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IS 15648 (2006): Pulverized fuel ash for lime-pozzolana mixture applications - [CED 4: Building Limes and Gypsum Products]



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Indian Standard

PULVERIZED FUEL ASH FOR LIME-POZZOLANA
MIXTURE APPLICATIONS — SPECIFICATION

ICS 91.100.10

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BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Building Lime and Gypsum Products Sectional Committee had been approved by Civil Engineering Division Council.

Pulverized fuel ash is a residue resulting from the combustion of ground or powdered or crushed bituminous coal or lignite. About 80 percent of the total ash is finely divided and gets out of boiler alongwith flue gases and is collected by suitable technologies. This ash generally and in this standard is termed as fly ash. It is sometimes referred as chimney ash or hopper ash. The balance about 20 percent of ash gets collected at the bottom of the boiler and is taken out by suitable technologies and is referred as bottom ash. Fly ash is collected and stored in dry condition. When fly ash alone or alongwith bottom ash is carried to storage or deposition lagoon or pond in the form of water slurry and deposited, it is termed as pond ash. Whereas if fly ash, alone or alongwith bottom ash is carried to a storage or deposition site in dry form and deposited, it is termed as mound ash.

Pulverized fuel ash is available in large quantities in the country as a by-product from a number of thermal power stations and industrial plants using pulverized or crushed or ground coal or lignite as fuel for boilers. The effective use of pulverized fuel ash as a pozzolana in the manufacture of and for part replacement of cement, as an admixture in cement, mortar and concrete and in lime-pozzolana mixture has been further established in the country in recent years. Recent investigations of Indian pulverized fuel ashes have indicated greater scope for their utilization as a construction material. Greater utilization of pulverized fuel ash will lead to not only saving of scarce construction materials but also assist in solving the problem of disposal of this waste product. The recent investigations have also indicated the necessity to provide proper collection methods for fly ash so as to yield fly ash of good quality and uniformity which are prime requirements of fly ash for use as a construction material. This standard has been prepared to give general guidance regarding suitability of pulverized fuel ash for its use in lime-pozzolana mixture applications.

Improvements have taken place over time in combustion technologies and ash collection technologies. These technological developments have resulted in improvement in ash qualities; especially the fineness and loss of ignition and segregation of ashes of different fineness with more ease and accuracy. Technologies have also been developed for a large number of utilizations of wide range of pulverized fuel ash. Application of technologies in the collection, transportation and deposition of ash have also resulted in availability of pulverized fuel ash in four forms, namely fly ash, bottom ash, pond ash and mound ash.

In view of the above, it was decided to bring out a series of specifications for pulverized fuel ash for various applications. The specifications of pulverized fuel ash for use as pozzolana and admixture in cement, mortar and concrete and for use as fine aggregates in mortar and concrete are covered in IS 3812 (Part 1) : 2003 'Pulverized fuel ash – Specification: Part 1 For use as pozzolana in cement, cement mortar and concrete' and IS 3812 (Part 2) : 2003 'Pulverized fuel ash – Specification: Part 2 For use as admixture in cement mortar and concrete'.

Following are the highlights of this standard:

- a) Two grades of pulverized fuel ash have been specified based on fineness, particles retained on 45 micron and lime reactivity; Grade 1 for use in lime based air/water cured and steam cured (at atmospheric pressure) products, and Grade 2 for use in lime based autoclaved products.
- b) Classification of fly ash based on its lime content has also been incorporated.
- c) Requirement for total chlorides has been incorporated as the same is important from durability point of view.
- d) Requirement of reactive silica (as an optional test) has been included for improved lime reactivity.
- e) Maximum limit of loss of ignition has been specified for better performance.
- f) Requirement of particles retained on 45 micron IS sieve has been included for better grading as an optional test.
- g) Concept of improvement of properties of pulverized fuel ash through beneficiation, segregation and processing has been introduced.

(Continued on third cover)

Indian Standard

PULVERIZED FUEL ASH FOR LIME-POZZOLANA MIXTURE APPLICATIONS — SPECIFICATION

1 SCOPE

This standard covers the extraction and the physical and chemical requirements of pulverized fuel ash for use in lime based products like bricks, blocks, concrete, etc.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 4305 and the following shall apply.

3.1 Pulverized Fuel Ash — Ash generated by burning of ground or pulverized or crushed coal or lignite fired boilers. It can be fly ash, bottom ash, pond ash or mound ash.

3.2 Siliceous Pulverized Fly Ash — Pulverized fuel ash with reactive calcium oxide less than 10 percent, by mass. Such fly ash are normally produced from burning anthracite or bituminous coal and has pozzolanic properties.

3.3 Calcareous Pulverized Fuel Ash — Pulverized fuel ash with reactive calcium oxide not less than 10 percent, by mass. Such fly ash are normally produced from lignite or sub-bituminous coal and have both pozzolanic and hydraulic properties.

