IS 455 : 1989
(Reaffirmed 1995)

Indian Standard

PORTLAND SLAG CEMENT – SPECIFICATION

(Fourth Revision)

भारतीय मानक

पोर्टलैंड धातुमल सीमेंट – विशिष्टि

(चौथा पुनरीक्षण)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

May 1990

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FOREWORD

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards on 30 October 1989, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

Portland slag cement is obtained by mixing Portland cement clinker, gypsum and granulated slag in suitable proportions and grinding the mixture to get a thorough and intimate mix between the constituents. It may also be manufactured by separately grinding Portland cement clinker, gypsum and granulated slag and then mixing them intimately. The resultant product is a cement which has physical properties similar to those of ordinary Portland cement. In addition, it has low heat of hydration and is relatively better resistant to soils and water containing excessive amounts of sulphates of alkali metals, alumina and iron, as well as to acidic waters, and can, therefore, be used for marine works with advantage.

The manufacture of Portland slag cement has been developed primarily to utilize blastfurnace slag, a waste product from blastfurnaces. The development of manufacture of this type of cement will considerably increase the total output of cement production in the country and will, in addition, provide a profitable use for an otherwise waste product. The slags obtained from other types of furnaces, but having identical properties as those of granulated blastfurnace slag conforming to this standard, may also be used for manufacture of Portland slag cement.

This standard was first published in 1953 and subsequently revised in 1962, 1967 and 1976. This fourth revision incorporates the modifications required as a result of experience gained with the use of this specification and to bring the standard in line with the present practices followed in the production and testing of cement.

Since publication of the third revision of this standard, large number of amendments have been issued from time to time in order to modify various requirements based on the experience gained with the use of the standard and the requirements of the users and also keeping in view the raw materials and fuel available in the country for manufacture of cement. The important amendments include incorporating a value of 28 day compressive strength, increasing the requirement regarding loss on ignition from 4·0 to 5·0, increasing the insoluble residue content from 2·5 to 4 percent, making autoclave soundness test compulsory, incorporating a provision for retest in respect of autoclave soundness test after aeration of the cement, incorporating a clause on false set of cement and permitting packaging of cement in 25 kg bags. In view of these large number of amendments, the Sectional Committee decided to bring out the fourth revision of the standard incorporating all these amendments so as to make it more convenient for the users. The desirable requirements of granulated slag suitable for the manufacture of Portland slag cement have been deleted from this revision and reference has been made to IS 12089 : 1987 'Specification for granulated slag for the manufacture of Portland slag cement'.

This standard contains clauses **5.1** and **11.4.1** which permit the purchaser to use his option and clauses **6.5, 9.2.1** and **9.3** which call for agreement between the purchaser and the manufacturer.

In the formulation of this standard considerable assistance has been rendered by National Council for Cement and Building Materials, New Delhi as many of these modifications are based on studies carried out by them.

The composition of the committee responsible for the formulation of this standard is given in Annex C.

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

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 or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PORTLAND SLAG CEMENT – SPECIFICATION

(Fourth Revision)

1 SCOPE

1.1 This standard covers the manufacture and chemical and physical requirements for Portland slag cement.

2 REFERENCES

2.1 The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 4845 : 1968 and the following shall apply.

3.2 Portland Slag Cement

An intimately interground mixture of Portland cement clinker and granulated slag with addition of gypsum and permitted additives or an intimate and uniform blend of Portland cement and finely ground granulated slag.

3.3 Portland Clinker

Clinker, consisting mostly of calcium silicates, obtained by heating to incipient fusion a predetermined and homogeneous mixture of materials principally containing lime (CaO) and silica (SiO_2) with a smaller proportion of alumina (Al_2O_3) and iron oxide (Fe_2O_3).

3.4 Granulated Slag

Slag in granulated form is used for the manufacture of hydraulic cement. Slag is a non-metallic product consisting essentially of glass containing silicates and alumino-silicates of lime and other bases, as in the case of blastfurnace slag, which is developed simultaneously with iron in blastfurnace or electric pig iron furnace. Granulated slag is obtained by further processing the molten slag by rapidly chilling or quenching it with water or steam and air.

4 MANUFACTURE

4.1 Portland slag cement shall be manufactured either by intimately intergrinding a mixture of Portland cement clinker and granulated slag with addition of gypsum (natural or chemical) or calcium sulphate, or by an intimate and uniform blending of Portland cement and finely ground granulated slag, so that the resultant mixture would produce a cement capable of complying with this specification. No material shall be added other than gypsum (natural or chemical) or water or both. However, when gypsum is added it shall be in such amounts that the sulphur trioxide (SO_3) in the cement produced does not exceed the limits specified in 5.2. Besides, not more than one percent of air-entraining agents or surfactants which have proved not to be harmful, may be added. The slag constituent shall be not less than 25 percent nor more than 65 percent of the Portland slag cement.

