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(Page 1 of 6)
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SPECIFICATION FOR BLAST FURNACE SLAG CEMENT FOR IN SITU LINING OF WATER MAINS

FOREWORD

This specification is one of a number of specifications which have been prepared by WRc plc under the direction of the Sewers and Water Mains Committee in consultation with the Water Industry and Manufacturing Associations in order to assist engineers responsible for repair and maintenance of water mains.

Compliance with this specification does not itself confer immunity from legal obligations.

This specification does not purport to include all the necessary provisions of a contract. Users of this specification are responsible for its correct application. Reference to a British Standard, Water Industry Specification or any other specification applies equally to any equivalent specification.

Purchasers are reminded that this specification requires that the manufacturer shall operate a quality system relating to the manufacture of materials to this specification in compliance with BS 5750: Part 2 (EN 29002) which should ensure that products claimed to comply with this specification consistently meet the required level of quality. Enquiries regarding the availability of third party certification should be addressed to an appropriate NACCB (National Accreditation Council for Certification Bodies) or equivalent accredited third party certification body or to WRc plc.

This specification calls for the use of substances and/or procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

It has been assumed in the drafting of this specification that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose guidance it has been prepared.

Information contained in this specification is given in good faith but neither the Water Services Association, Foundation for Water Research nor WRc plc can accept any responsibility for actions taken as a result.

Throughout this specification SI Units are used.

CONTENTS

1. SCOPE

2. DEFINITIONS

3. QUALITY ASSURANCE

4. EFFECT ON WATER QUALITY

5 MATERIALS
5.1 Cement

6. PREPARATION OF CEMENT
6.1 Batching
6.2 Mixing
6.3 Storage

7. TYPE TESTS
7.1 General
7.2 Composition tests

8. QUALITY CONTROL TESTS
8.1 Composition tests
8.2 Weight checks
8.3 Mortar strength tests
8.4 Setting time

Technical enquiries to:
WRc, Frankland Road, Blagrove, Swindon, Wilts, SN5 8YF Tel: (01793) 865151 E-mail: wisign@wrcplc.co.uk

9. INSPECTION AND CERTIFICATION
9.1 Inspection
9.2 Certification

10. PACKAGING AND MARKING

11. REFERENCES

APPENDIX A.
TYPICAL CERTIFICATE

1. SCOPE

This specification defines the requirements for manufacture of materials, quality assurance application, testing, packaging, marking, workmanship and storage of blast furnace slag cement intended for the renovation of water mains, where the lime rich cement lining acts as a corrosion inhibitor for the iron water mains.

2. DEFINITIONS

Blast furnace slag cement (BFS):

> A type of blended cement mortar containing 65% ground granulated blast furnace slag (GGBFS), intended for renovation of water mains, particularly where the water is moderately alkaline.

Ordinary Portland cement (OPC):

> A type of cement which is generally a major component of the blended cements.

3. QUALITY ASSURANCE

Manufacturers shall operate a quality system relating to this specification in compliance with BS 5750: Part 2 (EN 29002).

4. EFFECT ON WATER QUALITY

For use in public water supply in the UK 4.1 and 4.2 shall be complied with.

4.1 Basic requirement

When used under the conditions for which they are designated, non-metallic products in contact with or likely to come into contact with potable water shall comply with the requirements of BS 6920: Part 1: 1990.

NOTE Materials for use in contact with potable water which are verified and listed under the UK Water Fittings Advisory Scheme are deemed to satisfy the requirements of this clause. Details of the Scheme are obtainable from the Water Research Centre Advisory Scheme, Fern Close, Pen-Y-Fan Industrial Estate, Oakdale, Gwent, UK. NP11 3EH.

4.2 DoE.CCM requirements

Non-metallic products approved by the Department of the Environment Committee on Chemicals and Materials of Construction for use in Public Water Supply and Swimming Pools are considered free from adverse health effects for the purposes of compliance with this clause.

NOTE A list of approved chemicals and materials and details of the approvals scheme is available from the Secretary of the Committee at the Department of the Environment, Water Division, Romney House, 43 Marsham Street, London SW1P 3PY.

5. MATERIALS

5.1 Cement

The BFS cement shall be a preblended and prebagged intimate mixture of 65% by weight of ground, granulated blast furnace slag (GGBFS), and 35% by weight of ordinary Portland cement (OPC) and shall comply with all the requirements of BS 146 (Portland blast furnace Cement), excluding strength (Clause 6). The two components shall not be ground simultaneously, but shall be separately ground and subsequently, intimately mixed.

