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English version

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

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

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

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 51 "Cement and building limes", the secretariat of which is held by IBN.

This European Standard replaces ENV 197-1:1992

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of an identical text or by endorsement, at the latest by December 2000, and conflicting national standards shall be withdrawn at the latest by December 2000.

The 1992 version was modified by application of PNE rules, introduction of a revised clause 9, prepared by CEN/TC 51/WG 13, and by taking into account the results of a CEN/TC 51 enquiry in 1995 and a CEN enquiry in 1998.

EN 197-1 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 EN 197-1.

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 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 and -21. The scheme for the evaluation of conformity of common cements is specified in EN 197-2.

Annex A is informative.

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

Introduction

It is recognised that different cements have different properties and performance. Those performance tests now available (i.e. setting time, strength and soundness), 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 cement products 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 six strength classes. The definition also includes requirements the constituents have to meet and the mechanical, physical and chemical requirements of the 27 products and strength classes. EN 197-1 also states the conformity criteria and the related rules. Necessary durability requirements are also given.

NOTE 1 In addition to the specified requirements, an exchange of additional information between the cement manufacturer and user may 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 may 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

EN 197-1 incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to EN 197-1 only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to 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 196-21 ¹⁾, *Methods of testing cement - Part 21: Determination of the chloride, carbon dioxide and alkali content of cement.*

EN 197-2, *Cement - Part 2: Conformity evaluation.*

prEN 13639:1999, *Determination of total organic carbon content in limestone.*

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

¹⁾ EN 196-21 is currently being incorporated into EN 196-2.

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.*

3 Definitions

For the purposes of EN 197-1, 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 196-21), 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)

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)

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 (SiO₂) 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, SiO₂, Al₂O₃, Fe₂O₃ 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 · SiO₂ and 2CaO · SiO₂), the remainder consisting of aluminium and iron containing clinker phases and other compounds. The ratio by mass (CaO)/(SiO₂) shall be not less than 2,0. The content of magnesium oxide (MgO) shall not exceed 5,0 % by mass.

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 (SiO₂). The remainder contains aluminium oxide (Al₂O₃) together with small amounts of other compounds. The ratio by mass (CaO + MgO)/(SiO₂) 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 ($\text{Ca}(\text{OH})_2$) 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

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.

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 not exceed 5,0 % by mass.

Fly ash with loss on ignition of 5,0 % to 7,0 % by mass may also be accepted, provided that particular requirements for durability, especially frost resistance, and for compatibility with admixtures are met according to the appropriate standards and/or regulations for concrete or mortar in the place of use. In the case of fly ash with a loss on ignition between 5,0 % and 7,0 % by mass the maximum limit, 7,0 %, shall be stated on the packaging and/or the delivery note of the cement.

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 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 (SiO₂) and aluminium oxide (Al₂O₃). The remainder contains iron oxide (Fe₂O₃) 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 (SO₃) 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.

5.2.5 Burnt shale (T)

Burnt shale, specifically burnt oil shale, is produced in a special kiln at temperatures of approximately 800 °C. Owing to the composition of the natural material and the production process, burnt shale contains clinker phases, mainly dicalcium silicate and monocalcium aluminate. It also contains, besides small amounts of free calcium oxide and calcium sulfate, larger proportions of pozzolanically reacting oxides, especially silicon dioxide. Consequently, in a finely ground state burnt shale shows pronounced hydraulic properties like Portland cement and in addition pozzolanic properties.

Adequately ground burnt shale shall have a compressive strength of at least 25,0 MPa at 28 days when tested in accordance with EN 196-1. The test mortar shall be prepared with finely ground burnt shale only instead of cement. The mortar specimens shall be demoulded 48 h after preparation and cured in a moist atmosphere of relative humidity of at least 90 % until tested.

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

NOTE If the sulfate (SO_3) content of the burnt shale 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.

5.2.6 Limestone (L, LL)

Limestone shall meet the following requirements:

- a) The calcium carbonate (CaCO_3) content calculated from the calcium oxide content shall be at least 75 % by mass.
- b) The clay content, determined by the methylene blue test in accordance with EN 933-9, shall not exceed 1,20 g/100 g. For this test the limestone shall be ground to a fineness of approximately 5000 cm^2/g determined as specific surface in accordance with EN 196-6.
- c) The total organic carbon (TOC) content, when tested in accordance with prEN 13639:1999, shall conform to one of the following criteria:
 - LL: shall not exceed 0,20 % by mass;
 - L: shall not exceed 0,50 % by mass.

