Indian Standard

SPECIFICATION FOR SULPHATE RESISTING PORTLAND CEMENT

0. FOREWORD

0.1 This Indian Standard was adopted by the Bureau of Indian Standards on 12 May 1988, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Sulphate resisting Portland cement is a type of Portland cement in which the amount of tricalcium aluminate is restricted to an acceptably low value. This cement should not be mistaken for supersulphated cement, which is produced by intergrinding or intimately blending a mixture of granulated blast furnace slag, calcium sulphate and a small amount of Portland cement or Portland cement clinker or any other source of lime.

Sulphate resisting Portland cement can be used for structural concrete wherever ordinary Portland cement or Portland pozzolana cement or Portland slag cement are useable under normal conditions. Use of supersulphated cement is, however, generally restricted where the prevailing temperature is below 40°C. The later is not recommended for producing steam-cured products.

0.2.1 Use of sulphate resisting Portland cement is particularly beneficial in such conditions where the concrete is exposed to the risk of deterioration due to sulphate attack, for example, in contact with soils and ground waters containing excessive amounts of sulphates as well as for concrete in sea water or exposed directly to sea coast.

0.3 Mass of cement packed in bags and the tolerance requirements for the mass of cement packed in bags shall be in accordance with the relevant provisions of the Standards of Weights and Measures (Packaged Commodities) Rules, 1977 and **A-1.2** (*see* Appendix A for information). Any modification to these Rules in respect of tolerance on mass of cement would automatically apply to this standard.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard covers the manufacture, chemical and physical requirements and testing of sulphate resisting Portland cement.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 4845-1968* shall apply.

3. MANUFACTURE

3.1 Sulphate resisting Portland cement shall be manufactured by grinding and intimately mixing together calcareous and argillaceous and/or other silica, alumina and iron oxide bearing materials, burning them at clinkering temperature and grinding the resultant clinker so as to produce a cement capable of complying with this specification. No material shall be added after burning other than gypsum (natural or chemical) or water or both, and not more than one percent of air-entraining agents or other agents which have proved not to be harmful.

NOTE — Chemical gypsum may be added provided that the performance requirements of the final product as specified in this standard are met with.

*Definitions and terminology relating to hydraulic cement.

4. CHEMICAL REQUIREMENTS

4.1 When tested in accordance with the methods given in IS : 4032-1985*, sulphate resisting Portland cement shall comply with the chemical requirements given in Table 1.

5. PHYSICAL REQUIREMENTS

5.1 Fineness — When tested for fineness by Blaine's air permeability method as given in IS : 4031 (Part 2)-1988†, the specific surface of cement shall be not less than 225 m^2/kg.

*Methods of chemical analysis for hydraulic cement (*first revision*).

†Methods of physical tests for hydraulic cement: Part 2 Determination of fineness by specific surface by Blaine air permeability method (*first revision*).

TABLE 1 CHEMICAL REQUIREMENTS FOR SULPHATE RESISTING PORTLAND CEMENT

(*Clause* 4.1)

Sl No.	Characteristic	Requirement
i)	Ratio of percentage of lime to percentages of silica, alumina and iron oxide; when calculated by the formula: $\frac{CaO - 0{\cdot}7\ SO_3}{2{\cdot}8\ SiO_2 + 1{\cdot}2\ Al_2O_3 + 0{\cdot}65\ Fe_2O_3}$	Not greater than 1·02 and not less than 0·66
ii)	Insoluble residue, percent by mass	Not more than 4
iii)	Magnesia, percent by mass	Not more than 6
iv)	Total sulphur content calculated as sulphuric anhydride (SO_3), percent by mass	Not more than 2·5
v)	Tricalcium aluminate (C_3A), percent by mass (*see* Note 1)	Not more than 5
vi)	Tetracalcium alumino ferrite phase plus twice the tricalcium aluminate ($C_4AF + 2C_3A$), percent by mass (*see* Note 1)	Not more than 25
vii)	Total loss on ignition, percent by mass	Not more than 5

NOTE 1 — The tricalcium aluminate and tetracalcium alumino ferrite content are calculated by the following formulae:

$$C_3A = 2{\cdot}65\ Al_2O_3 - 1{\cdot}69\ Fe_2O_3$$
$$C_4AF = 3{\cdot}043\ Fe_2O_3$$

When the alumina — ferric oxide ratio is less than 0·64 (hence C_3A is absent), a calcium alumino ferrite solid solution expressed as SS ($C_4AF + C_2F$) is formed. Contents of this solid solution and of tricalcium silicate shall be calculated by the following formulae:

$$SS\ (C_4AF + C_2F) = (2{\cdot}100\ Al_2O_3) + (1{\cdot}702\ Fe_2O_3)$$
$$C_3S = (4{\cdot}071\ CaO) - (7{\cdot}600\ SiO_2) - (4{\cdot}479\ Al_2O_3) - (2{\cdot}859\ Fe_2O_3) - (2{\cdot}852\ SO_3)$$

