

PS:232-2015 (R)

ICS No.91.100.10

PAKISTAN STANDARD SPECIFICATION FOR

**Ordinary Portland Cement
(Forth Revision)**



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PAKISTAN STANDARDS AND QUALITY CONTROL AUTHORITY

STANDARDS DEVELOPMENT CENTRE

STANDARDIZATION WING

1ST FLOOR, ST-7-A, BLOCK-3

GULISTAN-E-JOHER

Karachi

PAKISTAN STANDARD
SPECIFICATION FOR ORDINARY PORTLAND CEMENT

PART 1: REQUIREMENTS
(4th Revision)

FOREWARD

This standard was adopted by Board of Directors of Pakistan Standards & Quality Control Authority after recommendation of Technical Committee for 'Cement & lime' (BDC-5) on 15th June 2015. The standard had been approved and endorsed by the National Standards Committee on 29-12-2015.

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

This Pakistan Standard No.**232-2013** 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 **BSEN197-2000**.

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.

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1.0 SCOPE

This Pakistan Standard PS 232: 2013 (R) defines and covers the requirements for composition, manufacture, mechanical, physical, chemical properties and marking of Ordinary Portland Cement.

The standards listed below are necessary adjuncts to this standard as “related documents”.

Pakistan Standards/Reference Documents

PS.5313-2014/BS EN 196-7: 1992 Part 7 ‘Method of taking and preparing samples of cement’

PS/EN 196-1-2014, Method of testing cement Part-1: Determination of Strength

PS/BSEN 196-2- 2014, Method of testing cement Part-2: Chemical analysis of cement

PS.BSEN 196-3-2013: Methods of testing cement-Part-3: Determination of setting time and soundness

PS/EN-196-6-2014: Methods of testing cement-Part-6: Determination of fineness

PS../ASTM C 151 ‘Test method for autoclave expansion of cement’

2.0 TERMINOLOGY AND DEFINATIONS

For the purpose of PS 232: 2013 (R) following definitions apply.

2.1 Reactive calcium oxide (CaO)

It is that fraction of the calcium oxide which under normal hardening conditions can form calcium silicate hydrates or calcium aluminates hydrates.

*Note 1: To evaluate this fraction the total calcium oxide content (see **PS/BS EN 196-2:2014**) is reduced by the fraction corresponding to calcium carbonates (CaCO_3), based on the measured carbon dioxide (CO_2) content (see *PS../EN 196-21*), and the fraction corresponding to calcium sulphate (CaSO_4), based on the measured sulphate (SO_3) content (see **PS/BS EN 196-2: 2014**) after subtraction of the SO_3 taken up by alkalis.*

2.2 Reactive silicon dioxide (SiO_2)

It is that fraction of the silicon dioxide which is soluble after treatment with hydrochloric acid (HCl) and with boiling potassium hydroxide (KOH) solution.

*Note 2: The quality of reactive silicon dioxide is determined by subtracting from total silicon dioxide content (See **PS/BS EN 196-2:2014**) the fraction of silicon dioxide which is contained in the insoluble residue (see **PS/BS EN 196-2:2014**), both on a dry basis.*

2.3 Strength Classes of Cement

Class of compressive strength for Ordinary Portland cement mentioned in this standard are PS 32.5 N/R, PS 42.5 N/R and PS 52.5 N/R as explained subsequently under serial number.

3.0 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 PS 232: 2013 R, 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 PS 232: 2013 R cements 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 PS 232: 2013 R cement shall be at least 50 % by mass when the proportions are determined in accordance with **PS/BS EN 196-2:2014**).

4.0 CONSTITUENTS

4.1 Ordinary Portland cement clinker

Ordinary 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 finally divided, intimately mixed and therefore homogeneous.

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

4.2 Performance Improvers

The requirements of the performance improvers, allowed to be added in the cement, are mentioned below:

4.2.1 Granulated Blast Furnace Slag

The quality of granulated Blast Furnace to be used in Pakistan Standard Ordinary Portland cement as performance improver is material made by rapid cooling of a slag melt of suitable composition, as obtained by smelting iron ore in a blast furnace and contains at least two-thirds by mass of glassy slag and possesses hydraulic properties when suitably activated. Granulated blast furnace slag shall consist of at least two-thirds by mass of the sum of calcium oxide, magnesium oxide and silicon oxide. The remainder contains aluminium oxide together with small amounts of other compounds. The ratio by mass (Ca O+MgO)/(SiO₂) shall exceed 1.0.

4.2.2 Limestone

The limestone to be used in Pakistan Standard Ordinary Portland cement as improver shall meet following requirement:

The calcium carbonate (CaCO_3) content calculated from the calcium oxide content shall not be less than 75 percent.

4.2.3 Fly Ash

The Fly ash to be used in Pakistan Standard Ordinary Portland cement as improver is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases from furnaces fired with pulverised coal. For fly ash definition see EN 450-1/PS....