5.2.7 Silica fume (D)

Silica fume originates from the reduction of high purity quartz with coal in electric arc furnaces in the production of silicon and ferrosilicon alloys and consists of very fine spherical particles containing at least 85 % by mass of amorphous silicon dioxide.

Silica fume shall meet the following requirements:

- a) The loss on ignition shall not exceed 4,0 % by mass determined in accordance with EN 196-2 but using an ignition time of 1 h.
- b) The specific surface (BET) of the untreated silica fume shall be at least 15,0 m^2/g when tested in accordance with ISO 9277.

For intergrinding with clinker and calcium sulfate the silica fume may be in its original state or compacted or pelletised (with water).

5.3 Minor additional constituents

Minor additional constituents are specially selected, inorganic natural mineral materials, inorganic mineral materials derived from the clinker production process or constituents as specified in 5.2 unless they are included as main constituents in the cement.

Minor additional constituents, after appropriate preparation and on account of their particle size distribution, improve the physical properties of the cement (such as workability or water retention). They can be inert or have slightly hydraulic, latent hydraulic or pozzolanic properties. However, no requirements are set for them in this respect.

Minor additional constituents shall be correctly prepared, i.e. selected, homogenised, dried and comminuted depending on their state of production or delivery. They shall not increase the water demand of the cement appreciably, impair the resistance of the concrete or mortar to deterioration in any way or reduce the corrosion protection of the reinforcement.

NOTE Information on the minor additional constituents in the cement should be available from the manufacturer on request.

5.4 Calcium sulfate

Calcium sulfate is added to the other constituents of cement during its manufacture to control setting.

Calcium sulfate can be gypsum (calcium sulfate dihydrate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), hemihydrate ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$), or anhydrite (anhydrous calcium sulfate, CaSO_4) or any mixture of them. Gypsum and anhydrite are found naturally. Calcium sulfate is also available as a by-product of certain industrial processes.

5.5 Additives

Additives for the purpose of EN 197-1 are constituents not covered in 5.2 to 5.4 which are added to improve the manufacture or the properties of the cement.

The total quantity of additives shall not exceed 1,0 % by mass of the cement (except for pigments). The quantity of organic additives on a dry basis shall not exceed 0,5 % by mass of the cement.

These additives shall not promote corrosion of the reinforcement or impair the properties of the cement or of the concrete or mortar made from the cement.

When admixtures for concrete, mortar or grouts conforming to the EN 934 series are used in cement the standard notation of the admixture shall be declared on bags or delivery documents.

6 Composition and notation

The 27 products in the family of common cements, covered by EN 197-1, and their notation are given in Table 1. They are grouped into five main cement types as follows:

- CEM I Portland cement
- CEM II Portland-composite cement
- CEM III Blastfurnace cement
- CEM IV Pozzolanic cement
- CEM V Composite cement

The composition of each of the 27 products in the family of common cements shall be in accordance with Table 1.

NOTE For clarity in definition, the requirements for the composition refer to the sum of all main and minor additional constituents. The final cement is to be understood as the main and minor additional constituents plus the necessary calcium sulfate (see 5.4) and any additives (see 5.5).

