

**PS: 612-2014 (R)**

ICS No.91.100.10

## **PAKISTAN STANDARD**

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### **SULFATE RESISTING PORTLAND CEMENT**

**2<sup>nd</sup> Revision**



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**PAKISTAN STANDARDS AND QUALITY CONTROL AUTHORITY**

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**PAKISTAN STANDARDS SPECIFICATION  
FOR  
SULFATE RESISTING PORTLAND CEMENT  
2<sup>nd</sup> Revision**

**0 FOREWORD:**

0.1 This Standard was adopted by Pakistan Standard & Quality Control Authority after recommendations of the Technical Committee for “**Cement and Lime**” (BDC-5) on **27-03-2014**. The same had been approved and endorsed by the Civil Engineering National Standards Committee on **08-05-2014**.

0.2 This Standard has been prepared after taking into consideration the views and suggestions of the manufacturers, technologists, suppliers and utilizing agencies.

0.3 This Pakistan Standard No.**612-1989** was prepared with the help of foreign specification which has been since revised/modified. Hence to keep up a par with the latest technology, it has been revised accordingly. In preparation of this Standard the Technical Committee acknowledges with thanks the assistance drawn from the standard **BS: 4027-1996**.

0.4 This Standard is subject to periodical review in order to keep pace with development in industry. Any suggestions for improvement will be recorded and placed before the committee in due course.

# **PAKISTAN STANDARDS SPECIFICATION FOR SULFATE RESISTING PORTLAND CEMENT**

## **1 SCOPE**

This Pakistan Standard specifies requirements for the composition and the manufacture and for the strength, physical and chemical properties of sulfate-resisting Portland cement, 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 auto control system to ensure conformity.

## **2 Definitions**

For the purposes of this Pakistan Standard the definitions in BS 6100 (PS...): 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 Pakistan 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 Pakistan Standard 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 calciumoxide ( $\text{CaO}$ )<sup>3</sup> and reactive silicon dioxide ( $\text{SiO}_2$ )<sup>4</sup> shall be not less than 50% (m/m).

Cement conforming to this Pakistan Standard ultimately consists of individual small grains of different materials but is shall be statistically homogenous 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 conforming to this Pakistan Standard. During the cement manufacturing

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

## **4 Constituents**

### **4.1 Portland sulfate resisting cement clinker**

Portland sulfate resisting cement clinker is a hydraulic material which shall consist of not less than two-thirds by mass of calcium silicates ( $(\text{CaO})_3\text{SiO}_2$  and  $(\text{CaO})_2\text{SiO}_2$ ), the remainder containing aluminium oxide ( $\text{Al}_2\text{O}_3$ ), iron oxide ( $\text{Fe}_2\text{O}_3$ ) and other oxides. The ratio by mass  $(\text{CaO})/(\text{SiO}_2)$  shall be not less than 2.0. The content of magnesium oxide ( $\text{MgO}$ ) shall not exceed 5.0% (m/m).

**4.2** 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  $\text{CaO}$ ,  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$  and small quantities of other materials. The raw meal, paste or slurry shall be finely divided, intimately mixed and therefore homogenous.

### **4.3 Calcium sulfate**

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

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

### **4.4 Additives**

If the total quantity of additives exceeds 1.0% (m/m) of the cement, the type and quantity shall be stated on the packaging and /or on the delivery note.

NOTE 1: These additives are constituents not specified in 4.1 and 4.2 which are added to improve the manufacture or the properties of the cement, e.g. grinding aids. They should not promote corrosion of the reinforcement or impair the properties of the cement or of the mortar or concrete made from the cement.

NOTE 2: The total quantity of additives should not exceed 1.0% (m/m).

## **5. Composition, notation and manufacture**

### **5.1 Composition**

The composition of the 'nucleus' (see B.1) of sulfate-resisting Portland cement shall be as follows.

Sulfate-resisting Portland      100% (m/m)  
Cement clinker

NOTE. For clarity in definition, calcium sulfate (see 5.2) and additives (see 5.3) are excluded. The final cement is to be understood as the nucleus plus the necessary calcium sulfate and any additives to the cement.