The GGBFS shall comply with BS 6699.

The OPC shall comply with BS 12.

Each consignment of cement shall be identified, stored in dry conditions, protected against deterioration, and used in order of manufacture.

ISSN 0267-0305

6. PREPARATION OF CEMENT

6.1 Batching

Weight batching shall be employed. The use of pre-bagged material will be acceptable provided the individual constituents and the final mix meet the requirements of this specification.

6.2 Mixing

Prior to blending a batch of material for dispatch, the blender shall be thoroughly cleaned and purged with neat GGBFS, except in the case of small batches (<2 tonne) where 65% GGBFS, 35% OPC, as defined in section 8.1, shall be used. This material shall be discarded and shall not be permitted to be re-used or sold as water mains lining material.

The two dry components, GGBFS and OPC are to be passed through a sieve with a mesh size no greater than 3mm and measured into the blender by weight in the proportions of 65% GGBFS to 35% OPC.

All constituents shall be uniformly dispersed throughout the mix and random text samples shall lie within the test specification.

It is convenient for site use that the BFS cement is supplied as a factory manufactured mixture with sand, thus avoiding the problems of mixing sand and cement on site.

When BFS cement is supplied as a factory mixture with sand, the cementitious component must conform to the requirements of this specification and the sand must conform to the requirements of the current In Situ Cement Mortar Lining - Operational Guidelines and Code of Practice. The cement:sand ratio should be 1:1 by weight.

Storage, packaging and marking of this cement:sand mix must be in accordance with the requirements of this specification.

6.3 Storage

Whilst under the control of the manufacturer the material should be stored in a dry location and protected from the weather, preferably in a closed container. To prevent the possibility of compaction of the lower layers the pallets shall not be stacked.

The bagged BFS cement shall be delivered on pallets which have a shrink wrap polyethylene covering and containing not more than 1.0 tonne of material per pallet. The covering is essential for product care to prevent ingress of water.

The stock shall be rotated and discarded if bagged more than six weeks previously.

NOTE The purchaser should also follow the above storage procedure on receipt of the goods.

7. TYPE TESTS

7.1 GENERAL

The requirements given in this section shall be met before compliance to this specification can be claimed. Whenever a significant change in process technique or introduction of a new or significantly modified material has occurred, it may be necessary to repeat some or all of these tests. Also, the Quality Assurance Plan of the quality system may require type tests to be repeated at specified intervals; this applies equally to quality control tests (clause 8).

Test samples shall be prepared from materials representative of those used in normal production and using the normal production method as far as possible.

7.2 Composition test

The raw materials purchased by the blender for incorporation into the BFS cement shall be sampled according to BS 4550: Part 1 for subsequent chemical analysis. The major constituents of the raw materials shall be determined using either the methods detailed in BS 4550: Part 2, or X-Ray Fluorescence (XRF) analytical techniques to the equipment manufacturer's recommended procedures.

8. QUALITY CONTROL TESTS

8.1 Composition tests

For the purposes of quality control, it is acceptable to use the following test to determine the concentration of a major component of the raw materials, for example, calcium, and then to compare this with the concentration of this component in the blend. The

concentration shall be consistent with a blend falling within the limits of 62% BFS, 38% OPC and 68% BFS, 32% OPC in the blended materials.

Random samples shall be taken from each batch of the blended material by the procedures detailed in BS 4550: Part 1, namely one sample per load irrespective of load size. The composition of the blended material shall be determined by the same method as utilised for the characterisation of the raw materials. If any sample fails to comply the batch from which it was taken shall be rejected.

The results obtained shall be compared to the expected composition determined by calculation from the analysis of the raw materials. The measured chemical composition of the blended material shall be within the range of compositions calculated from the raw material analyses representing the limits of 62% GGBFS, 38% OPC and 68% GGBFS, 32% OPC in the blended materials.

i.e. limits for X_{BLEND}

$$\left(\frac{62}{100}\times X_{GGBFS}\right)+\left(\frac{38}{100}\times X_{OPC}\right) \text{ and } \left(\frac{68}{100}\times X_{GGBFS}\right)+\left(\frac{32}{100}\times X_{OPC}\right)$$

where:

X_{OPC} = measured percentage of given component in OPC raw material

X_{GGBFS} = measured percentage of given component in GGBFS raw material

X_{BLEND} = measured percentage of given component is blended material

In addition, tests are required to ensure that the correct materials have been blended, and that the physical characteristics of mortars made with the BFS cement are acceptable.

