

Cement —

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

The European Standard EN 197-1:2000, incorporating amendments A1:2004 and A3:2007, has the status of a British Standard

ICS 91.100.10

National foreword

This British Standard is the UK implementation of the harmonized European Standard EN 197-1:2000, incorporating amendments A1:2004 and A3:2007. This British Standard includes national annexes that provide additional information and guidance to complement EN 197-1. It converts and supersedes DD ENV 197-1:1995 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted by Technical Committee B/516, Cements and lime, to Subcommittee B/516/6, Cement specifications.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This European Standard is subject to transitional arrangements agreed under a Commission mandate which is intended to lead to CE marking in support of the Construction Products Directive. In order to allow for any changes in national regulations, the Member States have agreed a transition period of 21 months for the co-existence of the British Standards listed below and EN 197-1. At the end of this period, the British Standards listed below will be withdrawn, notification of which will be made in *Update Standards*.

- BS 12:1996 *Specification for Portland cement*;
- BS 4246:1996 *Specification for high slag blastfurnace cement*;
- BS 6588:1996 *Specification for Portland pulverized-fuel ash cements*;
- BS 7583:1996 *Specification for Portland limestone cement*.

Common cements conforming to this standard, where the intended use is for the preparation of concrete, mortar, grout, other mixes for construction and for the manufacture of construction products, have been mandated by the European Commission to be specified under a system of attestation of conformity (see annex ZA). Attestation of conformity is a legal means for demonstrating that a product meets the requirements of a harmonized European technical specification, as defined in the Construction Products Directive (89/106/EEC). In the case of a system 1+, it is supported by an EC certificate of conformity, issued by an EU notified body, enabling the manufacturer to issue an EC declaration of conformity and to affix the minimum legal health, safety and environmental requirements in the EU Member States, it is not a quality mark.

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Amd. No.	Date	Comments
15209	9 July 2004	See national foreword
17352	28 September 2007	See national foreword

The detailed requirements for evaluating the conformity of common cements with this standard, including certification of conformity by a third party, are given in BS EN 197-2:2000, *Cement — Part 2: Conformity evaluation*. In addition, these same provisions describe all the tasks that will be required of the manufacturer and notified body for demonstrating legal attestation of conformity to a system 1+.

This British Standard forms a part of a group of related construction standards, which will include design and construction in concrete, standardized within the countries of the CEN members. The standards will include Part 1 of Eurocode 2 (EN 1992-1) for the design of concrete structures, EN 206-1, and its associated UK complementary British Standard (BS 8500), for the specifications and associated test methods for the constituent materials of concrete, including the BS EN 196 series of test methods for cement.

This British Standard does not include in its scope: the additional special properties of low heat Portland cement, conforming to BS 1370 or of sulfate-resisting Portland cement, conforming to BS 4027; or high slag blastfurnace cement, previously specified in BS 4246 or the low early strength classes of Portland blastfurnace cements, specified in BS 146, or pozzolanic pulverized-fuel ash cement, conforming to BS 6610; or other types of cement whose hardening is not primarily due to the hydration of calcium silicates, i.e. high alumina cement, conforming to BS 915-1, and supersulfated cement, conforming to BS 4248. It is intended that cements from within this range will be specified in further parts of BS EN 197 or in other standards.

National annex NA (informative) compares the notation for common cements given in Table 1 of this British Standard, with the notation in those British Standard specifications listed previously and which are to be withdrawn after the period of co-existence, and those still current. Table NA.1 in the national annex provides a means by which users of related construction standards that contain lists of permitted cements conforming to British Standards which are to be withdrawn can select common cements (by name and notation) that are their equivalent. This assessment of equivalence will only be necessary for a limited period. It arises because the British Standards Institution has agreed with industry that amendments to cement-related construction standards will not be issued to reflect the notation in use for common cements. When, however, the majority of such British Standards have themselves been replaced by European Standards the need to assess equivalence will cease.

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

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

This British Standard does not give fineness limits. National annex ND (informative) describes how specialist users in the UK 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 (normative) 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.

National annex NG (informative) lists publications referred to in the national annexes.

UK purchasers are recommended to specify common cement which has been manufactured and supplied to a nationally recognized third party product quality certification scheme.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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

This European Standard was approved by CEN on 21 May 2000.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.



