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SPECIFICATION FOR GRANULATED SLAG FOR THE MANUFACTURE OF PORTLAND SLAG CEMENT

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

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SPECIFICATION FOR GRANULATED SLAG FOR THE MANUFACTURE OF PORTLAND SLAG CEMENT

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Indian Standard

SPECIFICATION FOR GRANULATED SLAG FOR THE MANUFACTURE OF PORTLAND SLAG CEMENT

0. FOREWORD

0.1 This Indian Standard was adopted by the Bureau of Indian Standards on 27 May 1987, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Granulated slag is used for the manufacture of hydraulic cement 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. Portland slag cement may also be manufactured by separately grinding Portland cement clinker, gypsum and granulated slag and then mixing them intimately.

0.3 This standard contains clause **5.1** which calls for agreement between the purchaser and the supplier regarding the manner in which granulated slag shall be supplied and whether moisture content is to be determined.

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 or analysis, 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.

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1. SCOPE

1.1 This standard covers the requirements of granulated slag used in the manufacture of Portland slag cement conforming to IS : 455-1976†.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definition shall apply.

*Rules for rounding off numerical values (*revised*).
†Specification for Portland slag cement (*third revision*).

2.1 Granulated Slag — Slag is a non-metallic product consisting essentially of glass containing silicates and aluminates 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.

3. COMPOSITION

3.1 The physical state of aggregation of granulated slag shall be in the form of granules. The proportion of lumps exceeding 50 mm size shall not constitute more than 5 percent of the mass of slag.

3.2 When tested in accordance with the methods given in IS : 4032-1985*, the composition of granulated slag shall comply with the following chemical requirements:

Constituent	*Percent, Max*
Manganese oxide	5·5
Magnesium oxide	17·0
Sulphide sulphur	2·0

3.3 The percentages of major oxides in the granulated slag, determined in accordance with the methods given in IS : 4032-1985*, shall satisfy at least one of the following:

$$\frac{CaO+MgO+1/3\ Al_2O_3}{SiO_2+2/3\ Al_2O_3} \geqslant 1{\cdot}0$$

$$\frac{CaO+MgO+Al_2O_3}{SiO_2} \geqslant 1{\cdot}0$$

However, in case of slags containing more than 2·5 percent of manganese oxide (MnO), the slag shall also satisfy

$$\frac{CaO+CaS+1/2\ MgO+Al_2O_3}{SiO_2+MnO} \geqslant 1{\cdot}5$$

3.4 The insoluble residue of dried samples of granulated slag, determined in accordance with IS : 4032-1985* shall not be more than 5 percent.

3.4.1 The glass content of granulated slag shall not be less than 85 percent as determined by the method of optical microscope given at Appendix A.

*Method of chemical analysis of hydraulic cement (*first revision*).

4. SAMPLING

4.1 Granulated slag shall be supplied in lots of 500 tonnes each. If the quantity of slag delivered is less than 500 tonnes, it shall be considered a lot.

4.2 Samples shall be drawn from at least five points of the wagon or truck as the case may be. Each sample shall weigh about one kg.

4.3 The samples belonging to one lot collected as in **4.2**, shall be thoroughly mixed and a composite sample of 20 kg shall be collected.

4.4 The sample of 20 kg, obtained, as under **4.3**, shall be divided into two equal parts. One part shall be retained in a tightly sealed container for future reference.

4.5 From the remaining portion of the slag sample, three samples of about one kg each shall be drawn by methods of reduction and used for the determination of moisture content adopting the procedure given in Appendix B.

4.6 The remaining sample of slag, after drawing three samples as under **4.5**, shall be air dried and blended thoroughly with the dry samples obtained from **4.5** and tested for conformity with **3.1.** The coarse and fine fractions obtained in this test shall be blended again thoroughly and ground to pass 150 μm IS sieve. The material obtained as above shall be treated as the sample for all the tests under **3.2**, **3.3** and **3.4.**

NOTE — In case the moisture content of the slag is not to be determined, **4.5** may be skipped and the entire material remaining after **4.4** shall be air dried and tested for conformity with **3.1.**

5. INSPECTION

5.1 The manner in which granulated slag shall be supplied should be decided by agreement between the purchaser and the supplier. In case the moisture content is to be determined, the method given in Appendix B shall apply.