Table 1 — The 27 products in the family of common cements

Main types	Notation of the 27 products (types of common cement)		Composition (percentage by mass ^a)											Minor additional constituents
			Main constituents											
			Clinker K	Blast-furnace slag S	Silica fume D ^b	Pozzolana		Fly ash		Burnt shale T	Limestone			
natural P	natural calcined Q	siliceous V				calcareous W	L	LL						
CEM I	Portland cement	CEM I	95-100	—	—	—	—	—	—	—	—	—	—	0-5
CEM II	Portland-slag cement	CEM II/A-S	80-94	6-20	—	—	—	—	—	—	—	—	—	0-5
		CEM II/B-S	65-79	21-35	—	—	—	—	—	—	—	—	—	0-5
	Portland-silica fume cement	CEM II/A-D	90-94	—	6-10	—	—	—	—	—	—	—	—	0-5
	Portland-pozzolana cement	CEM II/A-P	80-94	—	—	6-20	—	—	—	—	—	—	—	0-5
		CEM II/B-P	65-79	—	—	21-35	—	—	—	—	—	—	—	0-5
		CEM II/A-Q	80-94	—	—	—	6-20	—	—	—	—	—	—	0-5
		CEM II/B-Q	65-79	—	—	—	21-35	—	—	—	—	—	—	0-5
	Portland-fly ash cement	CEM II/A-V	80-94	—	—	—	—	6-20	—	—	—	—	—	0-5
		CEM II/B-V	65-79	—	—	—	—	21-35	—	—	—	—	—	0-5
		CEM II/A-W	80-94	—	—	—	—	—	6-20	—	—	—	—	0-5
		CEM II/B-W	65-79	—	—	—	—	—	21-35	—	—	—	—	0-5
	Portland-burnt shale cement	CEM II/A-T	80-94	—	—	—	—	—	—	6-20	—	—	—	0-5
		CEM II/B-T	65-79	—	—	—	—	—	—	21-35	—	—	—	0-5
	Portland-limestone cement	CEM II/A-L	80-94	—	—	—	—	—	—	—	6-20	—	—	0-5
		CEM II/B-L	65-79	—	—	—	—	—	—	—	21-35	—	—	0-5
		CEM II/A-LL	80-94	—	—	—	—	—	—	—	—	6-20	—	0-5
		CEM II/B-LL	65-79	—	—	—	—	—	—	—	—	21-35	—	0-5
	Portland-composite cement ^c	CEM II/A-M	80-94	<----- 6-20 ----->										0-5
		CEM II/B-M	65-79	<----- 21-35 ----->										0-5
	CEM III	Blastfurnace cement	CEM III/A	35-64	36-65	—	—	—	—	—	—	—	—	—
CEM III/B			20-34	66-80	—	—	—	—	—	—	—	—	—	0-5
CEM III/C			5-19	81-95	—	—	—	—	—	—	—	—	—	0-5
CEM IV	Pozzolanic cement ^c	CEM IV/A	65-89	—	<----- 11-35 ----->						—	—	—	0-5
		CEM IV/B	45-64	—	<----- 36-55 ----->						—	—	—	0-5
CEM V	Composite cement ^c	CEM V/A	40-64	18-30	—	<----- 18-30 ----->			—	—	—	—	0-5	
		CEM V/B	20-38	31-50	—	<----- 31-50 ----->			—	—	—	—	0-5	

a The values in the table refer to the sum of the main and minor additional constituents.
b The proportion of silica fume is limited to 10 %.
c In Portland-composite cements CEM II/A-M and CEM II/B-M, in pozzolanic cements CEM IV/A and CEM IV/B and in composite cements CEM V/A and CEM V/B the main constituents other than clinker shall be declared by designation of the cement (for example see clause 8).

7 Mechanical, physical, chemical and durability requirements

7.1 Mechanical requirements

7.1.1 Standard strength

The standard strength of a cement is the compressive strength determined in accordance with EN 196-1 at 28 days and shall conform to the requirements in Table 2.

Three classes of standard strength are included: class 32,5, class 42,5 and class 52,5 (see Table 2).

7.1.2 Early strength

The early strength of a cement is the compressive strength determined in accordance with EN 196-1 at either 2 days or 7 days and shall conform to the requirements in Table 2.

Two classes of early strength are included for each class of standard strength, a class with ordinary early strength, indicated by N, and a class with high early strength, indicated by R (see Table 2).

Table 2 — Mechanical and physical requirements given as characteristic values

Strength class	Compressive strength MPa				Initial setting time min	Soundness (expansion) mm
	Early strength		Standard strength			
	2 days	7 days	28 days			
32,5 N	-	≥ 16,0	≥ 32,5	≤ 52,5	≥ 75	≤ 10
32,5 R	≥ 10,0	-				
42,5 N	≥ 10,0	-	≥ 42,5	≤ 62,5	≥ 60	
42,5 R	≥ 20,0	-				
52,5 N	≥ 20,0	-	≥ 52,5	-	≥ 45	
52,5 R	≥ 30,0	-				

7.2 Physical requirements

7.2.1 Initial setting time

The initial setting time, determined in accordance with EN 196-3, shall conform to the requirements in Table 2.

