

Pulverized-fuel ash

Part 1. Specification for pulverized-fuel ash for use with Portland cement

ICS 91.100

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Committees responsible for this British Standard

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- British Aggregate Construction Materials Industries
- British Cement Association
- British Precast Concrete Federation
- British Ready Mixed Concrete Association
- Cementitious Slag Makers' Association
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Property Services Agency)
- Department of Transport
- Electricity Association
- Federation of Civil Engineering Contractors
- Quality Ash Association

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Foreword

This British Standard has been prepared by Subcommittee B/516/101. It supersedes BS 3892 : Part 1 : 1993 which is withdrawn. This standard takes account of the Draft for Development DD ENV 197-1 even though pulverized-fuel ash (pfa) is not included as a separate material in that standard. DD ENV 197-1 introduces the principle of conformity criteria by continuous inspection during manufacture for cements and this principle has been included in this new edition in order that users may be provided with a similar system for the purpose of demonstrating compliance. Whenever possible in this new edition, test methods from BS EN 196 have been adopted.

Pulverized-fuel ash is extracted from the flue gases of furnaces fired by pulverized bituminous or other hard coal. It is a fine material, predominantly of spherical glassy particles, the bulk of which passes a 45 μm mesh sieve. To utilize its water reducing and pozzolanic properties, the finer fraction has been developed for specific use as a cementitious component of concrete with requirements additional to those of BS EN 450. Processing to obtain this finer fraction is referred to in BS EN 450. General guidance on the use of pfa is given in annex A.

Pulverized-fuel ash has been used in composite cements conforming to BS 6588 and BS 6610 and as a cementitious component of concrete for many years. Guidance on its direct use in concrete can be found in BS 5328 : Part 1, BS 6543 and BS 8110 : Part 1. Guidance on its use in mortar can be found in BRE Digest 362[1].

Information from the producer to aid the control of such uses is given in annex B of this standard.

The principal changes from the 1993 edition are as follows.

- a) The requirements are specified as characteristic values, except for strength factor and loss on ignition, and conformity is assessed by means of a statistical procedure for continuous inspection operated by the pfa producer (autocontrol) (see annex G). This includes the concept of major defects which are likely to reduce materially the usability of the pfa for its intended purpose. In addition, limits are given for acceptance inspection testing, to provide a means of assessing conformity at delivery.
- b) The requirements for production in clause 4 allow any form of processing the run-of-station pfa that yields a material conforming to the standard.
- c) The hard coal from which the pfa is obtained may be a blend of coals of specified gross calorific value.

BS 3892 : Part 2 specifies a grade of pfa of higher sieve residue and loss on ignition to be used as a type 1 (nearly inert) addition in concrete.

BS 3892 : Part 3 specifies a grade of pfa for use in cementitious grouts.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iii, pages 1 to 19, an inside back cover and a back cover.

Specification

1 Scope

This Part of BS 3892 specifies requirements for the composition, production and chemical and physical properties of processed pulverized-fuel ash (pfa) for use as a cementitious component in combination with Portland cement.

NOTE. Requirements are specified as characteristic values except for strength factor and loss on ignition for which an absolute upper limit is given.

2 References

2.1 Normative references

This Part of BS 3892 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate points in the text and the cited publications are listed on page 16. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Part of BS 3892 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This Part of BS 3892 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 3892, the definitions given in BS 6100 : Section 6.1 apply, together with the following.

3.1 characteristic value

That value of a property corresponding to an acceptable percentage of defects, generally 10 %.

3.2 lot

Quantity of pfa produced under conditions presumed uniform. After specified tests, this quantity is regarded as a whole, conforming or not conforming to the requirements.

3.3 spot sample

Sample taken at the same time and from one and the same place relating to the intended tests. It can be obtained by combining one or more immediately consecutive increments.

3.4 hard coal

Coal blend giving a gross calorific value of not less than 24 MJ/kg on a dry ash-free basis when tested in accordance with BS 1016 : Part 105.

4 Composition, production and processing

Pfa is a fine powder of mainly spherical glass particles having pozzolanic properties which shall consist essentially of reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3), the remainder being iron (III) oxide (Fe_2O_3) and other oxides.

Pfa shall be obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases of power station furnaces fired with pulverized bituminous or other hard coal. Ash from other coals or obtained by other means is not considered in this standard.

Pfa conforming to this specification shall be produced by processing the run-of-station pfa in such a way that it meets the requirements specified in clauses 5 to 12 and does not contribute materials that have a deleterious effect on the properties of fresh or hardened concrete or give rise to a health or safety risk.

5 Moisture content

The moisture content of the pfa shall be not more than 0.5 % when determined in accordance with the method described in annex C.

6 Fineness

The fineness of the pfa expressed as the proportion by mass retained on a 45 μm test sieve shall be not more than 12.0 % when determined in accordance with the method described in annex D.

7 Particle density

The particle density of the pfa shall be not less than 2000 kg/m^3 when determined in accordance with 4.5.3 of BS EN 196-6 : 1992.

