

Specification for

Sulfate-resisting Portland cement

Spécification du ciment Portland résistant au
sulfate

Spezifikation für sulfatbeständigen
Portlandzement

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee (CAB/-) to Technical Committee CAB/1, upon which the following bodies were represented:

Association of Consulting Engineers
Association of Quality Pulverised Fuel Ash Suppliers
Brick Development Association
British Aggregate Construction Materials Industries
British Cement Association
British Precast Concrete Federation
British Ready Mixed Concrete Association
British Steel Industry
Cementitious Slag Makers' Association
Concrete Society
County Surveyors' Society
Department of the Environment (Building Research Establishment)
Department of the Environment (Property Services Agency)
Department of Transport
Electricity Supply Industry in United Kingdom
Federation of Civil Engineering Contractors
Institute of Concrete Technology
Institution of Civil Engineers
Institution of Structural Engineers
Mortar Producers' Association
Royal Institution of Chartered Surveyors
Society of Chemical Industry
Water Services Association of England and Wales

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Foreword

This revision of this British Standard is published under the authority of the Technical Sector Board for Building and Civil Engineering. It was revised to align it more closely with developments in the work of Technical Committee 51, Cement and building limes, of the European Committee for Standardization (CEN), which is preparing a European Prestandard for cements. As an intrinsic part of this activity, CEN has published EN 196, a series of methods for testing cement, which the UK is obliged to implement by the withdrawal of the relevant Parts of BS 4550. In consequence, this British Standard specifies requirements in terms of the EN 196 test procedures. It supersedes BS 4027 : 1980 which is withdrawn.

The June 1989 draft European Prestandard specification for cements did not specify requirements for sulfate-resisting Portland cement which has been manufactured and used in the United Kingdom since 1949. This standard specification thus covers a cement which was outside the scope of the original European Prestandard, but which is expected to be specified in a later Part.

There is at present no reliable direct test for sulfate resistance other than prolonged storage of concrete or mortar specimens in sulfate solutions and this type of test is not suitable as the basis for a standard. However, experimental work and practical experience have shown that a considerable degree of sulfate resistance is conferred on Portland cement if the tricalcium aluminate content is limited to a maximum of 3.5 % (*m/m*) of the cement.

It should be noted that, in order to attain the required durability, it is necessary for concrete or mortar to have an adequate cement content. See BS 8110 : Part 1 for recommendations on concrete and BS 6528 : Part 3 for recommendations on mortar.

This revision introduces the following changes.

- (a) Since this cement can be produced with a low alkali content for use in concrete made with aggregates suspected of reacting with the alkali contained in the cement in the presence of moisture, a special type, designated 'LA', has been introduced.
- (b) Compositional requirements are expressed as a percentage of the total mass of the constituents but exclude calcium sulfate and any additives. This departure from the traditional method of calculation in the UK is fully explained in appendix B.
- (c) Additives to improve the manufacture or the properties of the cement are permitted up to a level of 1.0 % (*m/m*) without declaration by the manufacturer.
- (d) The requirements are, in general, based on the results of tests on cement according to EN 196 that consists of the following Parts¹⁾.

Part 1	Determination of strength
Part 2	Chemical analysis of cement
Part 3	Determination of setting time and soundness
Part 4	Quantitative determination of constituents
Part 5	Pozzolanicity test for pozzolanic cements
Part 6	Determination of fineness
Part 7	Methods of taking and preparing samples of cement
Part 21	Determination of the chloride, carbon dioxide and alkali content of cement

¹⁾ These European Standards will be published as Parts of BS EN 196.

(e) The requirements are specified as characteristic values and conformity is assessed by means of a statistical procedure for continuous inspection operated by the cement manufacturer (autocontrol) (see appendix A). This includes the concept of 'major defects' which are 'likely to reduce materially the usability of the cement for its intended purpose'. However, the 1989 draft European Prestandard is considered to be inappropriate for the manufacture of cement in the UK and the appendix therefore incorporates several footnotes identifying specific aspects. In particular, it is assumed, for this revision of this British Standard, that some limits are required for acceptance inspection, corresponding to those specified in BS 4027 : 1980. Clause 11 therefore gives appropriate values which in several cases are more stringent than those for major defects given in appendix A.

(f) The strength requirements are based on the EN 196 : Part 1 mortar prism test in place of the BS 4550 concrete cube test and the concept of a maximum value for the strength at 28 days has been introduced. In addition to the two classes of standard strength, 32.5 and 42.5, each with two subclasses of early strength, this British Standard includes a higher class of standard strength, 52.5, to cover all sulfate-resisting Portland cements available in the UK (see table 1).

(g) The test for initial setting time is essentially unchanged, but a requirement is not specified for the final setting time.

(h) Requirements are not specified for fineness.

(i) The 4.0 % (m/m) limit for magnesium oxide content of the cement has been changed to a maximum of 5.0 % (m/m) for the clinker.

(j) The limit for total sulfur (expressed as SO₃) of 2.5 % has been changed to an autocontrol maximum limit for sulfate (corresponding to an acceptance inspection limit of 2.6 % (m/m) of the final cement).

(k) A limit for chloride content has been introduced.

(l) The lime saturation factor requirement has been omitted; it was originally introduced essentially as a safeguard against unsoundness which is now covered adequately by the soundness requirement specified in 8.2. The lime saturation factor provides no guidance on strength giving properties.