7.2.2 Soundness

The expansion, determined in accordance with EN 196-3, shall conform to the requirement in Table 2.

7.3 Chemical requirements

The properties of the cements of the cement type and strength class shown in columns 3 and 4 respectively of Table 3 shall conform to the requirements listed in column 5 of this table when tested in accordance with the standard referred to in column 2.

NOTE Some European countries have additional requirements for the content of water-soluble hexavalent chromium (see informative annex A).

7.4 Durability requirements

In many applications, particularly in severe environmental conditions, the choice of cement has an influence on the durability of concrete, mortar and grouts, e.g. frost resistance, chemical resistance and protection of reinforcement.

The choice of cement, from EN 197-1, particularly as regards type and strength class for different applications and exposure classes shall follow the appropriate standards and/or regulations for concrete or mortar valid in the place of use.

Table 3 — Chemical requirements given as characteristic values

1	2	3	4	5
Property	Test reference	Cement type	Strength class	Requirements ^a
Loss on ignition	EN 196-2	CEM I CEM III	all	≤ 5,0 %
Insoluble residue	EN 196-2 ^b	CEM I CEM III	all	≤ 5,0 %
Sulfate content (as SO ₃)	EN 196-2	CEM I CEM II ^c CEM IV CEM V	32,5 N 32,5 R 42,5 N	≤ 3,5 %
			42,5 R 52,5 N 52,5 R	≤ 4,0 %
		CEM III ^d	all	
Chloride content	EN 196-21	all ^e	all	≤ 0,10 % ^f
Pozzolanicity	EN 196-5	CEM IV	all	Satisfies the test

- a Requirements are given as percentage by mass of the final cement.
b Determination of residue insoluble in hydrochloric acid and sodium carbonate.
c Cement type CEM II/B-T may contain up to 4,5 % sulfate for all strength classes.
d Cement type CEM III/C may contain up to 4,5 % sulfate.
e Cement type CEM III may contain more than 0,10 % chloride but in that case the maximum chloride content shall be stated on the packaging and/or the delivery note.
f For pre-stressing applications cements may be produced according to a lower requirement. If so, the value of 0,10 % shall be replaced by this lower value which shall be stated in the delivery note.

8 Standard designation

CEM cements shall be identified by at least the notation of the cement type as specified in Table 1 and the figures 32,5, 42,5 or 52,5 indicating the strength class (see 7.1). In order to indicate the early strength class the letter N or the letter R shall be added as appropriate (see 7.1).

EXAMPLE 1

Portland cement conforming to EN 197-1 of strength class 42,5 with a high early strength is identified by:

Portland cement EN 197-1 - CEM I 42,5 R

EXAMPLE 2

Portland-limestone cement containing between 6 % and 20 % by mass of limestone with a TOC content not exceeding 0,50 % by mass (L) of strength class 32,5 with an ordinary early strength is identified by:

Portland-limestone cement EN 197-1 - CEM II/A-L 32,5 N

EXAMPLE 3

Portland-composite cement containing in total a quantity of granulated blastfurnace slag (S), siliceous fly ash (V) and limestone (L) of between 6 % and 20 % by mass and of strength class 32,5 with a high early strength is identified by:

Portland-composite cement EN 197-1 - CEM II/A-M (S-V-L) 32,5 R

EXAMPLE 4

Composite cement containing between 18 % and 30 % by mass of granulated blastfurnace slag (S) and between 18 % and 30 % by mass of siliceous fly ash (V) of strength class 32,5 with an ordinary early strength is identified by:

Composite cement EN 197-1 - CEM V/A (S-V) 32,5 N

9 Conformity criteria

9.1 General requirements

Conformity of the 27 products to EN 197-1 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 4. 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 EN 197-1 shall be evaluated in accordance with EN 197-2.

NOTE EN 197-1 does not deal with acceptance inspection at delivery.

