BDS EN 197-1 : 2003

Bangladesh Standard

Cement-

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

European Standard EN 197-1: 2000 is adopted as a BDS Standard.

BANGLADESH STANDARDS AND TESTING INSTITUTION

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NATIONAL FOREWORD

0.1 This Bangladesh standard was adopted by the Bangladesh Standards and Testing Institution on 25.05.03 after recommendation by the Sectional Committee for Cement and Cementing Materials and had been endorsed in accordance with the decision taken by the Engineering (Civil) Divisional Committee to adopt, without alteration EN 197-1: 2000 as Bangladesh Standard.

0.2 This standard BDS EN 197-1 is the official English language version of the harmonized European Standard EN 197-1: 2000, Cement-Part 1 Composition, specifications and conformity criteria for common cements, prepared by Technical Committee CEN/TC 51, Cement and building limes.

0.3 This Bangladesh Standards is subject to transitional arrangements. In order to allow for any changes in national regulations the members of the technical committee, the manufacturers have agreed a transition period up to 01-04-2004 for the co-existence of the Bangladesh Standards listed below and BDS EN 197-1. At the end of this period Bangladesh Standards listed below will be withdrawn and notification of which will be made in *Update standards:*

BDS 232: 1993 Specification for Portland cement (ordinary & rapid hardening)

BDS 1558: 1997 Specification for Portland cement blast furnace slag cement;

BDS 1557: 1997 Specification for Portland pulverized fuel ash cement.

0.4 Common cements conforming to this standard, where the intended use is for the preparation of concerete, mortar, grout, other mixes for construction and for the manufacture of construction products, have been mandated by the Govt. of Bangladesh.

0.5 In this standard, in the case of CE Conformity Marking, the BSTI Certification Marking will be used and each type of cement (27 common types) may be marked with the BSTI Certification Mark. National Annex NA (informative) provides guidance in this regard.

The use of the BSTI certification mark is governed by the provisions of the Bangladesh Standards & Testing Institution Ordinance 1985, and Regulations made there under. The details of conditions for obtaining licence for using Standard Mark may be obtained from the Institution.

0.6 National annex NB (informative) details the exchange of additional information between the cement manufacturer and user including the revision of information for alkali contents.

National annex NC (informative) gives recommendations for sampling and testing for acceptance inspection at delivery.

This Bangladesh Standard does not give fineness limits, National annex ND (informative) describes how specialist users in the Bangladesh can order a controlled fineness CEM I cement having a small agreed range of fineness. It also includes provisions for pigmented cement.

National Annex NE (informative) gives a requirement, which is permitted to be standardized on a national basis, for the loss on ignition property of a siliceous fly ash constituent.

National annex NF (informative) gives guidance on the general use of common cements including health and safety aspects.

Contents

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 replace 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 Demenber 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 inquiry 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 reuqest of a member state later in 1973, the work was given to the European Committee for Standardization (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 standardized 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 croduced and used in these countries for many years. The view of CEN/TC 51 was then that the more regional cements should continue to the standardized 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 standardized 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 standardized nationally. It became obvious that some of the cements described as traditional by the respective national standardization 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 standardized national 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 sommon cements. This includes all common cements which are described by the respective national standardization 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, Lreland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

INTRODUCTION

It is recognized 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 publication. 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, Methods of testing cement- Part21: Determination of the chloride, carbon dioxide and alkali content of cement.

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

EN 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.

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 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 (HCI) 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.

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* EN 196-21 is currently being incorporated into EN 196-2

3.5

type of common cement

one of the 27 products (see Table I) 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 producting 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 said 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 form 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 ($3CaO.SiO_2$ and $2CaO.SiO_2$), 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.

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 strentth-developing calcium silicate and calcium aluminate compounds. These compounds are similar to those which are formed in the hardening of hydraulic materials. Pozzolanas consist essentially of reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other oxides. The proportion of reactive calcium oxide for hardening is negligible. The reactive silicon dioxide content shall be not less than 25.0% by mass.

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

5.2.3.2 Natural Pozzoiana (P)

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

5.2.3.3 Natural calcined Pozzolana (Q)

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

5.2.4 Fly ashes (V,W)

5.2.4.1 General

Fly ash is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases from furnaces fired with pulverized coal. 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 and 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 particless having Pozzolanic properties. It consists essentially of reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contrins 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 10mm when tested in accordance with EN 196-3 using a mixture of 30% by mass of silliceous fly ash and 70% by mass of a CEMI I cement conforming to EN 197-1.