5 CHEMICAL REQUIREMENTS

5.1 Portland cement clinker used in the manufacture of Portland slag cement shall comply in all respects with the chemical requirements specified for the 33 grade ordinary Portland cement in IS 269 : 1989, and the purchaser shall have the right, if he so desires, to obtain samples of the clinker used in the manufacture of Portland slag cement.

5.2 The Portland slag cement shall comply with the following chemical requirements when tested in accordance with the methods given in IS 4032 : 1985:

	Percent, Max
Magnesium oxide (MgO)	8·0
Sulphur trioxide (SO_3)	3·0
Sulphide sulphur (S)	1·5
Loss on ignition	5·0
Insoluble residue	4·0

NOTES

1 Total chloride content in cement shall not exceed 0·05 percent by mass for cement used in prestressed concrete structures and long span reinforced concrete structures. (Method of test for determination of chloride content in cement is given in IS 12423 : 1988.)

2 The limit of total chloride content in cement for use in plain and other reinforced concrete structures is being reviewed. Till that time, the limit may be mutually agreed to between the purchaser and the manufacturer.

3 Granulated slag conforming to IS 12089 : 1987 has been found suitable for the manufacture of Portland slag cement.

6 PHYSICAL REQUIREMENTS

6.1 Fineness

When tested for fineness in terms of specific surface by Blaine's Air permeability method described in IS 4031 (Part 2) : 1988, the specific surface of slag cement shall be not less than 225 m^2/kg.

6.2 Soundness

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

6.2.1.1 In the event of cements failing to comply with any one or both the requirements specified in **6.2.1**, 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 be not more than 5 mm and 0·6 percent when tested by 'Le-Chatelier' method and autoclave test respectively.

6.3 Setting Time

The setting time of slag cement, when tested by the Vicat apparatus method described in IS 4031 (Part 5) : 1988, shall be as follows:

a) Initial setting time	Not less than 30 minutes
b) Final setting time	Not more than 600 minutes

6.3.1 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 not 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 **6.3**.

6.4 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 (*see* Note 1) 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:

a) 72 ±1 h	Not less than 16 MPa
b) 168 ±2 h	Not less than 22 MPa
c) 672 ±4 h	Not less than 33 MPa

NOTES

1 Standard sand shall conform to IS 650 : 1966.

2 P is the percentage of water required to produce a paste of standard consistency (*see* **11.3**).

6.5 By agreement 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 **6.4**. The permissible values of the transverse strength by this method shall be as agreed to between the purchaser and the manufacturer at the time of placing the order.

6.6 Notwithstanding the strength requirements in **6.4** and **6.5**, the Portland slag cement shall show a progressive increase in strength from the strength at 72 hours.

7 STORAGE

7.1 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.

8 MANUFACTURER'S CERTIFICATION

8.1 The manufacturer shall satisfy himself that the cement conforms 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 cement.

8.2 The manufacturer shall furnish a certificate, within ten days of despatch of the cement, indicating the total chloride content in percent by mass of cement.

9 DELIVERY

9.1 The cement shall be packed in bags [jute sacking bag conforming to IS 2580 : 1982, double hessian bituminized (CRI type), multi-wall paper conforming to IS 11761 : 1986, polyethylene lined (CRI type) jute, light weight jute conforming to 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 'Portland Slag Cement' or a suitable mark to distinguish Portland slag cement from other Portland cements shall be clearly and indelibly marked on each bag. The number of bags (net mass) to the tonne or the average net mass of the cement shall be legibly and indelibly marked on each bag. The bags shall be in good condition at the time of inspection.

9.1.1 Similar information shall be provided in the delivery advices accompanying the shipment of packed or bulk cement (*see* **9.3**).

9.2 The average net mass of cement per bag shall be 50 kg (*see* Annex B).

9.2.1 The average net mass of cement per bag may also be 25 kg subject to tolerances as given in **9.2.1.1** and packed in suitable bags as agreed to between the purchaser and the manufacturer.

9.2.1.1 The number of bags in a sample taken for weighment showing a minus error greater than 2 percent of the specified net mass shall be not 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 cement in the bag. However, the average net mass of cement in a sample shall be equal to or more than 25 kg.

9.3 Supplies of cement in bulk may be made by agreement between the purchaser and the supplier (manufacturer or stockist).

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.

10 SAMPLING

10.1 Samples for Testing

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

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

10.1.2 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.

10.2 In addition to the requirements of **10.1**, the methods and procedure of sampling shall be in accordance with IS 3535 : 1986.

10.3 Facilities for Sampling and Identifying

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 the cement sampled.

11 TESTS

11.1 The sample or samples of cement for tests shall be taken as described in IS 3535 : 1986 and shall be tested in the manner prescribed in the relevant clauses.

11.2 Temperature for Testing

The temperature at which the physical tests may be carried out shall, as far as possible, be 27 ±2°C. The actual temperature during the testing shall be recorded.

11.3 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 test and for the determination of soundness and setting time, shall be obtained by the method described in IS 4031 (Part 4) : 1988.

11.4 Independent Testing

11.4.1 If the purchaser or his representative requires independent test, 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.