Table 4 — Properties, test methods and minimum testing frequencies for the autocontrol testing by the manufacturer, and the statistical assessment procedure

Property	Cements to be tested	Test method ^{a b}	Autocontrol testing			
			Minimum testing frequency		Statistical assessment procedure	
			Routine situation	Initial period for a new type of cement	Variables ^e	Attributes
1	2	3	4	5	6	7
Early strength Standard strength	All	EN 196-1	2/week	4/week	x	
Initial setting time	All	EN 196-3	2/week	4/week		x ^f
Soundness (Expansion)	All	EN 196-3	1/week	4/week		x
Loss on ignition	CEM I, CEM III	EN 196-2	2/month ^c	1/week		x ^f
Insoluble residue	CEM I, CEM III	EN 196-2	2/month ^c	1/week		x ^f
Sulfate content	All	EN 196-2	2/week	4/week		x ^f
Chloride content	All	EN 196-21	2/month ^c	1/week		x ^f
Pozzolanicity	CEM IV	EN 196-5	2/month	1/week		x
Composition	All	- ^d	1/month	1/week		

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 The 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 Appropriate test method chosen by the manufacturer.
e If the data are not normally distributed then the method of assessment may be decided on a case by case basis.
f 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 for mechanical, physical and chemical properties and evaluation procedure

9.2.1 General

Conformity of cement with the requirements for mechanical, physical and chemical properties in EN 197-1 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:

- the specified characteristic values for mechanical, physical and chemical properties as given in 7.1, 7.2, and 7.3 of EN 197-1;
- the percentile P_k , on which the specified characteristic value is based, as given in Table 5;
- the allowable probability of acceptance CR, as given in Table 5.

Table 5 — Required values P_k and CR

	Mechanical requirements		Physical and chemical requirements
	Early and standard strength (Lower limit)	Standard strength (Upper limit)	
The percentile P_k on which the characteristic value is based	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 EN 197-1 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 4.

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 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 Table 2 referred to in 7.1;
- U is the specified upper limit given in Tables 2 and 3 referred to in clause 7.

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 on the number n of the test results. Values of k_A are listed in Table 6.

Table 6 — Acceptability constant k_A

Number of test results n	k_A^a	
	for $P_k = 5\%$	for $P_k = 10\%$
	(early and standard strength, lower limit)	(other properties)
20 to 21	2,40	1,93
22 to 23	2,35	1,89
24 to 25	2,31	1,85
26 to 27	2,27	1,82
28 to 29	2,24	1,80
30 to 34	2,22	1,78
35 to 39	2,17	1,73
40 to 44	2,13	1,70
45 to 49	2,09	1,67
50 to 59	2,07	1,65
60 to 69	2,02	1,61
70 to 79	1,99	1,58
80 to 89	1,97	1,56
90 to 99	1,94	1,54
100 to 149	1,93	1,53
150 to 199	1,87	1,48
200 to 299	1,84	1,45
300 to 399	1,80	1,42
> 400	1,78	1,40

NOTE Values given in this table are valid for CR = 5 %.

^a Values of k_A valid for intermediate values of n may also be used.

9.2.2.3 Inspection by attributes

The number c_D of test results outside the characteristic value shall be counted and compared with an acceptable number c_A , calculated from the number n of autocontrol test results and the percentile P_k as specified in Table 7.

Conformity is verified when equation (3) is satisfied:

$$c_D \leq c_A \quad (3)$$

The value of c_A depends on the percentile P_k on which the characteristic value is based, on the allowable probability of acceptance CR and on a number n of the test results. Values of c_A are listed in Table 7.

Table 7 — Values of c_A

Number of test results n^a	c_A for $P_k = 10\%$
20 to 39	0
40 to 54	1
55 to 69	2
70 to 84	3
85 to 99	4
100 to 109	5
110 to 123	6
124 to 136	7
NOTE Values given in this table are valid for CR = 5 %.	
^a If the number of test results is $n < 20$ (for $P_k = 10\%$) a statistically based conformity criterion is not possible. Despite this, a criterion of $c_A = 0$ shall be used in cases where $n < 20$.	

9.2.3 Single result conformity criteria

In addition to the statistical conformity criteria, conformity of test results to the requirements of EN 197-1 requires that it shall be verified that each test result remains within the single result limit values specified in Table 8.