The relative 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 calclum oxide (CaO), reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other compounds. The proportion of reactive calcium oxide shall not be less than 10,0% by mass. Calcareous fly ash containing between 10,0% and 15,0% by mass of reactive calcium oxide shall contain not less than 25,0% by mass of reactive silicon dioxide.

5.2.3.2 Natural Pozzoiana (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 Poxxolana (Q)

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

5.2.4 Fly ashes (V,W)

5.2.4.1 General

Fly ash is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases from furnaces fired with pulverized coal. 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 concerete or mortar in the place of use. I 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 aceptable 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 (Fe_2O_3) and other compounds. The proportion of reactive calcium oxide shall not be less than 10,0% by mass. Calcareous fly ash containing

between 10,0% and 15,0% by mass of reactive calcium oxide shall contain not less than 25,0% by mass of reactive silicon dioxide.

Adequately ground calcareous fly ash containing more than 15,0% by mass of reactive calcium oxide, shall have a compressive strength of a least 10,0% by mass of reactive calcium oxide, shall have a compressive strength of a 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 um mesh sieve, shall be between 10% and 30% by mass. The test mortar shall be prepared with ground calcarous 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 a least 90% untill tested.

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

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

5.2.5 Burnt shale (T)

Burnt shale, specifically burnt oil shale, is produced in a special kiln at temperatures of approximately 800 ^{0}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 bant 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 10mm 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.

i) The calcium carbonate ($CaCO_3$) content calculated from the calcium oxide content shall be at least 75% by mass.

ii) 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.

iii) 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 arcfurnaces 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:

i) 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.

ii) 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 pelletized (with water).

5.3 Minor additional constituents

Miner 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, laternt hydraulic or Pozzolanic properties. Howerver, no requirements are set for them in this respect.

Minor additional constituents shall be correctly prepared, i.e. selected, homogenized, 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, $CaSO_4.2H_2O$), hemihydrate ($CaSO_4$ $½H_2O$), 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: 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]										
			Main constituents										Minor aditional constituents
			Clinker	Blast-furnace slag	silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
						natural	natural calcined	siliceous	calcareous				
			K	S	D [b]	P	Q	V	W	T	L	LL	
CEM I	Portland cement	CEM I	95-100	-	-	-	-	-	-	-	-	-	0 to 5
	Portland-slag cement	CEM II/A-S	80to94	6to20	-	-	-	-	-	-	-	-	0 to 5
		CEM II/B-S	65to79	21to35	-	-	-	-	-	-	-	-	0 to 5
	Portland-silica fume cement	CEM II/A-D	90to94	-	6 to 10	-	-	-	-	-	-	-	0 to 5
CEM II	Portland pozzolana cement	CEM II/A-P	80to94	-	-	6 to 20	-	-	-	-	-	-	0 to 5
		CEM II/B-P	65to79	-	-	21to35	-	-	-	--	-	-	0 to 5
		CEM II/A-Q	80to94	-	-	-	6 to 20	-	-	-	-	-	0 to 5
		CEM II/B-Q	65to79	-	-	-	21to35	-	-	-	-	-	0 to 5
	Portland-fly ash cement	CEM II/A-V	80to94	-	-	-	-	6 to 20	-	-	-	-	0 to 5
		CEM II/B-V	65to79	-	-	-	-	21to35	-	-	-	-	0 to 5
		CEM II/A-W	80to94	-	-	-	-	-	6 to 20	-	-	-	0 to 5
		CEM II/B-W	65to79	-	-	-	-	-	21to35	-	-	-	0 to 5
	Portland-burnt shale cement	CEM II/A-T	80to94	-	-	-	-	-	-	6 to 20	-	-	0 to 5
		CEM II/B-T	65to79	-	-	-	-	-	-	21to35	-	-	0 to 5
	Portland-limestone cement	CEM II/A-L	80to94	-	-	-	-	-	-	-	6 to 20		0 to 5
		CEM II/B-L	65to79	-	-	-	-	-	-	-	21to35		0 to 5
		CEM II/A-LL	80to94	-	-	-	-	-	-	-	-	6 to 20	0 to 5
		CEM II/B-LL	65to79	-	-	-	-	-	-	-	-	21to35	0 to 5
	Portland-composite cement [c]	CEM II/A-M	80to94	<----------6 to 20---------->									0 to 5
		CEM II/B-M	65to79	<----------21 to 35---------->									0 to 5
CEM III	Blastfurnace cement	CEM III/A	35to64	36to65	-	-	-	-	-	-	-	-	0 to 5
		CEM III/B	20to34	66to80	-	-	-	-	-	-	-	-	0 to 5
		CEM III/C	5to19	81to95	-	-	-	-	-	-	-	-	0 to 5
CEM IV	Pozzolanic cement [c]	CEM IV/A	65to89	-	<----------11 to 35---------->					-	-	-	0 to 5
		CEM IV/B	45to64	-	<----------36 to 55---------->					-	-	-	0 to 5
CEM V	Composite cement [c]	CEM V/A	40to64	18to30	-	<----------18 to 30---------->			-	-	-	-	0 to 5
		CEM V/B	20to38	31to50	-	<----------31 to 50---------->			-	-	-	-	0 to 5