3.4 Reactive Calcium Oxide (CaO) — That fraction of the calcium oxide which under normal hardening condition can form calcium silicate hydrates or calcium aluminate hydrates.

NOTE — To evaluate this fraction, the total calcium oxide contents is to be reduced by the fraction calculated as calcium carbonate (CaCO_3), based on the measured carbon dioxide (CO_2) content and the fraction calculated as calcium sulphate (CaSO_4), based on the measured sulphate (SO_3), content, disregarding the SO_3 taken up by alkalis.

3.5 Fly Ash — Pulverized fuel ash extracted from flue gases by any suitable process such as by cyclone separator or electro-static precipitator.

3.6 Bottom Ash — Pulverized fuel ash collected from the bottom of boilers by any suitable process.

3.7 Pond Ash — Fly ash or bottom ash or both mixed in any proportion and conveyed in the form of water slurry and deposited in pond or lagoon.

3.8 Mound Ash — Fly ash or bottom ash or both mixed in any proportion and conveyed or carried in dry form and deposited dry.

4 DESIGNATION

Pulverized fuel ash shall be supplied in the following two grades corresponding to the properties specified in 7 and 8 :

<i>Grade</i>	<i>General Use (see Note)</i>
<i>Designation</i>	
Grade 1	: For use in lime based air/water cured and steam cured (at atmospheric pressure) products.
Grade 2	: For use in lime based autoclaved products.

NOTE — Grade 1 can be used in place of Grade 2.

5 EXTRACTION OF PULVERIZED FUEL ASH

5.1 Fly ash may be extracted from flue gases of ground or pulverized or crushed coal or lignite fired boilers by any suitable process; such as by cyclone separation or electrostatic precipitation; bottom ash from the boilers shall not be added to the fly ash. Fly ash collected at later stages of electrostatic precipitator is finer than the fly ash collected at initial stages of electrostatic precipitator.

5.2 Bottom ash may be extracted from the bottom of ground or pulverized or crushed coal or lignite fired boiler by any suitable process. It is generally in the form of clinkers, which are ground or broken to smaller size to facilitate extraction.

5.3 When fly ash and bottom ash are mixed and transported in the form of water slurry to a lagoon or pond for storage, it is called pond ash. Pond ash may be extracted from the pond or lagoon by conventional excavation techniques.

5.4 When fly ash and bottom ash are mixed and transported

in dry form to a storage or deposition site, it is called mound ash. Mound ash may be extracted from the mound by conventional excavation techniques.

6 BENEFICIATION, SEGREGATION AND PROCESSING OF PULVERIZED FUEL ASH

6.1 Pulverized fuel ash as collected, if does not conforms to requirement of this standard or if required otherwise, may be processed and/or beneficiated and/or segregated to modify its physical or chemical characteristics.

6.2 Appropriate technologies may be applied for beneficiation, segregation and processing of any form of pulverized fuel ash to improve its properties, such as lime reactivity, loss of ignition, particle size distribution and any of other physical and chemical properties. Some of the technologies that may be used are burning/removal of unburned carbon, sieving/grading of fineness, grinding/attrition for reducing particle size, thermal treatment and blending of fly ash of different qualities.

7 CHEMICAL REQUIREMENTS

7.1 Pulverized fuel ash, shall conform to the chemical requirements given in Table 1.

7.2 Limits regarding moisture content of pulverized fuel

ash shall be as agreed to between the purchaser and the supplier. All tests for the properties specified in 7.1 shall, however, be carried out on oven dry samples.

8 PHYSICAL REQUIREMENTS

Pulverized fuel ash, when tested in accordance with the methods of test specified in IS 1727, shall conform to the physical requirements given in Table 2.

9 STORAGE

Pulverized fuel ash may be stored in accordance with the recommendation given in IS 4082 for cement.

10 MANUFACTURER'S CERTIFICATE

The supplier/manufacturer shall satisfy himself that the pulverized fuel ash conforms to the requirements of this standard, and if mutually agreed upon shall furnish a certificate to this effect to the purchaser or his representative.

11 DELIVERY

11.1 Supplies of pulverized fuel ash may be made in bulk in suitable quantities mutually agreed upon between the purchaser and the supplier. Where so required by the purchaser, the pulverized fuel ash may also be supplied in yellow bags (jute, jute-laminated, multiple paper or polyethylene lined) bearing the net mass (may be 15 kg,

Table 1 Chemical Requirements
(Clause 7.1)