Table 8 — Limit values for single results

Property		Limit values for single results					
		Strength class					
		32,5N	32,5R	42,5N	42,5R	52,5N	52,5R
Early strength (MPa) lower limit value	2 day	-	8,0	8,0	18,0	18,0	28,0
	7 day	14,0	-	-	-	-	-
Standard strength (MPa) lower limit value	28 day	30,0	30,0	40,0	40,0	50,0	50,0
Initial setting time (min) lower limit value		60		50		40	
Soundness (expansion, mm) upper limit value		10					
Sulfate content (as % SO ₃) upper limit value	CEM I CEM II ^a CEM IV CEM V	4,0			4,5		
	CEM III/A CEM III/B	4,5					
	CEM III/C	5,0					
Chloride content (%) ^b upper limit value		0,10 ^c					
Pozzolanicity		positive at 15 days					
<p>a Cement type CEM II/B-T may contain up to 5,0 % SO₃ for all strength classes.</p> <p>b Cement type CEM III may contain more than 0,10 % chloride but in that case the maximum chloride content shall be declared.</p> <p>c For pre-stressing applications cements may be produced according to a lower requirement. If so, the value of 0,10 % shall be replaced by this lower value which shall be stated in the delivery note.</p>							

9.3 Conformity criteria for cement composition

At least once per month the composition of the cement shall be checked by the manufacturer, using as a rule a spot sample taken at the point of release of the cement. The cement composition shall meet the requirements specified in Table 1. The limiting quantities of the main constituents specified in Table 1 are reference values to be met by the average composition calculated from the spot samples taken in the control period. For single results, maximum deviations of -2 at the lower and +2 at the higher reference value are allowed. Suitable procedures during production and appropriate verification methods to ensure conformity to this requirement shall be applied and documented.

9.4 Conformity criteria for properties of the cement constituents

The cement constituents shall meet the requirements specified in clause 5. Suitable procedures during production to ensure conformity with this requirement shall be applied and documented.

Annex A (informative) A-deviation

A-deviation: national deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC members. In the CEN member countries these A-deviations are valid in addition to the relevant requirements of EN 197-1 until they have been removed.

For EN 197-1 national A-deviations have been applied according to EC-Directive 90/531 by Denmark, Finland, Germany, Iceland, Norway and Sweden. Reference is made to the following national regulations.

- Denmark: Arbejdstilsynets bekendtgørelse nr. 661 af 28. November 1983 om vandopløseligt chromat i cement.
- Finland: Decision of the Council of State concerning the content of chromate in cement for concrete and masonry cement, No. 593, July 24, 1986.
- Germany: Gefahrstoffverordnung (GefStoffV) together with TRGS 613 "Ersatzstoffe, Ersatzverfahren und Verwendungsbeschränkungen für chromathaltige Zemente und chromathaltige zementhaltige Zubereitungen, April 1993 (BArbBI Nr. 4.1993)".
- Iceland: Reglur nr. 330/1989 um króm i sementi, Order No. 330 of 19 June 1989.
- Norway: Directorate of Labour Inspection: Regulations relating to the Working Environment, laid down on 23 October 1987.
- Sweden: Kemikalieinspektionens föreskrifter om kemiska produkter och biotekniska organismer, KIFS 1998:8, 4 avdelning, 8 kap §§ 10-13, Kemikalieinspektionens allmänna råd till föreskrifterna om krom i cement, 1989:1.

Annex ZA (informative) Provisions for the CE marking of common cements under the EU Construction Products Directive

ZA.1 Clauses of EN 197-1 addressing the provisions of EU Construction Products Directive

EN 197-1 and this annex ZA have been prepared under a Mandate ²⁾ given to CEN by the European Commission and the European Free Trade Association.

The clauses of EN 197-1, shown in table ZA.1, meet the requirements of this Mandate given under the EU Construction Products Directive (89/106/EEC).

Compliance with these clauses confers a presumption of fitness of common cements covered by EN 197-1 for the intended use(s) under consideration in table ZA.2.

WARNING Other requirements and other EU Directives, not affecting the fitness for intended use(s), can be applicable to a construction product falling within the scope of EN 197-1.

There may be requirements on dangerous substances applicable to the products falling within the scope of EN 197-1 (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the EU Construction Products Directive, these requirements need also to be complied with, when and where they apply. *Note: an informative database of European and national provisions on dangerous substances is available at the Construction website on EUROPA (CREATE, accessed through <http://europa.eu.int>).*

²⁾ M114 "Cement, building limes and other hydraulic binders".