## 5.2 Notation

Sulfate-resisting Portland cement shall be identified by at least the name, a figure indicating the standard strength class (see note 1 to table 1) and a letter indicating the subclass of early strength (see note 2 to table 1). If the cement has an alkali content conforming to 8.3 the letters LA are added.

## 5.3 Manufacture

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).

## 6 Compressive strength

The compressive strength, determined in accordance with BS EN 196: Part I, shall conform to table 1.

<b>Table 1. Compressive strength</b>				
<b>Strength class</b>	<b>Early strength</b>		<b>Standard strength</b>	
	<b>2 day N/mm<sup>2</sup></b>	<b>7 day N/mm<sup>2</sup></b>	<b>28 day N/mm<sup>2</sup></b>	
32.5N	-	≥16	≥32.5	≤52.5
32.5R	≥10	-		
42.5N	≥10	-	≥42.5	≤62.5
42.5R	≥20	-		
52.5N	≥20	-	≥52.5	-

NOTE 1: The standard strength of cement is the compressive strength determined in accordance with BS EN 196: Part 1 at 28 days.

Three classes of standard strength are covered: class 32.5, class 42.5 and class 52.5.

The classification of a cement according to standard strength is indicated by the figure 32.5, 42.5 or 52.5.

NOTE 2: The early strength of cement is the compressive strength determined in accordance with BS EN 196: Part 1 at either 2 days or 7 days.

Two subclasses of early strength are defined for standard strength classes 32.5 and 42.5, a class with ordinary early strength and a class with high early strength.

The classification of a cement according to early strength is indicated by the letter N or R, for ordinary or high early strength respectively, following the figure indicating the standing strength class.

NOTE 3: Local sand can be used if it qualifies BSEN 196: Part I for grain size and other properties.

## 7. Physical properties

### 7.1 Initial setting time

The initial setting time, determined in accordance with BS EN 196: Part 3, shall be not less than 60 min for the 32.5N, 32.5R, 42.5N and 42.5R strength classes nor less than 45 min for the 52.5N strength class.

### 7.2 Soundness

The expansion, determined in accordance with BS EN 196: Part 3, shall be not more than 10 mm.

## 8 Chemical properties

### 8.1 General

The properties shall conform to table 2 when tested in accordance with the tests referred to in column 2 of table 2.

1	2	3	4
Property	Test reference	Strength class	Requirement 1
<b>Loss on ignition</b>	Clause 7 of BS EN 196: Part 2: 1995	All classes	% (m/m) ≤3.0 (≤4.0, if the value is declared by the manufacturer see 11.1g))
<b>Insoluble residue</b>	Clause 9 of BS EN 196: Part 2: 1995	All classes	≤1.5
<b>Sulfate (expressed as SO<sub>3</sub>)</b>	Clause 8 of BS EN 196: Part 2: 1995	All classes	≤2.5
<b>Chloride</b>	Clause 4 of BS EN 196: Part 21: 1992	All classes	≤0.10(2)

1) Requirements are given as percentages by mass of the final cement.  
2) BS 5328: Part 1 and BS 8110: Part 1 give recommendations for the maximum total chloride content of the concrete mix for various applications.

### 8.2 Tricalcium aluminate

The tricalcium aluminate (C<sub>3</sub>A) content shall not exceed 3.5% (m/m) when calculated by the formula:

$$(C_3A) = 2.65A - 1.69F$$

Where

A is the proportion of aluminium oxide (Al<sub>2</sub>O<sub>3</sub>) by mass of the total cement when tested in accordance with 13.11 of BS EN 196: Part 2: 1995/(PD...)(in %);

F is the proportion of iron (III) oxide by mass of the total cement when tested in accordance with 13.10 of BS EN 196: Part 2: 1995/(PS...)(in %).

### **8.3 Alkali content (type LA)**

For sulfate-resisting Portland cement, type Low Alkali (LA), the alkali content shall not exceed 0.60% (m/m) when tested in accordance with BS EN 196: Part 21 (PD...) or by an X-ray fluorescence technique calibrated against the reference method described in BS EN 196: Part 21 (PS...).