NOTE — The moisture content in granulated slag shall be as agreed to between the purchaser and the manufacturer.

5.2 The manufacturer shall guarantee the conformity of the granulated slag with the requirements of the standard and furnish each lot of supplied slag with a certificate bearing the following:

a) Name and address of the manufacturer,
b) Certificate number and date of issue, and
c) Number of wagons containing the said lot.

5.2.1 If desired by the purchaser, the test results of the consignment according to this standard shall also be supplied.

APPENDIX A

(*Clause* 3.4.1)

METHOD OF TEST FOR GLASS CONTENT OF GRANULATED SLAG

A-1. APPARATUS

A-1.1 Microscope — The microscope used for the purpose shall be polarizing microscope used generally for the examination of thin sections, and should have provision for mechanical stage and point counting. The magnifying power of the microscope shall not be less than 100×.

A-2. REAGENT

A-2.1 Bromoform — Bromoform shall be of A.R or G.R grade chemical.

NOTE — Any other liquid having refractive index between 1·5 to 1·6 may also be used as an alternative to bromoform.

A-3. PROCEDURE

A-3.1 From about 5 g of a representative sample of powdered slag, a fraction passing through 90 μm IS Sieve and retained on 52 μm IS Sieve shall be treated as the sample for microscopic investigation as under **A-3.2.**

A-3.2 About one mg of powdered slag is placed on a rectangular glass slide and a cover glass having its size less than the width of the rectangular slide is placed on the material. One or two drops of bromoform or any other suitable liquid (*see* **A-2.1**) is added at the rim of the cover glass. It is seen that the liquid enters between the cover glass and glass slide. A gentle relative motion between the slide and cover glass shall be created to disperse the material evenly in the immersion liquid. No attempt shall be made to rub one slide over the other after the bromoform has been added. The powder immersion section is examined with transmitted light under the polarizing microscope at a magnification of about 200. About 1 500 grains are counted (N_1) by changing the field of view and traverses using a mechanical stage with the help of cross-wire in the eye piece. Subsequently under crossed nicols, the same field of view already scanned is examined once again in similar fashion and grains which appear anisotropic and opaque are counted (N_2).

A-4. CALCULATION

A.4.1 Calculate the glass content of granulated slag as follows:

$$\text{Glass content, percent} = 100 \times \frac{(N_1 - N_2)}{N_1}$$

APPENDIX B

(*Clauses* 4.5 *and* 5.1)

METHOD FOR DETERMINATION OF MOISTURE CONTENT OF GRANULATED SLAG

B-1. APPARATUS

B-1.1. Drying Chamber — The air oven or other device such as an infra-red moist determinator used for the purpose shall have adequate chamber space to contain at least three samples of about one kg each of granulated slag, when the material is spread in a metallic tray, with the thickness of the material layer not exceeding 3 cm. The drying chamber shall also have provision for temperature control at 110 ± 5°C. The drying chamber shall be an electrically operated unit.

B-2. PROCEDURE

B-2.1 The mass of the three samples of moist granulated slag of about one kg are determined, nearest to one g (W_1, W_2, W_3). The samples are spread separately in metallic rays of suitable dimensions such that the thickness of the slag layer does not exceed 3 cm. The trays are kept in the drying chamber maintained at 110 ± 5°C, and retained there till the mass of sample becomes constant nearest one g, as determined by periodic weighing. The final masses of the dry samples are recorded as W_4, W_5, W_6 respectively.

B-3. CALCULATION

B-3.1 Calculate the moisture content of granulated slag as follows:

$$\text{Moisture content, percent} = \frac{100 \times (W_1 + W_2 + W_3) - (W_4 + W_5 + W_6)}{(W_1 + W_2 + W_3)}$$

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INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volts	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2