8 Water requirement

The water requirement of a combination by mass of 30 % pfa and 70 % Portland cement, conforming to BS 12 : 1996 standard strength class 42.5, intimately mixed together shall be not greater than 95 % of that for the Portland cement alone when determined in accordance with the method described in annex E.

The alkali content of the Portland cement shall be not less than 0.5 % and not more than 0.9 % when determined in accordance with clause 7 of BS EN 196-21 : 1992.

9 Strength factor

The strength factor of the combination of pfa and Portland cement given in clause 8 shall have a minimum limit value of 0.80 when determined in accordance with the method described in annex F.

10 Initial setting time

The initial setting time, when determined in accordance with BS EN 196-3, of a paste of standard consistence made from the combination of pfa and Portland cement given in clause 8 shall be not less than the initial setting time of the Portland cement when tested alone.

11 Soundness

The soundness of a paste made from the combination of pfa and Portland cement given in clause 8 shall have an expansion of not more than 10 mm when determined in accordance with BS EN 196-3.

12 Chemical composition

12.1 Sulfuric anhydride

The content of sulfuric anhydride, SO_3 , shall be not more than 2.0 % (m/m) when determined in accordance with clause 8 of BS EN 196-2 : 1995.

12.2 Loss on ignition

The loss on ignition shall have a maximum limit value of 7 % (m/m) when determined in accordance with clause 7 of BS EN 196-2 : 1995 but using an ignition time of 1 h.

12.3 Chloride

The chloride ion content shall be not more than 0.10 % (m/m) when determined in accordance with clause 4 of BS EN 196-21 : 1992.

12.4 Calcium oxide

The calcium oxide content shall be not more than 10.0 % (m/m) when determined in accordance with clause 13 of BS EN 196-2 : 1995.

13 Marking

Pulverized-fuel ash shall be marked on the bag or the delivery note and on any certificate with the following particulars:

- a) the name, trademark or other means of identification of the producer and the works at which the pfa was produced;
- b) the name of the material, i.e. pulverized-fuel ash;
- c) the number and date of this British Standard, i.e. BS 3892 : Part 1 : 1997¹⁾.

14 Information to be provided

14.1 Test certificate

If a test certificate is requested, it shall include results of the following tests on samples of the pfa relating to the material delivered:

- a) moisture content;
- b) fineness (45 μm sieve residue);
- c) particle density;
- d) water requirement;
- e) strength factor;
- f) initial setting time;
- g) soundness;
- h) the source of the Portland cement used in the tests d) to g) and its initial setting time and soundness when determined in accordance with BS EN 196-3 and compressive strength at 28 days when determined in accordance with BS EN 196-1 in the laboratory which is testing the pfa;
- i) sulfuric anhydride content;
- j) loss on ignition;
- k) chloride content;
- l) calcium oxide content.

NOTE. The certificate should be available from the producer.

¹⁾ Marking BS 3892 : Part 1 : 1997 on or in relation to a product represents a producer's declaration of conformity, i.e. a claim by or on behalf of the producer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

14.2 Additional information

The following information shall also be made available, if requested at the time of ordering, relating to the pfa delivered:

- a) an indication of the variability of the chloride content when its mean level exceeds 0.05 % by mass;
- b) total acid soluble alkali content determined in accordance with **7.5.2** of BS EN 196-21 : 1992 or by an X-ray fluorescence technique calibrated against the method described in **NA.5.2** of BS EN 196-21 : 1992.
- c) water soluble alkali content;
- d) an indication of the variability of the alkali content.

15 Sampling and testing for acceptance inspection at delivery

15.1 When required by the purchaser for assessing conformity at delivery, a spot sample of the pfa shall be taken in accordance with **3.6** and **6.2**, **6.3**, **6.4** or **6.5** of BS EN 196-7 : 1992 either before, or at the time of delivery. A laboratory sample shall be prepared and packed in accordance with clauses **8** and **9** of BS EN 196-7 : 1992. A sampling report shall be completed at the time of sampling and shall be attached to the laboratory sample in accordance with clause **10** of BS EN 196-7 : 1992.

NOTE. Testing may be delayed for up to 5 weeks from the time of sampling, provided there is confirmation that the sample has been stored continuously as described in **9.2** of BS EN 196-7 : 1992.

15.2 When the pfa is tested for water requirement, strength factor, initial setting time and soundness, the source of the Portland cement and, where appropriate, of the CEN Standard sand, EN 196-1 and the compaction procedure used shall be those in use by the producer at the time when the combination was originally tested. Alternatively, they may be agreed between the purchaser and the producer.

15.3 When the pfa is tested for chemical composition (see clause **12**), the sample shall be prepared by the method described in clause **6** of BS EN 196-2 : 1995 except that it is not required to pass a magnet over the pfa to remove metallic iron, and that the pfa to be tested shall be dried in accordance with annex C.

15.4 The limiting values applicable to acceptance inspection shall be the same as the major defect levels, as defined in table G.3.