Table ZA.1 Harmonised clauses

Construction Products: 27 different common cement products (see Table 1)				
Intended use(s): Preparation of concrete, mortar, grout and other mixes for construction and for the manufacture of construction products (see notes in this table)				
Requirements/performance characteristics	Harmonised clauses^a in EN 197-1		CPD Article 3.2 level(s) and/or class(es)	Notes
	Clauses^a	Outline of the requirements		
Common cements (Subfamilies) constituents and composition	3 4 5 6 8 9	Constitutions of the 27 different products (Table 1) in the Product family “Common cements”, defined on the basis of constituent materials and composition.	None	Selection of cements by the Member States in technical regulations for particular intended uses shall be possible, based on the different cement products and on strength classes.
Compressive strength (early and standard)	7.1 8 9	Compressive strength requirements expressed in terms of strength classes and limits. ^b	None	
Setting time	7.2 9	Requirements expressed in terms of lower limits. ^b	None	
Insoluble residue	7.3 9	Requirements expressed in terms of upper limits. ^b	None	Only for CEM I and CEM III.
Loss on ignition	7.3 9	Requirements expressed in terms of upper limits. ^b	None	Only for CEM I and CEM III.
Soundness - Expansion	7.2 9	Requirements expressed in terms of upper limits. ^b	None	
- SO ₃ content	7.3 9			
Chloride content	7.3 9	Requirements expressed in terms of upper limits. ^b	None	
Pozzolanicity (for pozzolanic cement only)	7.3 9	Requirements expressed in terms of limits. ^b	None	Only for CEM IV.
Durability	4 5 7.4			Durability relates to the concrete, mortar, grout and other mixes made from cement according to the application rules valid in the place of use.

a The requirements in these clauses, including the entire contents and tables of the clauses listed, are fully integrated parts of this harmonised European Standard for cement.

b These limits are part of the definition of the products covered by this harmonised European Standard for cement.

ZA.2 Procedure for the attestation of conformity of products

The system of attestation of conformity for the 27 common cement products indicated in table ZA.1 is shown in table ZA.2 for the indicated intended use(s), in accordance with the Commission Decision of 14 July 1997 (97/555/EC) published in the Official Journal of the European Communities and given in annex 3 of the Mandate for the product family "Cements".

Table ZA.2 System of attestation of conformity

Product(s)	Intended use(s)	Level(s) or class(es)	Attestation of conformity system(s)
Common cements, including: - Portland cements - Portland composite cements Portland-slag cement Portland-silica fume cement Portland-pozzolana cement Portland-fly ash cement Portland-burnt shale cement Portland-limestone cement Portland composite cement - Blastfurnace cements - Pozzolanic cements - Composite cements	Preparation of concrete, mortar, grout and other mixes for construction and for the manufacture of construction products	1+
System 1+: See annex III Section 2 point (i) of Directive 89/106/EEC, with audit-testing of samples taken at the factory			

The attestation of conformity to the specifications in EN 197-1 shall be based on clause 9 of EN 197-1 and on evaluation of conformity³⁾ which shall be in accordance with EN 197-2. Clause 8 of EN 197-2 does not apply since it is superseded for CE marking purposes by the rules given in clauses ZA.3 and ZA.4. Clause 9 of EN 197-2, giving rules relating to Dispatching Centres, is not part of the procedure of attestation of conformity for the affixing of the CE marking under the CPD. However, Member States, within their market surveillance obligations, must ensure that CE marking is correctly used (Article 15.1 of the CPD). Clause 9 of EN 197-2 should be used for the corresponding national provisions concerning Dispatching Centres.

³⁾ This term corresponds to the establishment of conformity that is mentioned in article 13.2 of the CPD.

ZA.3 EC certificate of conformity and EC declaration of conformity

When compliance with the system of attestation of conformity is achieved in accordance with clause 7 of EN 197-2, the certification body shall draw up a certificate of conformity (EC certificate of conformity) with the information indicated below. This EC certificate of conformity entitles the manufacturer to affix the CE marking, as described in ZA.4.