Sl. No.	Characteristic	Requirement for Grade 1 and Grade 2 Pulverized Fuel Ash		Method of Test, Ref to IS
		Siliceous Pulverized Fuel Ash	Calcareous Pulverized Fuel Ash	
(1)	(2)	(3)	(4)	(5)
i)	Silicon dioxide (SiO_2) plus aluminium oxide (Al_2O_3) plus iron oxide (Fe_2O_3) in percent by mass, <i>Min</i>	70	50	1727
ii)	Silicon dioxide (SiO_2) in percent by mass, <i>Min</i>	35	25	1727
iii)	Reactive silica in percent by mass ¹⁾ , <i>Min</i>	20	15	3812 (Part 1)
iv)	Magnesium oxide (MgO) in percent by mass, <i>Max</i>	5.0	5.0	1727
v)	Total sulphur as sulphur trioxide (SO_3) in percent by mass, <i>Max</i>	5.0	5.0	1727
vi)	Available alkalis as sodium oxide (Na_2O) in percent by mass, <i>Max</i>	2.5	2.5	4032
vii)	Total chlorides in percent by mass, <i>Max</i>	0.05	0.05	12423 ²⁾
viii)	Loss on ignition in percent by mass, <i>Max</i>	5.0	5.0	1727

¹⁾ Optional test.

²⁾ For the purpose of this test, wherever reference to cement has been made, it may be read as pulverized fuel ash.

Table 2 Physical Requirements
(Clauses 8 and 12.1)

Sl No.	Characteristic	Requirement	
		Grade 1 (3)	Grade 2 (4)
i)	Fineness-specific surface by Blaine's permeability method in m^2/kg , <i>Min</i>	250	200
ii)	Particles retained on 45 micron IS sieve (wet sieving) in percent ¹⁾ , <i>Max</i>	40	45
iii)	Lime reactivity – average compressive strength in N/mm^2 , <i>Min</i>	3.5	3.0

¹⁾ Optional test.

30 kg, 40 kg, 300 kg, 600 kg, 800 kg as agreed to between the purchaser and the supplier), supplier's name or registered trade-mark, if any. The tolerance on the mass of pulverized fuel ash in each bag or consignment shall be as mutually agreed upon between the purchaser and the supplier.

11.2 Tolerance Requirements for the Mass of Pulverized Fuel Ash Packed in Bags

11.2.1 The average net mass of pulverized fuel ash packed in bags at the plant in a sample shall be equal to or more than 15 kg, 30 kg, 40 kg, 300 kg, 600 kg or 800 kg as applicable. 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).

11.2.2 The number of bags in a sample 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 pulverized fuel ash in the bag.

NOTE — The matter in 11.2.1 and 11.2.2. 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.

11.2.3 In case of a wagon or truck load of 5 to 25 tonne,

the overall tolerance on net mass of pulverized fuel ash shall be 0 to + 0.5 percent.

12 MARKING

12.1 Each bag/consignment of pulverized fuel ash shall be clearly and permanently marked with the following information:

- Identification of the manufacturer of pulverized fuel ash;
- Type of pulverized fuel ash, that is, siliceous or calcareous as applicable;
- Form of pulverized fuel ash, that is fly ash and its minimum fineness as per Table 2;
- Batch/Control unit No.;
- Net mass;
- Month and year of packing; and
- Any other identification mark as required by the purchaser.

12.2 BIS Certification Marking

The pulverized fuel ash may also be marked with the Standard Mark.

12.2.1 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 details of conditions under which a licence for the use of Standard Mark may be granted to the manufacturers or the producers may be obtained from the Bureau of Indian Standards.

13 SAMPLING

13.1 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 purchase of which the pulverized fuel ash is required or by the later's representative.

13.2 In addition to the requirements of 13.1, the methods and procedure of sampling shall be in accordance with IS 6491.

13.3 Facilities for Sampling and Identifying

The supplier shall afford every facility, and shall provide all labour and materials for taking and packing the samples for testing the pulverized fuel ash and for subsequent identification of pulverized fuel ash sampled.

14 TESTS

14.1 The sample or samples of pulverized fuel ash for test shall be taken as described in 13 and shall be tested in accordance with 7 and 8.

14.2 All tests for the properties of the pulverized

fuel ash shall be carried out as it is supplied. In case the pulverized fuel ash supplied is to be beneficiated or segregated or processed, the tests shall be carried out only after beneficiation, segregation or processing as applicable.

14.3 Independent Testing

14.3.1 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/arranged by the purchaser in accordance with this standard. The supplier shall make available, free of charge, the pulverized fuel ash required for testing.

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

ANNEX A

(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	Title	IS No.	Title
1727 : 1967	Methods of test for pozzolanic material (<i>first revision</i>)		storage of construction materials and components at site (<i>second revision</i>)
3812 (Part 1) : 2003	Pulverized fuel ash — Specification: Part 1 For use as pozzolana in cement, cement mortar and concrete (<i>second revision</i>)	4305 : 1967	Glossary of terms relating to pozzolana
4032 : 1985	Method of chemical analysis of hydraulic cement (<i>first revision</i>)	4905 : 1968	Methods for random sampling
4082 : 1996	Recommendations for stacking and	6491 : 1972	Methods of sampling fly ash
		12423 : 1988	Method for colorimetric analysis of hydraulic cement

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- h) Net mass of pulverized fuel ash packing in bags has been specified; specific colours of 30 kg bags for packing has been suggested to distinguish it from cement bags.

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.

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