i) The values in the table refer to the sum of the main and minor additional constituents.

ii) The proportion of silica fume is limited to 10%

iii) In Portland-composite cements CEM II/A-M and CEM II/B-M, in Pozzolanic cernent 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: calss 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 include 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 Table2)

Table-2-Mechanical and physical requirements given as characteristic values

Strength class	Compressive strength MPa				Intitial setting time	Sound-ness (expansion)
	Early strength		Standard strength			
	2 days	7 days	28 days		min	mm
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, shell 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 rquirements for the content of water-soluble hexavalent chromium (see informative annex A).

7.4 Durability requirements

In many applications, particularly in severe environmental condition, the choice of cement has an induence 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.

Property	Test reference	Cement type	Strength class	Requirements
1	2	3	4	5
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)]	32,5 N 32,5 R 42,5 N	≤ 3,5%
		CEM IV CEMV	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

i) Requirements are given as percentage by mass of the final cement.

ii) Determination of residue insoluble in hydrochloric acid and sodium carbonate.

iii) Cement type CEM II/B-T may contain up to 4,5% sulfate for all strength classes.

iv) Cement type CEM III/C may contain up to 4,5% sulfate.

v) 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.

vi) 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 lawer 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 ro 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 calss 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 calss 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 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) 21,5 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 apporved certification body, conformity of cement with EN 197-1 shall be evaluated in accordance with EN 197-2.

NOTE: 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	Inspection by	
					variables [g)]	Attributes
1	2	3	4	5	6	7
Early 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[e)]	1/week		x[f)]
Insloluble residue	CEM I, CEM III	EN 196-2	2/month[e)]	1/week	-	x[f)]
Sulfate content	All	EN 196-2	2/week	4/week	-	x[f)]
Chloride content	All	EN 196-21	2/month[e)]	1/week	-	x[f)]
Pozzolanicity	CEM IV	EN 196-5	2/month	1/week	-	x
Composition	All	-[d)]	1/month	1/week	-	

i) 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.

ii) The methods used to take and prepare samples shall be in accordance with EN 196-7.

iii) 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.

iv) Appropriate test method chose by the manufacturer.

v) If the data are not normally distributed then the method of assessment may be decided on a case by case basis.

vi) 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 take 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 varified 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 equations(s) (1) and (2), as relevant, are satisfied:

$$x - K_A \times s \geq L \quad (1)$$

and:

$$x + K_A \times s \leq U \quad (2)$$

where:

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	KA [a]	
	for Pk=5% (early and standard strength, lower limit)	for Pk=10% (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 vlaue 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:

$$C_D \leq C_A \qquad (3)$$

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		-	8,0	8,0	18,0	18,0	28,0
		14,0	-	-	-	-	-
Standard strength (MPa) lower limit value		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					

i) Cement type CEM II/B-T may contain up to 5,0 % SO_3 for all strength classes.

ii) Cement type CEM III may contain more than 0,10% chloride but in that case the maximum chloride content shall be declared.

iii) For pre-stressing applications cements may be produced according to a lower requirement. If so, the value of 0,10% shall be repiaced by this lower value which shall be stated in the delivery note.

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 cment. 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.