## **9 Marking**

Sulfate-resisting Portland cement shall be marked on the bag or the delivery note, and on any test certificate, with the following particulars:

- a) The name, trade mark or other means of identification of the manufacture to facilitate traceability to the works in which the cement was manufactured;
- b) The name and strength class of the material, e.g. sulfate-resisting Portland cement, class 42.5N (with the letters LA if appropriate);
- c) The number and date of this Pakistan Standard, i.e. 612-2014)

### **9.1 Information to be provided**

#### **9.2 Test certificate**

If a test certificate is requested, it shall be provided and shall include results of the following tests on samples of the cement relating to the material delivered:

- a) Compressive strength at either 2 days or 7 days as appropriate, and also at 28 days, obtained from tests on mortar prisms in accordance with BS EN 196: Part 1(PS...) (see clause 6);
- b) Initial setting time (see 7.1);
- c) Soundness (see 7.2)
- d) Chloride content (see 8.1);
- e) Alkali content (see 8.3), expressed as the certified sodium oxide equivalent averaged over the manufacture's latest 25 consecutive composite samples, together with an indication of its variability;
- f) Type and quantity of additives, if exceeding 1.0% (m/m) (see 4.4);
- g) Loss on ignition, if exceeding 3.0% (m/m) (see 8.1).

NOTE: the certificate should be available from the manufacturer.

#### **9.3 Additional information**

The following information shall also be made available, if requested at the time of ordering relating to the material delivered:

- a) The fineness;
- b) The silicon dioxide, aluminium oxide, iron (III) oxide, calcium oxide and magnesium oxide contents of the clinker;
- c) The sulfate content expressed as SO<sub>3</sub> (see 8.1);
- d) An indication of the variability of the chloride content when its mean level exceeds 0.05% (m/m)

## **10 Sampling and testing for acceptance inspection at delivery**

10.1 For assessing compliance at delivery, when requested a spot sample of the cement shall be taken in accordance with 3.6 and 6.2, 6.3, 6.4 or 6.5 of BS EN 196: Part 7: 1992 (PS...) either before, or at the time of, delivery. A laboratory sample shall be prepared and packed in accordance with clauses 8 and 9 of

BS EN 196: Part 7: 1992. A sampling report shall be completed at the time of sampling and shall be attached to the laboratory sample in accordance with clause 10 of BS EN 196: Part 7: 1992/ (PS...).

NOTE: Testing may be delayed for up to 5 weeks from the time of sampling provided that there is confirmation that the sample has been stored continuously in the manner described in 9.2 of BS EN 196: Part 7: 1992 (PS...).

10.2 When the cement is tested for strength (see clause 6), unless otherwise agreed between the purchaser and the manufacturer, the pit/quarry from which the CEN Standard sand is obtained and the compaction procedure to be used shall be those in use by the manufacturer at the time when the cement was originally tested.

10.3 When the cement is tested for chemical properties (see clause 8) the sample shall be prepared by the method described in clause 6 of BS EN196: Part 2: 1995/(PS...).

10.4 The limiting values applicable to acceptance inspection shall be those given in table 3.

NOTE: These values are, in general, based on the ‘major defects’, defined in annex A which, however, does not contain values of deviation for strength upper limit, loss on ignition, insoluble residue, tricalcium aluminates’ and alkali contents.

<b>Table 3. Acceptance inspection limits</b>	
Property	Deviation from the requirements in clauses 6,7 and 8 in excess of
Strength lower limit 28 day 2 day (7 day)	- 2.5 N/mm <sup>2</sup> - 2.0 N/mm <sup>2</sup>
Strength upper limit 28 day	+ 4.0 N/mm <sup>2</sup>
Initial setting time	- 15min
Soundness	+ 1 mm
Loss on ignition	+ 0.1 % (m/m)
Insoluble residue	+ 0.1 % (m/m)
Sulfate content	+ 0.1 % (m/m)
Chloride content	+ 0.1 % (m/m)
Tricalcium aliminate content	+ 0 % (m/m)
Alkali content	+ 0.04 % (m/m)
<b>NOTE.</b> The deviation for sulfate content of 0.1 % (m/m) in this table for acceptance inspection limits is reduced from the value of 0.5 % (m/m) in table A.3 for major defects.	



# **Annexes**

## **Annex A (informative)**

### **Conformity criteria (cement manufacture's autocontrol)**

NOTE: This annex is based on the text of clause 11 'Conformity criteria' from the June 1989 draft European Prestandard specification for cements, which has been retained in ENV 197-1. However, some of the details are considered to be inappropriate for the manufacture of cement in the UK and the annex therefore incorporates several footnotes identifying these aspects.