The EC certificate of conformity shall include the following information:

- Name and address of the certification body,
- Name and address of the manufacturer, or his authorised representative established in the EEA, and place of production,
- Description of the product (the standard designation of the cement according to EN 197-1 and any additional identification required),
- Provisions to which the product conforms (annex ZA of EN 197-1, with conformity established according to EN 197-2 as given in annex ZA of EN 197-1),
- Particular conditions applicable to the use of the product (none as regards conformity),
- The certificate's number,
- Conditions and period of validity of the certificate, where applicable,
- Name of, and position held by, the person empowered to sign the certificate.

In addition, for each product covered by an EC certificate of conformity, the manufacturer shall draw up a declaration of conformity (EC declaration of conformity) including the following information:

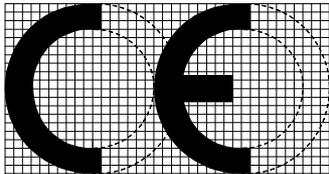
- Name and address of the manufacturer, or his authorised representative established in the EEA,
- Number of the attached EC certificate of conformity,
- Name of, and position held by, the person empowered to sign the declaration on behalf of the manufacturer or of his authorised representative.

Both documents must be presented in the official language or languages of the Member State of the EU in which the product is to be used.

ZA.4 CE conformity marking

ZA.4.1 Bagged cement

In the case of bagged cement, the CE conformity marking, the identification number of the certification body and the accompanying information as given below should be affixed either on the bag or on the accompanying commercial documents or on a combination of these. If all the information is not placed on the bag, but only part, then the full information should be given on the accompanying commercial documents.

 0123
Any Company The registered address Any Factory ⁴⁾ Year 01 (or position of date stamping) 0123-CPD-0456 EN 197-1 CEM I 42,5R Additional information

CE conformity marking, consisting of the "CE"-symbol given in Directive 93/68/EEC

Identification number of the certification body

Name or identifying mark of the producer

Registered address of the producer

Name or identifying mark of the factory where the cement was produced ⁴⁾

The last two digits of the year in which the marking was affixed ⁵⁾

Number of the EC certificate of conformity

Number of European standard

Example of standard designation, indicating the cement product and the strength class, as specified in clause 8 of EN 197-1

Limit for chloride, in % ⁶⁾
Limit for loss on ignition of fly ash, in % ⁷⁾
Standard notation of admixture ⁸⁾

For reasons of practicality, selections from the following alternative arrangements for bagged cement concerning the presentation of the accompanying information may be used:

- ⁴⁾ Considered necessary for the requirements of EN 197-2 but not compulsory.
- ⁵⁾ The year of marking should relate to either the time of packing into bags or the time of dispatch from the factory or depot.
- ⁶⁾ Only where the common cement is produced to meet a different chloride content limit to the value specified in Table 3 of EN 197-1.
- ⁷⁾ Only where, in accordance with 5.2.4.1 of EN 197-1, a fly ash loss on ignition limit of 5,0% to 7,0% is used.
- ⁸⁾ Only where, in accordance with 5.5 of EN 197-1, an admixture conforming to the EN 934 series is used.

- a) When the CE marking is given on the bag (this is the normal situation and is preferred) the following elements of the accompanying information may be given on the accompanying commercial documents instead of on the bag:
- the name or identifying mark of the factory;
 - the year of affixing the CE marking;
 - the number of the EC certificate of conformity;
 - additional information.
- b) Where the last two digits of the year in which the CE marking is affixed is pre-printed on the bag, the year so printed should relate to the date of affixing with an accuracy of within plus or minus three months.
- c) Where the last two digits of the year in which the marking is affixed is to be presented but not pre-printed on the bag it may be applied by means of date-stamping of the bag in any easily visible position. This position should be indicated in the information accompanying the CE marking.

The product should be accompanied, when and where required and in the appropriate form, by documentation listing any legislation on dangerous substances for which compliance is claimed, together with any information required by that legislation. *Note: European legislation without national derogations need not be mentioned.*

ZA.4.2 Bulk cement

In the case of bulk cement, the CE conformity marking, the identification number of the certification body and the accompanying information as listed for bagged cement in ZA.4.1 should be affixed in some suitable practical form on the accompanying commercial documents.