(m) Guidance on the use of cement has been included and attention is drawn to the safety precautions recommended in appendix C when working with cement. Cement will partially hydrate when exposed to water vapour; appendix C also includes guidance on storage.

(n) Purchasers are recommended to specify cement manufactured and supplied to a nationally recognized third party product certification scheme.

Other British Standards for cement, i.e. BS 12, BS 146, BS 4246, BS 6588 and BS 6610, have been revised at the same time.

Product certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier's quality systems against the appropriate Part of BS 5750.

Enquiries as to the availability of third party certification schemes will be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Specification

1 Scope

This British Standard specifies requirements for the composition and the manufacture and for the strength, physical and chemical properties of sulfate-resisting Portland cements, as 'characteristic' values. Requirements for marking, provision of information, sampling and testing for acceptance at delivery are also specified. It specifies the procedures for the manufacturer's autocontrol system to ensure conformity and for the purchaser's assessment of compliance at delivery. This standard specifies requirements for cement as commonly used in Western Europe¹⁾.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the definitions in BS 6100 : Section 6.1 apply together with the following.

2.1 characteristic value

That value of a property corresponding to an acceptable percentage of defects, generally 10 % but 5 % for the lower strength limits.

3 Cement

NOTE 1. Cement is a hydraulic binder, i.e. it is a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water.

Cement conforming to this British Standard shall, when appropriately batched and mixed with aggregate and water, be capable of producing mortar or concrete which retains workability for a sufficient time and shall after defined periods attain specified strength levels and also possess long-term volume stability.

NOTE 2. Hydraulic hardening of cement conforming to this British Standard is primarily due to the hydration of calcium silicates²⁾, but other chemical compounds may also participate in the hardening process, e.g. aluminates.

The sum of the proportions of reactive calcium oxide (CaO)³⁾ and reactive silicon dioxide (SiO₂)⁴⁾ shall be not less than 50 % (*m/m*).

Cement conforming to this British Standard ultimately consists of individual small grains of different materials but it shall be statistically homogeneous in composition. A high degree of uniformity in all cement properties shall be obtained through continuous mass production processes, in particular adequate grinding and homogenization processes.

NOTE 3. Qualified and skilled personnel and the facilities to test, evaluate and adjust product quality are essential for producing cement complying with this British Standard.

During the cement manufacturing process and its control, the composition of the cement shall be kept within the limits specified in this British Standard.

Sulfate-resisting Portland cement shall be obtained by grinding a Portland cement clinker in which the amount of tricalcium aluminate has been limited so that its content in the cement will not exceed the amount stated in 8.2. Calcium sulfate shall also be added (see 4.2).

4 Constituents

4.1 Portland cement clinker

Portland cement clinker is a hydraulic material which shall consist of not less than two-thirds by mass of calcium silicates ((CaO)₃.SiO₂ and (CaO)₂.SiO₂), the remainder containing aluminium oxide (Al₂O₃), iron oxide (Fe₂O₃) and other oxides. The ratio by mass (CaO)/(SiO₂) shall be not less than 2.0. The content of magnesium oxide (MgO) shall not exceed 5.0 % (*m/m*).

Portland cement clinker shall be made by burning, at least to sintering, a precisely specified mixture of raw materials (raw meal, paste or slurry) containing CaO, SiO₂, Al₂O₃ and small quantities of other materials. The raw meal, paste or slurry shall be finely divided, intimately mixed and therefore homogeneous.

4.2 Calcium sulfate

Calcium sulfate shall be added in small quantities to the other constituents of cement during its manufacture in order to control setting.

NOTE. Calcium sulfate can be gypsum (calcium sulfate dihydrate, CaSO₄.2H₂O), hemihydrate (partially dehydrated gypsum, CaSO₄.½H₂O), or anhydrite (anhydrous calcium sulfate, CaSO₄) or any mixture of them. Gypsum and anhydrite are found naturally. Calcium sulfate is also available as a by-product of certain industrial processes.

¹⁾Other types of cement standardized in the UK are specified in BS 12, BS 146 BS 915, BS 1370, BS 4246, BS 4248, BS 6588 and BS 6610.

²⁾There are also cements whose hardening is mainly due to other compounds, e.g. calcium aluminate in high alumina cement.

³⁾Reactive calcium oxide (CaO) is considered to be only that fraction of the CaO which under normal hardening conditions can form calcium silicate hydrates or calcium aluminate hydrates. To evaluate this fraction, the total CaO content is to be reduced by the part calculated as calcium carbonate (CaCO₃) on the basis of the measured carbon dioxide (CO₂) content and the part calculated as calcium sulfate (CaSO₄) on the basis of the measured sulfate content (expressed as SO₃) disregarding the SO₃ taken up by alkalis.

⁴⁾Reactive silicon dioxide (SiO₂) is defined as that fraction of the SiO₂ which, after treatment with hydrochloric acid (HCl), is soluble in boiling potassium hydroxide (KOH) solution. The quantity of reactive SiO₂ is determined by subtracting from the total SiO₂ content (see 13.9 of EN 196 : Part 2 : 1987) that fraction of the SiO₂ contained in the insoluble residue (see clause 10 of EN 196 : Part 2 : 1987), both on a dry basis.