In particular, the concept of 'major defects' (see A.6), i.e. a non-conformity with a requirement 'which is likely to reduce materially the usability of the cement for the intended purpose', is not considered to form a meaningful part of a statistically controlled autocontrol system operated by the cement manufacturer. However, a method for assessment by the purchaser of compliance at delivery has been incorporated into clause 12.

#### **A.1 Introduction**

**A.1.1** A statistically formulated conformity criterion includes three elements as follows:

- a) A definition of the requirement in terms of characteristic value, as given in clauses 7, 8 and 9;
- b) The acceptable percentage  $P^a$  of defects or, in other words, the fractile of the normal (Gaussain) distribution to which the characteristic value corresponds. In this standard, this is the 10% fractile or, for the lower strength limits, the 5% fractile;
- c) The probability of acceptance of a lot<sup>6</sup>) of cement which does not conform to the requirements.

A sampling inspection procedure can only produce an approximate value for the percentage of defects in a lot. The bigger the sample the better the approximation. The probability of acceptance, also named consumer's risk, controls the degree of approximation by the sampling plan and in this case shall be 5% for the continuous inspection which is the basis for the assessment of conformity.

A.1.2 The conformity criteria for continuous inspection (see A.3, A.4 and A.5) are based upon the principles of A.1.1. The European Prestandard specification for cements contains, however, an additional conformity criterion of a different type. In order to provide means for the rejection of cement which is likely to reduce materially the usability of the cement for the intended purpose, the prestandard specifies (see A.6) that a quantity of cement containing one or more so-called major defects does not conform to the requirements.

#### **A.2 Application of conformity procedures**

A.2.1 Conformity of cements to this standard should be continuously assessed. In consequence this standard specifies that the conformity of such cements should be verified by means of a statistical quality control scheme based upon continuous inspection of the manufactured cement. This inspection is operated by the cement producer (autocontrol).

NOTE: International or national regulations may require the autocontrol of cements to be monitored by an officially recognized testing laboratory.

Terms of delivery or other contractual conditions, normally included in documents exchanged between the supplier and the purchaser of cement, are outside the scope of this standard.

A.2.2 The European Prestandard specification for cements does not deal with acceptance inspection at delivery. However, application in this standard of the principles of statistical quality control puts some constraints on any additional acceptance inspection at delivery of cements which have been found to conform to this standard according to A.3, A.4 and A.5 on continuous inspection.

A sampling plan for additional acceptance inspection at delivery of a cement should not be allowed to increase the producer's risk of rejection to a higher value than that deduced from the scheme of continuous inspection, according to A.3, A.4 and A.5.

Pending additional standards on acceptance and other terms of delivery for cements, specification of additional acceptance inspection at delivery has not been dealt with in the European Prestandard specification for cements.

### A.3 General procedure for assessing conformity with the characteristic values

A.3.1 The assessment should be based upon continuous sampling inspection using spot samples) of cement taken in accordance with BS EN 196: Part 7.

A.3.2 The continuous inspection should take place at the cement plant and be operated by the producer (autocontrol).

The series of samples used for assessing the conformity should be taken over a period of not less than 6 months and not more than 12 months except in the cases) of a new factory or a new type or strength class of cement at an existing factory.

Minimum testing frequencies are specified in table A.1.

<b>Table A.1 Minimum testing frequencies</b>	
<b>Property</b>	<b>Number of samples</b>
Strength	2 per week
Sulfate content	
Initial setting time	
Soundness	
Tricalcium aluminate content (see 9.3)	
Chloride content	1 per month
Loss on ignition	
Insoluble residue	

A.3.3 An observed test value which does not conform to the appropriate values in clauses 7, 8 and 9 is characterized as a defect. The European Prestandard distinguishes between minor and major defects. Separate limits are specified for major defects (see A.6).

### A.4 Conformity criteria and procedure for strength

A.4.1 The strength requirements of clause 6 comprise:

- |                       |   |
|-----------------------|---|
| 28 day strength,      | lower limit ( <i>L</i> ) and<br>Upper limit ( <i>U</i> ); |
| 2 (or 7) day strength | lower limit ( <i>L</i> )                                  |

A.4.2 In the case of the strength requirements, the conformity procedure is based upon sampling inspection by variables.