NOTE 2 — When expressing compounds, certain symbols have been used, namely, $C = CaO$, $S = SiO_2$, $A = Al_2O_3$, and $F = Fe_2O_3$. For example, $C_3A = 3CaO.Al_2O_3$. Titanium dioxide and phosphorous pentoxide (TiO_2 and P_2O_5) shall be included with the Al_2O_3 content. The value historically and traditionally used for Al_2O_3 in calculating potential compounds for specification purposes is the ammonium hydroxide group minus ferric oxide ($R_2O_3 - Fe_2O_3$) as obtained by classical wet chemical methods. This procedure includes as Al_2O_3 the TiO_2, P_2O_5 and other trace oxides which precipitate with the ammonium hydroxide group in the classical wet chemical methods. Many modern instrumental methods of cement analysis determine aluminium or aluminium oxide directly without the minor and trace oxides included as in the classical method. Consequently, for consistency and to provide comparability with historic data and among various analytical methods, when calculating potential compounds for specification purposes, those using methods which determine Al or Al_2O_3 directly should add to the determined Al_2O_3 mass quantities of P_2O_5, TiO_2 and any other oxide except Fe_2O_3 which would precipitate with the ammonium hydroxide group when analyzed by the classical method and which is present in an amount of 0·05 percent by mass or greater. The percentage (by mass) of minor or trace oxides to be added to Al_2O_3 by those using direct methods may be obtained by actual analysis of those oxides in the sample being tested or estimated from historical data on those oxides on cements from the same source, provided that the estimated values are identified as such.

5.2 Soundness

5.2.1 When tested by Le Chatelier method and autoclave test described in IS : 4031 (Part 3)-1988* unaerated sulphate resisting Portland cement shall not have an expansion of more than 10 mm and 0·8 percent, respectively.

5.2.1.1 In the event of cement failing to comply with any one or both the requirements specified in **5.2.1**, further tests in respect of each failure shall be made as described in IS : 4031 (Part 3)-1988* from another portion of the same sample after aeration. The aeration shall be done by spreading out the sample to a depth of 75 mm at a relative humidity of 50 to 80 percent for a total period of 7 days. The expansion of cements so aerated shall not be more than 5 mm and 0 6 percent when tested by Le Chatelier method and autoclave test respectively.

5.3 Setting Time — The setting time of sulphate resisting Portland cement, when tested by the Vicat apparatus method described in IS : 4031 (Part 5)-1988* shall conform to the following requirement

a) Initial setting time in minutes, not less than 30, and

b) Final setting time in minutes, not more than 600.

5.3.1 If cement exhibits false set, the ratio of final penetration measured after 5 minutes of completion of mixing period to the initial penetration measured exactly after 20 seconds of completion of mixing period, expressed as percent, shall be less than 50. In the event of cement exhibiting false set, the initial and final setting time of cement when tested by the method described in IS : 4031 (Part 5)-1988* after breaking the false set, shall conform to **5.3**.

*Methods of physical tests for hydraulic cement: Part 3 Determination of soundness (*first revision*).

*Methods of physical tests for hydraulic cement: Part 5 Determination of initial and final setting time (*first revision*).

5.4 Sulphate Expansion

5.4.1 The sulphate expansion of the sulphate resisting Portland cement when tested by the method described in **5.4.2**, shall not be more than 0 045 percent at 14 days. This test is optional and shall be carried out by agreement between the purchaser and the manufacturer at the time of placing order.

5.4.2 For this test a mixture of sulphate resisting Portland cement and gypsum should be prepared in such proportions that the total SO_3 content is 7 0 percent by mass. The gypsum used shall be natural gypsum 100 percent passing 150 μm IS Sieve, at least 94 percent passing 75 μm IS Sieve and at least 90 percent passing 45 μm IS Sieve. Mortar should have proportion of (cement + gypsum) : sand as 1 : 2·75 and water : (cement + gypsum) as 0·485. The sand used shall conform to IS : 650-1966*. The dimension of mortar bars shall be 25 × 25 × 250 mm. After demoulding, the bars shall be stored horizontally in water. The average expansion of three specimens after 14 days shall be reported.

5.5 Compressive Strength — The average compressive strength of at least three mortar cubes (area of face 50 cm^2) composed of one part of cement, three parts of standard sand (conforming to IS : 650-1966*) by mass and $P/4$ + 3·0 percent (of combined mass of cement plus sand) water and prepared, stored and tested in the manner described in IS : 4031 (Part 6)-1988† shall be as follows:

i) 72 ± 1 h, not less than 10 MPa
ii) 168 ± 2 h, not less than 16 MPa
iii) 672 ± 4 h, not less than 33 MPa

NOTE — P is the percentage of water required to produce a paste of standard consistency (*see* **10.3**).

5.6 By arrangement between the purchaser and the manufacturer, transverse strength test of plastic mortar in accordance with the method described in IS : 4031 (Part 8)-1988‡ may be specified in addition to the test specified in **5.5**. The permissible values of the transverse strength shall be mutually agreed to between the purchaser and the supplier at the time of placing order.

5.7 Notwithstanding the strength requirements specified in **5.5** and **5.6**, sulphate resisting Portland cement shall show a progressive increase in strength from the strength at 72 h.

*Specification for standard sand for testing of cement (*first revision*).