Fly ash may be siliceous or calcareous in nature. The former has pozzolanic properties; the later may have, in addition, hydraulic properties. The loss on ignition of fly ash determined in accordance with **PS/BS EN 196-2:2014**, but using an ignition time of 1 h, shall be within one of the following limits:

- a) 0% to 5% by mass
- b) 2.0% to 7.0% by mass
- c) 4.0% to 9.0% by mass

4.2.4 Silica Fume

Silica fumes as improver 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. The content of elemental silicon (Si) determined according to ISO 9286/PS..., shall not be greater than 0.4% by mass.

Silica fume shall meet the following requirements:

- 1) The loss on ignition shall not exceed 4.0% by mass determined in accordance with **PS/BS EN 196-2:2014** but using in ignition time of 1 h.
- 2) The specific surface (BET) of the untreated silica fume shall be at least $15.0 \text{ m}^2/\text{g}$ when tested in accordance with ISO 9277/PS...
- 3) For intergrinding with clinker and calcium sulphate the silica fume may be in its original state or compacted or pelletized (with water) or equivalent processed

4.3 Calcium Sulphate

Calcium sulphate is added to the other constituents of cement during its manufacture to control setting time. Calcium sulphate can be gypsum (calcium sulphate di-hydrate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), hemi-hydrate (CaSO_4)^{1/2} or anhydrite (anhydrous calcium sulphate, CaSO_4) or any mixture of them. Gypsum and anhydrite are found naturally. Calcium sulphate is also available as a by-product of certain industrial processes.

4.4 Additives

Additives for the purpose of PS-232: 2013 (R) are constituents not covered in 4.2.1 to 4.2.4 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 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/PS... series are used in cement, the standard notation of admixture shall be declared on bags or delivery document. Cement containing these admixtures shall be tested according to EN 934 at equal consistence or at equal water-cement ratio as provided in the said references. In case of any discrepancy, compressive strength of such additive containing cement mortar can be verified as per ASTM C-109/ PS.4967-2008 at a flow of 110 ± 5 . For such additives containing cements, following definitions would be for control and test mixes: (a) control mix: not containing any additives; (b) test mix: containing an additive.

5.0 MANUFACTURE

Ordinary Portland cement shall be manufactured by intimately mixing together calcareous and argillaceous and/or other silica, alumina or iron oxide bearing materials, burning them at a clinkering temperature and grinding the resultant clinker so as to produce a cement capable of complying with these specifications.

No material shall be added after burning, other than gypsum (natural or chemical); or performance improvers or both; or additives given in 4.2 and not more than one percent of air-entraining agents or other agents including colouring agents, which have proved not to be harmful.

Limit of addition of performance improvers to the clinker shall be as given in Table-1 and shall be inclusive of one percent additives as mentioned above. If a combination of performance improvers is added to the clinker, the maximum limit of addition shall be 5 percent.

Table 1: Performance Improvers for Ordinary Portland cement

Performance Improver	Percentage Addition (Maximum)
Granulated Blast Furnace Slag	5
Fly Ash	5
Limestone	5
Silica Fume	5

6.0 CHEMICAL REQUIREMENTS

Ordinary Portland cement shall comply with the chemical requirements given in Table-2. Total chloride content in all classes of Ordinary Portland cement shall not exceed 0.1 percent by mass when tested as per test method PS.EN 196-21-2013 for cement used in structure other than pre-stressed concrete.

Table-2 Chemical Requirements

Property	Test Reference	Strength Class	Requirements
Loss on ignition*	PS./EN 196-2-2014	PS 32.5 N/R PS 42.5 N/R PS 52.5 N/R	≤ 5%
Insoluble Residue**	PS./EN 196-2-2014	PS 32.5 N/R PS 42.5 N/R PS 52.5 N/R	≤ 5%
Sulphate content (SO ₃)	PS./EN 196-2-2014	PS 32.5 N/R PS 42.5 N	≤ 3.5%
		PS 42.5 R PS 52.5 N/R	≤ 4.0
Chloride content	EN 196-21/PS...	PS 32.5 N/R PS 42.5 N/R PS 52.5 N/R	≤ 0.10%

* Shall not exceed 3.0% in case cement does not contain any of the above improvers

** Shall be ≤ 1.5% in case cement does not contain any of the above improvers

Note 1:

Alkali aggregate reactions have been noticed in aggregates in some parts of the country. On large and important jobs where the concrete is likely to be exposed to humid atmosphere or wetting action, it is advisable that the aggregate to be tested for alkali aggregate reaction. In the case of reactive aggregates, the use of cement with alkali content below 0.6 % expressed as sodium oxide (Na₂O) is recommended.

7.0 MECHANICAL REQUIREMENTS

7.1 Compressive Strength

Table-3 Compressive Strength

Strength Class	Compressive Strength (Mpa)			
	Early Strength		Standard Strength	
	2 days	7 days	28 days	
PS 32.5 N	-	≥ 16.0	≥ 32.5	≤ 52.5
PS 32.5 R	≥ 10.0	-		
PS 42.5 N	≥ 10.0	-	≥ 42.5	≤ 62.5
PS 42.5 R	≥ 20.0	-		
PS 52.5 N	≥ 20.0	-	≥ 52.5	-
PS 52.5 R	≥ 30.0	-		

8.0 PHYSICAL REQUIREMENTS

8.1 Soundness

The expansion of Ordinary Portland cement determined in accordance with PS.EN 196-3-2013 shall conform to the requirement in Table 4.