In principle, the overall percentage of defects in the lot from which samples are taken is estimated from the test results. Conformity requires that the estimate does not exceed the acceptable percentage of defects.

NOTE: For practical calculations the so-called acceptability constant,  $k_A$ , is used for the evaluation of conformity instead of the percentage of defects (see A.7.2).

A.4.3 The sampling plan (including the number of single spot samples to be taken) is established by means of the following two parameters which are tabulated in table A.2:

- a) acceptable overall percentage of defects;
- b) acceptable consumer's risk.

The two parameters together are used for the selection of sampling plans for continuous autocontrol.

Some convenient sampling plans for inspection by variables have been collected in A.7. Any other plan satisfying the values in table A.2 is, in principle, acceptable for the conformity procedure.

<b>Table A.2 Parameters determining the conformity procedure</b>			
	2 (or 7) day and 28 day strength (lower limit <i>L</i> )	28 day strength (upper limit <i>U</i> )	Physical and chemical properties (all limits)
Continuous inspection procedure	By variables	By variables	By attributes (by variables is allowed)
Percentage of defects, $P_a$	5%	10%	10%
Consumer's risk	5%	5%	5%
<p>NOTE: In the European Prestandard specification for cements, sampling plans for additional acceptance inspection at delivery of a consignment of cement are, in accordance with A.2.2, chosen on the basis of the procedure's risk instead of the consumer's risk.</p> <p>The consumer's risk is represented by a point on the operating characteristic curve corresponding to a predetermined low probability of acceptance (in this annex, 5%).</p> <p>The procedure's risk is represented by a point on the operating characteristic curve corresponding to a predetermined low probability of rejection (in this annex, 5%).</p> <p>This note is not appropriate to this Pakistan Standard.</p>			

## **A.5 Conformity criteria and procedure for physical and chemical properties**

**A.5.1** Clauses 8 and 9 specify requirements for the following properties:

- a) Physical properties:
  - 1) Initial setting time;
  - 2) Soundness;
  
- b) Chemical properties:
  - 1) Loss on ignition;
  - 2) Insoluble residue;
  - 3) Sulfate content;
  - 4) Chloride content;
  - 5) Tricalcium aluminate content;
  - 6) Alkali content

Conformity should be assessed for one property at a time.

**A.5.2** In the case of the physical and chemical requirements, the conformity procedure is based upon sampling inspection by attributes.

The number of defective items is counted and compared with an estimated number of defects, calculated from the number of tests and the specified acceptable overall percentage of defects.

In order to improve inspection efficiency, the cement producer is allowed to employ inspection by variables (see A.4). This is preferable for sulfate content and initial setting time, and for chloride content in the case where this is close to the specified limit.

**A.5.3** The sampling plan (including the number of spot samples to be taken) is established on the same basis as in A.4 (see also table A.2).

Some convenient sampling plans for inspection by attributes have been collected in A.7. Any other plan satisfying the values in table A.2 is, in principle, acceptable for the conformity procedure.

## **A.6 Limits for major defects**

A quantity of cement yielding one or more major defective samples does not conform to the requirements of the European Prestandard specification for cements.

In general terms, a major defect is defined as a deviation from the requirements in clauses 7, 8 and 9 so large that the usability of the cement for its intended purpose is likely to be reduced and that in extreme cases even failure may be produced. Table A.3 presents a more specific definition for the different properties. If a test result deviates by more than the value in this table it is denoted major defective.

<b>Table A.3 Major defects</b>		
<b>Property</b>		
Strength lower limit	28 day	- 2.5 N/mm <sup>2</sup>
	2 day	- 2.0 N/mm <sup>2</sup>
	(7 day)	-
Strength lower limit	28 day	Value of deviation not specified
Initial setting time		- 15 min
Soundness		+ 1 mm
Loss on ignition		Value of deviation not specified
Sulfate content		+ 0.5% (m/m)
Chloride content		+ 0.01% (m/m)
Insoluble residue		Value of deviation not specified

## A.7 Sampling plans

### A.7.1 General

This clause contains a number of sampling plans for the following two alternatives which satisfy the conditions of table A.2. The alternatives are as follows:

- a) Continuous inspection by variables;
- b) Continuous inspection by attributes.