†Methods of physical tests for hydraulic cement: Part 6 Determination of compressive strength of hydraulic cement (other than masonry cement) (*first revision*).

‡Methods of physical tests for hydraulic cement: Part 8 Determination of transverse and compressive strength of plastic mortar using prism (*first revision*).

6. STORAGE

6.1 The sulphate resisting Portland 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.

7. MANUFACTURER'S CERTIFICATE

7.1 The manufacturer shall furnish a certificate to the purchaser or his representative, within 10 days of despatch of the cement stating that the material conforms to all the requirements of this standard.

8. DELIVERY

8.1 The cement shall be packed in bags [jute sacking bag conforming to IS : 2580-1982*, double hessian bituminized (CRI type), multiwall paper conforming to IS : 11761-1986†, polyethylene lined (CRI type) jute, light weight jute conforming IS : 12154-1987‡ woven HDPE conforming to IS : 11652-1986§, woven polypropylene conforming to IS : 11653-1986‖, jute synthetic union conforming to IS : 12174-1987¶ or any other approved composite bags] bearing the manufacturer's name or his registered trade-mark, if any. The words 'sulphate resisting Portland cement' and the number of bags (net mass) to the tonne or the net mass (*see* **8.2**) of the cement shall be legibly and indelibly marked on each bag. The bags shall be in good condition at the time of inspection.

8.1.1 Similar information shall be provided in the delivery advices accompanying the shipment of packed or bulk cement (*see* **8.3**).

8.1.2 The bags or packages may also be marked with the Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers, may be obtained from the Bureau of Indian Standards.

8.2 The net mass of cement per bag shall be 50 kg (*see* Appendix A).

*Specification for jute sacking bags for packing cement (*second revision*).

†Specification for multiwall paper sacks for cement, valved-sewn-gussetted type.

‡Specification for light weight jute bags for packing cement

§Specification for high density polyethylene (HDPE) woven sacks for packing cement.

‖Specification for polypropylene (PP) woven sacks for packing cement.

¶Specification for jute synthetic union bag for packing cement.

8.3 Supplies of cement in bulk may be made by arrangement between the purchaser and the supplier (manufacturer or stockists).

NOTE — A single bag or container containing 1 000 kg or more net mass of cement shall be considered as bulk supply of cement. Supplies of cement may also be made in intermediate containers, for example, drums of 200 kg, by agreement between the purchaser and the manufacturer.

9. SAMPLING

9.1 Samples for Testing and by Whom to be Taken — A sample or samples for testing may be taken by the purchaser or his representative, or by any person appointed to superintend the work for purpose of which the cement is required or by the latter's representative.

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

9.1.2 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.

9.2 In addition to the requirements of **9.1**, the methods and procedure of sampling shall be in accordance with IS : 3535-1986*.

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

10. TESTS

10.1 The sample or samples of cement for test shall be taken as described in **9** and shall be tested in the manner described in the relevant clauses.

*Methods of sampling hydraulic cements (*first revision*).

10.2 Temperature for Testing — The temperature range within which physical tests may be carried out shall, as far as possible, be 27 ± 2°C. The actual temperature during the testing shall be recorded.

10.3 Consistency of Standard Cement Paste — 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 in IS : 4031 (Part 4)-1988*.

10.4 Independent Testing

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

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

11. REJECTION

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

11.2 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.

*Methods of physical tests for hydraulic cement: Part 4 Determination of consistency of standard cement paste (*first revision*).

APPENDIX A

(*Clauses* 0.3 *and* 8.2)

TOLERANCE REQUIREMENTS FOR THE MASS OF CEMENT PACKED IN BAGS

A-1. The net mass of cement packed in bags at the plant in a sample shall be equal to or more than 50 kg. The number of bags in a sample shall be as given below:

Batch Size	*Sample Size*
100 to 150	20
151 to 280	32
281 to 500	50
501 to 1 200	80
1 201 to 3 200	125
3 201 and above	200

The bags in a sample shall be selected at random (*see* IS : 4905-1968*).

A-1.1 The number of bags in a sample showing a minus error greater than 2 percent of the specified net mass (50 kg) shall be not more than 5 percent of the bags in the sample and the minus error in none of such bags in the sample shall exceed 4 percent of the specified net mass of the bag.

*Methods for random sampling.

NOTE — The matter given in **A-1** and **A-1.1** are extracts based on the Standards of Weights and Measure (Packaged Commodities) Rules, 1977 to which references shall be made for full details. Any modification made in these Rules and other related Acts and Rules would apply automatically.

A-1.2 In case of a wagon/truck load of up to 25 tonnes, the overall tolerance on net mass of cement shall be zero to +0·5 percent.

NOTE — The mass of a jute sacking bag conforming to IS : 2580-1982* to hold 50 kg of cement is 531 g, the mass of a double hessian bituminized (CRI type) bag to hold 50 kg of cement is 630 g, the mass of a 6-ply paper bag to hold 50 kg of cement is approximately 400 g and the mass of a polyethylene lined (CRI type) jute bag to hold 50 kg of cement is approximately 480 g.

*Specification for jute bags for packing cement (*second revision*).