8.2 Setting Time

The initial setting time of Ordinary Portland cement determined in accordance with PS.EN 196- 3-2013, shall conform to the requirement in Table 4.

Table No.4 Physical requirement of Ordinary Portland Cement

Strength Class (Ordinary Portland Cement)	Initial Setting Time (Minutes)	Soundness Expansion (mm)
PS 32.5 N	≥ 75	≤ 10
PS 32.5 R		
PS 42.5 N	≥ 60	
PS 42.5 R		
PS 52.5 N	≥ 45	
PS 52.5 R		

Table-4

9.0 STORAGE

The cement shall be stored in such a manner as to permit easy access for proper inspection and identification and in a suitable weather-tight building to protect the cement from dampness and to minimize warehouse deterioration.

10.0 MANUFACTURER'S CERTIFICATE

10.1 The manufacturer shall ensure that the cements specified in this standard conform to the requirements of this standard and, if requested, shall furnish a certificate to this effect to the purchaser or his representative, within ten days of despatch of the cement.

10.2 The manufacturer, if requested, shall furnish a certificate, within ten days of despatch of cement, indicating the total chloride content in percent by mass of cement and the type and percentage of performance improvers added.

11.0 DELIVERY

11.1 Unless otherwise agreed between the purchaser and the manufacturer, the cement shall be packed in bags, of which there shall be 20 to the ton (1000 kg), bearing the manufacturer's name or registered mark.

11.2 The net mass of cement per bag may be 50 kg and packed in suitable bag.

11.3 The number of bags in a sample taken for weighment showing a minus error greater than 2 percent of the specified mass shall not be more than 5 percent of the bags in the sample. Also the minus error in none of such bags in the sample shall exceed 4 percent of the specified net mass of the cement in the bag. However, the net mass of the cement in a sample shall be equal to or more than 50 Kg.

12.0 MARKING

Ordinary Portland cement manufactured in compliance with this standard shall be marked on the bag legibly and indelibly with the following particulars:

- (a) The name, trade mark or other means of identification of the vendor
- (b) The name and class of the Ordinary Portland Cement
- (c) The number and year of this Pakistan Standard i.e. PS 232: 2013 (R)
- (d) PSQCA certification mark

13.0 SAMPLING

13.1 Samples for Testing

A sample or samples for testing may be taken by the purchaser or his representative, or by any person appointed to manage the work for the purpose of which the cement is required or by latter's representative.

13.1.1 The samples shall be taken with in three weeks of the delivery and all the tests shall be commenced within one week of sampling.

13.1.2 When it is not possible to test the samples within one week, the samples shall be packed and stored in air-tight containers till such time that they are tested.

13.2 In addition to the requirement of 13.1, the methods and procedure of sampling shall be in accordance with PS.BS EN 196-7-2014.

13.3 Facilities for Sampling and Identification

The manufacturer or supplier shall afford every facility, and shall provide all labour and materials for taking and packing samples for testing the cement and for subsequent identification of the cement sampled.

14.0 TESTS

14.1 The sample or samples of cement for test shall be taken as described in PS.BS EN 196-7-2014 and shall be tested in the manner described in the relevant clauses.

14.2 Temperature for Testing

All physical tests shall be carried out at 20 ± 2 °C.

14.3 Standard consistence test

The quantity of water required to produce a paste of standard consistency, to be used for the determination of the water content of mortar for the compressive strength tests and for the determination of soundness and setting time, shall be obtained by the method described PS.BS EN 196-3-2013.

14.4 Independent Testing

14.4.1 If the purchaser or his representative requires independent tests, the samples shall be taken before or immediately after delivery at the option of the purchaser or his representative, and tests shall be carried out in accordance with this standard on the written instruction of the purchaser or his representative.

14.4.2 The manufacturer shall supply, free of charge, the cement required for testing.

Unless otherwise specified in the enquiry and order, the cost of the tests shall be born as follows:

- a) By the manufacturer if the results show that the cement does not comply with this standard,
- b) By the purchaser if the results show that the cement complies with this standard.

14.4.3 After a representative sample has been drawn, test on the sample shall be carried out as expeditiously as possible.

15.0 REJECTION

15.1 Cement may be rejected if it does not comply with any of the requirements of this specification.

15.2 Cement remaining in bulk storage at the mill, prior to shipment, for more than six months, or cement in bags in local storage in the hands of a vendor for more than 3 months after completion of tests, may be retested before use and may be rejected, if it fails to conform to any of the requirements of this specification.

Note for Guidance of users for storage

The bags of Ordinary Portland Cement which are not in good condition, due to causes such as moisture patches, torn bags, burst stitches, spilling cement or exudation of cement dust, shall be rejected.

NOTE: 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 ten 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.