requirements

7.1 Compressive strength

The compressive strength of calcium aluminate cement shall not be less than 18,0 MPa at 6 h and 40,0 MPa at 24 h, when tested in accordance with EN 196-1 at 6 h and 24 h (see also Table 1) under the following conditions:

- composition of the mortar shall be 1 350 g of CEN Standard sand, 500 g of calcium aluminate cement, and 200 g of water, i.e. a water/cement ratio of 0,40;
- all specimens shall be demoulded after 6 h ± 15 min;
- specimens to be tested at 6 h shall be tested immediately after demoulding;
- specimens to be tested at 24 h shall be stored in water after demoulding, and tested at 24 h ± 15 min.

7.2 Initial setting time

The initial setting time, determined in accordance with EN 196-3, shall not be less than 90 min (see also Table 1).

Other methods than EN 196-3 may be used provided that they give results correlated and equivalent to those obtained with EN 196-3.

Table 1 — Mechanical and physical requirements given as characteristic values

Compressive strength (MPa)		Initial setting time
at 6 h	at 24 h	(min)
≥ 18,0	≥ 40,0	≥ 90
NOTE 1 Calcium aluminate cements are very rapid hardening so 28 day strengths at 20 °C are not relevant. It is traditional to test conformity for strength at these early ages. NOTE 2 Values obtained from these tests should not be used for design purposes for concrete. An explanation of the strength development of calcium aluminate cement concretes and a method for predicting their minimum long term strength is given in Annex A.		

7.3 Chemical requirements

The properties of calcium aluminate cement shall conform to the requirements listed in Table 2 when tested in accordance with the European Standard referred to.

NOTE Some European countries have regulations for the content of water-soluble hexavalent chromium (see Annex B).

Table 2 — Chemical requirements given as characteristic values

Property	Test reference	Requirements [a]
Alumina content (as Al_2O_3)	EN 196-2	35 % ≤ Al_2O_3 ≤ 58 %
Sulfide content (as S^{-2})	EN 196-2	≤ 0,10 %
Chloride content	EN 196-2	≤ 0,10 %
Alkali content [b]	EN 196-2	≤ 0,4 %
Sulfate content (as SO_3)	EN 196-2	≤ 0,5 %

[a] Requirements are given as percentage by mass of the final cement.

[b] Expressed as Na_2O equivalent (Na_2O + 0,658 K_2O).

8 Standard designation

Calcium aluminate cement conforming to this European Standard shall be identified by:

Calcium aluminate cement EN 14647 CAC

The notation CAC covers definition (Clause 4), composition (Clauses 5 and 6) and requirements (Clauses 7 and 9).

NOTE 1 European cements are normally identified by type and a figure indicating the strength class. With calcium aluminate cement, care must be taken when assessing strength, due to the difference that is seen in cement hydration and hence strength development. Consequently it is normal that the designation of calcium aluminate cement does not refer to a strength class.

NOTE 2 A more extensive description of the strength development of calcium aluminate cement in concrete and mortar is given in Annex A.

9 Conformity criteria

9.1 General requirements

Conformity of calcium aluminate cement to this European Standard shall be continually evaluated on the basis of testing of spot samples. The properties, test methods and the minimum testing frequencies for the autocontrol testing by the manufacturer are specified in Table 3. Concerning testing frequencies for cement not being dispatched continuously and other details, see EN 197-2.

For certification of conformity by an approved certification body, conformity of cement with this European Standard shall be evaluated in accordance with EN 197-2.

NOTE This European Standard does not deal with acceptance inspection at delivery.

Table 3 — Properties and test methods and minimum testing frequencies for the autocontrol testing by the manufacturer and the statistical assessment procedure

Property	Test method [a] [b]	Minimum testing frequency		Statistical assessment procedure	
				Inspection by	
		Routine situation	Initial period	variables [d]	attributs [e]
Strength	EN 196-1	2/week	4/week	x	
Initial setting time	EN 196-3	2/week	4/week	x	
Alumina content	EN 196-2	2/month	1/week		x
Chloride content	EN 196-2	2/month [c]	1/week		x
Alkali content	EN 196-2	1/month	1/week		x
Sulfate content	EN 196-2	1/month	1/week		x
Sulfide content	EN 196-2	1/month	1/week		x

[a] Where allowed in the relevant part of EN 196, other methods than those indicated may be used provided they give results correlated and equivalent to those obtained with the reference method.

[b] Methods used to take and prepare samples shall be in accordance with EN 196-7.

[c] When none of the test results within a period of 12 months exceeds 50 % of the characteristic value, the frequency may be reduced to one per month.

[d] If the data are not normally distributed, then the method of assessment may be decided on a case by case basis.

[e] If the number of samples is at least one per week during the control period, the assessment may be made by variables.

9.2 Conformity criteria and evaluation procedure

9.2.1 General

Conformity of calcium aluminate cement with this European Standard is assumed if the conformity criteria specified in 9.2.2 and 9.2.3 are met. Conformity shall be evaluated on the basis of continual sampling using spot samples taken at the point of release and on the basis of the test results obtained on all autocontrol samples taken during the control period.

9.2.2 Statistical conformity criteria

9.2.2.1 General

Conformity shall be formulated in terms of a statistical criterion based on:

— specified characteristic values for mechanical, physical and chemical properties as given in 7.1, 7.2 and 7.3;

— percentile P_k, on which the specified characteristic value is based, as given in Table 4;

— allowable probability of acceptance *CR*, as given in Table 4.

Table 4 — Required values for P_k and *CR*

	Mechanical requirements		Physical and chemical requirements
	6 h strength (Lower limit)	24 h strength (Lower limit)	
The percentile P_k on which the characteristic value is based	10 %	5 %	10 %
Allowable probability of acceptance *CR*		5 %	

NOTE Conformity evaluation by a procedure based on a finite number of test results can only produce an approximate value for the proportion of results outside the specified characteristic value in a population. The larger the sample size (number of test results), the better the approximation. The selected probability of acceptance *CR* controls the degree of approximation by the sampling plan.

Conformity with the requirements of this European Standard shall be verified either by variables or by attributes as described in 9.2.2.2 and 9.2.2.3 as specified in Table 3.

The control period shall be 12 months.

9.2.2.2 Inspection by variables

For this inspection the test results are assumed to be normally distributed.

Conformity is verified when the following Equation(s) (1) and (2), as relevant, are satisfied:

$$\bar{x} - k_A \times s \geq L \quad (1)$$

and

$$\bar{x} + k_A \times s \leq U \quad (2)$$

where

$\bar{x}$ is the arithmetic mean of the totality of the autocontrol test results in the control period;

s is the standard deviation of the totality of the autocontrol test results in the control period;

k_A is the acceptability constant;

L is the specified lower limit given in Tables 1 and 2 referred to in 7.1 and 7.3;

U is the specified upper limit given in Table 2 referred to in 7.3.

The acceptability constant k_A depends on the percentile P_K on which the characteristic value is based, on the allowable probability of acceptance *CR* and the number n of the test results. Values of k_A are listed in Table 5.