11.4.2 Cost of Testing

The manufacturer shall supply, free of charge, the cement required for testing. Unless otherwise specified in the enquiry and order, the cost of tests shall be borne as follows:

a) By the manufacturer if the results show that the cement does not comply with this standard; and

b) By the purchaser if the results show that the cement complies with this standard.

11.4.3 After a representative sample has been drawn and hermetically sealed, tests on the sample shall be carried out as expeditiously as possible.

12 REJECTION

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

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

ANNEX A

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*	*IS No.*	*Title*
269 : 1989	Specification for 33 grade ordinary Portland cement (*fourth revision*)	11652 : 1986	Specification for high density polyethylene (HDPE) woven sacks for packing cement
650 : 1966	Specification for standard sand for testing of cement (*first revision*)	11653 : 1986	Specification for polypropylene (PP) woven sacks for packing cement
2580 : 1982	Specification for jute sacking bags for packing cement (*second revision*)	11761 : 1986	Specification for multi-wall paper sacks for cement valved-sewn gussetted type
3535 : 1986	Methods of sampling hydraulic cements (*first revision*)	12089 : 1987	Specification for granulated slag for the manufacture of Portland slag cement
4031 (Part 1 to Part 13)	Methods of physical test for hydraulic cement (*first revision*)	12154 : 1987	Specification for light weight jute bags for packing cement
4032 : 1985	Method of chemical analysis of hydraulic cement (*first revision*)	12174 : 1987	Specification for jute synthetic union bag for packing cement
4845 : 1968	Definitions and terminology relating to hydraulic cement	12423 : 1988	Method for colorimetric analysis of hydraulic cement
4905 : 1968	Methods for randam sampling		

ANNEX B

(*Clause* 9.2)

TOLERANCE REQUIREMENTS FOR THE MASS OF CEMENT PACKED IN BAGS

B-1 The average 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 over	200

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

B-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. Also the minus error in none of such bags in the sample shall exceed 4 percent of the specified net mas of cement in the bag.

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

B-1.2 In case of a wagon/truck load of 20 to 25 tonnes, the overall tolerance on net mass of cement shall be 0 to + 0·5 percent.

NOTE — The mass of a jute sacking bag conforming to IS 2580 : 1982 to hold 50 kg of cement in 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.

ANNEX C

(*Foreword*)

COMPOSITION OF THE TECHNICAL COMMITTEE

CEMENT AND CONCRETE SECTIONAL COMMITTEE, CED 2

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'.

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Amendments Issued Since Publication

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AMENDMENT NO. 1 APRIL 1991

TO

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(Fourth Revision)

(*Page* 3, *clause* **9.2.1.1**) — Insert the following new clauses after **9.2.1.1**:

"**9.2.2** When cement is intended for export and if the purchaser so requires, packing of cement may be done in bags with an average net mass per bag as agreed to by the purchaser and the manufacturer.

9.2.2.1 For this purpose the permission of the certifying authority shall be obtained in advance for each export order.

9.2.2.2 The words 'FOR EXPORT' and the average net mass of cement per bag shall be clearly marked in indelible ink on each bag.

9.2.2.3 The packing material shall be as agreed to between the supplier and the purchaser.

9.2.2.4 The tolerance requirements for the mass of cement packed in bags shall be as given in **9.2.1.1** except the average net mass which shall be equal to or more than the quantity in **9.2.2.**"

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TO
IS 455 : 1989 PORTLAND SLAG CEMENT — SPECIFICATION

(Fourth Revision)

(*Page* 4, *clause* B-1.2) — Substitute 'up to 25 tonnes' *for* 'of 20 to 25 tonnes'.

(CED 2)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 3 JUNE 1993
TO
IS 455 : 1989 PORTLAND SLAG CEMENT — SPECIFICATION

(Fourth Revision)

[*Page* 3, *clause* **9.2.1.1** (*see also Amendment No.* 1)] — Substitute the following for the existing clauses **9.2.2** to **9.2.2.4**:

"**9.2.2** When cement is intended for export and if the purchaser so requires, packing of cement may be done in bags or in drums with an average net mass of cement per bag or drum as agreed to between the purchaser and the manufacturer.

9.2.2.1 For this purpose the permission of the certifying authority shall be obtained in advance for each export order.

9.2.2.2 The words 'FOR EXPORT' and the average net mass of cement per bag/drum shall be clearly marked in indelible ink on each bag/drum.

9.2.2.3 The packing material shall be as agreed to between the manufacturer and the purchaser.

9.2.2.4 The tolerance requirements for the mass of cement packed in bags/drum shall be as given in **9.2.1.1** except the average net mass which shall be equal to or more than the quantity in **9.2.2.**"

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 4 MAY 2000
TO
IS 455 : 1989 PORTLAND SLAG CEMENT — SPECIFICATION

(Fourth Revision)

Substitute 'net mass' *for* 'average net mass' wherever it appears in the standard.

(*Page* 1, *clause* **4.1**, *last sentence*) — Substitute '70 percent' *for* '65 percent'.

(CED 2)

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