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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. ^{A1} The amendment A1:2004 contained the low heat common cements. ^{A1} ^{A3} Amendment A3:2007 contains the modified requirements for fly ash as a cement constituent. ^{A3}

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 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 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 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 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 A_1 and common cements with low heat of hydration A_1 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 A_1 -8, -9 A_1 and -21. The scheme for the evaluation of conformity of common cements A_1 and common cements with low heat of hydration A_1 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.

Foreword to amendment A1

This document EN (197-1:2000/A1:2004) has been prepared by Technical Committee CEN/TC 51, Cement and building lime, the Secretariat of which is held by IBN.

This Amendment to the European Standard EN 197-1:2000 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2004, and conflicting national standards shall be withdrawn at the latest by October 2004.

This Amendment extends the European Standard EN 197-1:2000 to cover the optional property of low heat of hydration for common cement. The technical content of EN 197-1:2000 has not been changed.

Very low heat special cements are dealt with in EN 14216.

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

For relationship with EU Directives, see informative annex ZA, which is an integral part of this document.

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

Foreword to amendment A3

This document (EN 197-1:2000/A3:2007) has been prepared by Technical Committee CEN/TC 51 "Cement and building limes", the secretariat of which is held by NBN.

This Amendment to the European Standard EN 197-1:2000 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2008, and conflicting national standards shall be withdrawn at the latest by January 2008.

This Amendment extends the European Standard EN 197-1:2000 for common cement to cover the modified requirements for fly ash as a cement constituent. The remaining technical content of EN 197-1:2000 has not been changed.

The numbering of the clauses refers to EN 197-1:2000.

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

Introduction

It is recognized that different cements have different properties and performance. Those performance tests now available (i.e. setting time, strength, $\square_{A1}$ soundness and heat of hydration) $\square_{A1}$, 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 $\square_{A1}$ including, where appropriate, heat of hydration requirements $\square_{A1}$ 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.*
- $\square_{A1}$ EN 196-8, *Methods of testing cement - Part 8: Heat of hydration - Solution method.*
- EN 196-9, *Methods of testing cement - Part 9: Heat of hydration - Semi-adiabatic method.* $\square_{A1}$

- 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.*
- 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.*
- Ⓐ EN 13639:1999, *Determination of total organic carbon content in limestone.* Ⓐ
- 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

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

3.6

strength class of cement

class of compressive strength

3.7

autocontrol testing

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

3.8

control period

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

3.9

characteristic value

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

3.10

specified characteristic value

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

3.11

single result limit value

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

3.12

allowable probability of acceptance CR

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

3.13

sampling plan

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

3.14

spot sample

sample taken at the same time and from one and the same place, relating to the intended tests. It can be obtained by combining one or more immediately consecutive increments (see EN 196-7)



3.15

heat of hydration

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

3.16

low heat common cement

common cement with a limited heat of hydration

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 (Ca(OH)₂) to form strength-developing calcium silicate and calcium aluminate compounds. These compounds are similar to those which are formed in the hardening of hydraulic materials. Pozzolanas consist essentially of reactive silicon dioxide (SiO₂) and aluminium oxide (Al₂O₃). The remainder contains iron oxide (Fe₂O₃) and other oxides. The proportion of reactive calcium oxide for hardening is negligible. The reactive silicon dioxide content shall be not less than 25,0 % by mass.

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

5.2.3.2 Natural Pozzolana (P)

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

5.2.3.3 Natural calcined Pozzolana (Q)

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

5.2.4 Fly ashes (V, W)

5.2.4.1 General

A3 (1) Fly ash is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases from furnaces fired with pulverised coal.

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

Ash obtained by other methods shall not be used in cement that conforms to EN 197-1.

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

- a) 0 % to 5,0 % by mass
- b) 2,0 % to 7,0 % by mass
- c) 4,0 % to 9,0 % by mass

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

(3) The use of fly ash with loss on ignition up to 7,0 % or up to 9,0 % by mass is permitted 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.

NOTE 2 The purpose of the requirement for the loss on ignition is to limit the residue of unburnt carbon in the fly ash. It is sufficient, therefore, to show, through direct measurement of unburnt carbon residue, that the content of unburnt carbon falls within the limits specified above. The content of unburnt carbon is determined in accordance with ISO 10694. **A3**

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

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

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

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

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 Pozzolan 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 5 000 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 pelletized (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, 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, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), 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).