The number of samples and the minimum testing frequency are specified in table A.1.

### A.7.2 Inspection by Variables

In this case the mean value,  $\bar{x}$  and the standard deviation,  $s$ , of the complete series of test results (one result per sample) are calculated. The conformity criteria are:

$$\bar{x} - k_{AS} \geq L$$

and

$$\bar{x} + k_{AS} \leq U$$

where

$k_A$  is the acceptability constant;

$L$  is the specified lower limit;

$U$  is the specified upper limit.

The acceptability constant  $k_A$  depends on the parameters specified in table A.2 and on the number of test results ( $n$ ). Values of  $k_A$  are listed in table A.4.

<b>Table A.4 Acceptability constant <math>k_A</math></b>		
<b><math>n</math></b>	<b><math>Pa = 5\%</math></b>	<b><math>Pa = 10\%</math></b>
40 to 49	2.13	1.70
50 to 59	2.07	1.65
60 to 79	2.02	1.61
80 to 99	1.97	1.56
100 to 149	1.93	1.53
150 to 199	1.87	1.48
$\geq 200$	1.84	1.45

### A.7.3 Inspection by attributes

In this case the number  $c_D$  of defective test results (one result per sample) in the complete series of samples is counted.

The conformity is checked by the equation:

$$c_D \leq c_A$$

where the acceptable number of defects  $c_A$  depends on the parameters specified in table A.2 and on the number  $n$  of test results. Values of  $c_A$  are listed in table A.5.

$n$	$c_A$
0 to 39	0
40 to 54	1
55 to 69	2
70 to 84	3
85 to 99	4
100 to 109	5
NOTE: if $n \geq 110$ , $c_A = 0.075 (n - 30)$ .	

## Annex B (informative) Compositional requirements for all cement types

**B.1** The constituents of any cement type may comprise:

- a) Portland cement clinker;
- b) Other main constituents such as granulated blastfurnace slag, natural pozzolana, pulverized-fuel ash or limestone (not applicable to the sulfate-resisting Portland cement specified in this Pakistan Standard).
- c) Minor additional constituents (not applicable to the sulfate-resisting Portland cement specified in this Pakistan Standard).
- d) Calcium sulfate (gypsum or anhydrite or other forms of calcium sulfate, or any combination of them);
- e) Additives

The Pakistan Standard specifications for cement now adopt the common European convention of assuming that the sum of a), b), and c) amounts to 100%. This is referred to as the cement nucleus. The alternative approach, which is no longer adopted in the Pakistan Standards would regard the sum of a) to e) as amounting to 100%.

**B.2** Calcium sulfate and any additives typically amount to about 5% ( $m/m$ ) of the final cement and table B.1 illustrates the extreme compositional possibilities using the method of calculation given in the

Pakistan Standards. The bracketed values are those which would be obtained if the calculation were based on the sum of all constituents amounting to 100%.

**B.3** It is important to note that the calculations based on the cement nucleus refer only to compositional requirements. The chemical requirements specified in the Pakistan Standards are given as percentages of the final cement. i.e. cement nucleus plus calcium sulfate and any additives.

<b>Table B.1 Extreme compositional possibilities</b>					
British Standard	Clinker (see B.1a)	Other main constituents (see B.1 b)		Minor additional constituents (ssB.1c)	Calcium sulfate plus additives (see B.1d) and e)
	Minimum	Current edition Maximum	1980 edition Maximum	Maximum	Typical
	%	%	%	%	%
BS 12	95 (90.4)	0	0	5(4.8)	5(4.8)
BS 146	65 (62.0)	35(33.2)	n.a	1)	5(4.8)
	35 (33.2)	65 (62.0)	(65)	1)	5(4.8)
BS 4027	100 (95.2)	0	0	0	5(4.8)
BS 4246	15 (14.3)	85 (80.9)	(90)	1)	5(4.8)
BS 6588	80 (76.2)	20 (19.0)	n.a	1)	5(4.8)
	65 (62.0)	35(33.2)	(35)	1)	5(4.8)
BS 6610	45 (42.8)	55 (52.4)	(50)	1)	5(4.8)
BS 7583	80 (76.2)	20 (19.0)	n.a.	1)	5(4.8)
Other main constituent can include not more than 5% of minor additional constituents.					

## **Annex C (informative)**

### **Product guidance**

#### **C.1 General**

Guidance on the use of sulfate-resisting Portland cement in concrete can be found in BS 5328: Part 1, BS 8000: Part 1, BS 8000: Part 2 and BS 8110: Part 1. Guidance on the use of this cement in mortar can be found in BS 5262, BS 5628: Part 3 and BS 8000: Part 3.

#### **C.2 Safety warning**

Dry cement in normal use has no harmful effect on dry skin. When cement is mixed with water, alkali is released. Precautions should therefore be taken to avoid dry cement entering the eyes, mouth and nose and to prevent skin contact with wet cement.

Repeated skin contact with wet cement over a period may cause irritant contact dermatitis. The abrasiveness of the particles of cement and aggregate in mortar or concrete can contribute to this effect.

Continued contact during a working day can lead to cement burns with ulceration but this is not common. Some people are sensitive to the small amounts of chromate which may be present in cements and can develop allergic contact dermatitis, but this is rare.

When working in places where dry cement becomes airborne, protection for the eyes, mouth and nose should be worn.

When working with wet mortar or concrete, waterproof or other suitable protective clothing should be worn such as long sleeved shirts, full length trousers, waterproof gloves and wellington boots. Clothing contaminated with wet cement, mortar or concrete should be removed and washed before further use.

If cement enters the eye it should immediately be washed out thoroughly with clean water and medical treatment should be sought without delay. Wet mortar or concrete on the skin should be washed off immediately.

### **C.3 Storage**

To protect cement from premature hydration after delivery, bulk silos should be waterproof and internal condensation should be minimized.

Paper bags should be stored clear of the ground, not more than eight bags high and protected by a waterproof structure. As significant strength losses begin after 4 weeks to 6 weeks of storage in bags in normal conditions, and considerably sooner under adverse weather conditions or high humidity, deliveries should be controlled and used in order of receipt. Manufacturers are able to provide a system of marking a high proportion of the bags in each delivery to indicate when they were filled.

### **C.4 Test temperature**

BS EN 196 requires that the strength and setting time tests are carried out at a temperature of  $(20 \pm 1) ^\circ\text{C}$ . When cement is tested at a different temperature the results are likely to be affected. Appropriate advice may be obtained from the manufacturer.

### **C.5 Grouting and rendering**

Where cement is to be used in grouts or renders that are pumped through small apertures, such as spray nozzles, it is recommended that the user passes the cement or suspension through a screen of suitable mesh aperture to retain any occasional coarse particles.

### **C.6 Heat generation**

The cement hydration process generates heat, particularly in the first few days. Cements with higher early strength usually have a higher initial rate of heat generation than those with lower early strength. A higher initial rate of heat generation may be an advantage for thinner concrete sections in cold weather because it reduces the need for extended striking times and the tendency for early-age frost damage. Conversely, it may be a disadvantage for longer concrete sections in either hot or cold weather on account of the temperature gradients which are set up.



## C.7 Alkali-silica reaction

Sulfate-resisting Portland cement, type LA, may be specified by the purchaser to counteract alkali-silica reaction (see 4.2.4 of BS 5328: Part 1: 1991 and 6.2.5.4 of BS 8110: Part 1: 1985).

### List of references (see clause 2)

#### Normative references

#### BSI publications

British Standards Institution, London

BS 6100(PS...):	Glossary of building and civil engineering terms
BS 6100: Part 6:	Concrete and plaster
BS 6100: Section 6.1: 1984	Binders
BS EN 196(PS...):	Methods of testing cement
BS EN 196-1: 1995(PS...)	Determination of strength
BS EN 196-2: 1995(PS...)	Chemical analysis of cement
BS EN 196-3: 1995(PS:196-3-2014)	Determination of setting time and soundness
BS EN 196-7: 1992(PS...)	Methods of taking and preparing samples of cement
BS EN 196-21: 1992(PS...)	Determination of the chloride, carbon dioxide and alkali content of cement