To ensure GGBFS has been used in the mix, add an excess of dilute hydrochloric acid to a sample of the blended cement. The gas produced shall be tested for the presence of hydrogen sulphide (H_2S) by using lead acetate Drager tubes or dampened lead acetate paper. If the tubes or the paper change colour to black, H_2S is present, indicating the presence of GGBFS in the blended cement.

WARNING: In view of the generation of H_2S, the appropriate health and safety precautions should be observed.

8.2 Weight checks

Records shall be maintained of the weights of each component used for each batch of material blended, and the final total bagged weight recorded to enable an approximate check on the composition.

8.3 Mortar strength tests

Mortar cubes with a composition of 1:1, sand:cement and a 0.38:1 water : cementitious component ratio will be made, and tested according to the procedures detailed in BS 4550: Section 3.4. The sand grading shall be within the ranges specified in Table 1 when tested according to BS 812: Part 1.

Three day strength should be $\geq$16 MPa and the seven day strength $\geq$41MPa.

Table 1 - Specified sand grading

BS410 test sieve	Percentage by weight passing
mm	
1.0	100
mm	
710	100
500	95-100
355	90-100
250	65-100
180	30-85
125	5-60
90	0-30

8.4 Setting time

This test may be requested in cases of dispute. The initial and final setting times for the blended material shall be determined using the procedure detailed in BS 4550: Section 3.6. The initial setting time shall be a minimum of 3 hours, and the final setting time shall be a maximum of 10 hours at a standard temperature of 20℃, when using a water:solid ratio of 0.19:1.

9. INSPECTION AND CERTIFICATION

9.1 Inspection

In addition to the manufacturer's own inspection and supervision, the purchaser or his appointed inspecting authority shall have access at all reasonable times to those areas used for manufacture and testing and to all relevant test records.

ISSN 0267-0305

9.2 Certification

The manufacturer shall, upon request, furnish the purchaser or purchaser's representative with copies of a signed certificate stating that the testing of the material supplied complies with the requirements of this specification. If required by the purchaser, the quality control test results or a suitable summary shall be provided with the certificate. A typical certificate is shown in Appendix A.

10. PACKAGING AND MARKING

When intimately mixed the materials shall be packed in bags with a minimum of three layers of paper, one of which shall be polyethylene coated. The preferred weight shall be 25kg ± 1.25kg. Other weights shall be supplied, to ± 5% where requested by the purchaser. The bags should be readily differentiated from OPC bags by a difference in colour.

Materials manufactured to this specification shall be in clearly and legibly marked bags. The marking shall give the following information:

(a) Manufacturer's identification.

(b) The number of this Water Industry Specification, i.e. WIS No. 4-13-01.

(The use of this mark is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of this specification and the claim is his sole responsibility).

(c) Batch identification code and date the material was bagged.

(d) Nominal weight of the contents of the bag.

(e) Trade name of the material or the composition.

(f) A third party certification mark (if permissible).

11. REFERENCES

This specification refers to the latest editions of the following publications (except where otherwise indicated), including all addenda and revisions.

British Standards

BS 12 Specification for Portland cements

BS410 Specification for test sieves

BS 812 Methods for sampling and testing of mineral aggregates, sands and fillers
Part 1 : Sampling, size, shape and classification

BS 146 Specification for Portland blast furnace cement
Part 2 : metric units

BS 4550 Methods of testing cement
Part 1 : Sampling
Part 2 : Chemical tests
Part 3 : Section 3.4 Strength test
Part 3 : Section 3.6 Test for setting times

BS 5750 Quality systems.
Part 2 Specification for production and installation.

BS 6699 Specification for ground granulated blast furnace slag for use with Portland cement.

BS 6920 Suitability of non-metallic products for use in contact with potable water intended for human consumption with regard to their effect on the quality of water.
Part 1 : Specification

European Standard

EN 29002 Quality Systems - Model for quality assurance in production and installation

Codes of Practice

In Situ Cement Mortar Lining - Operational Guidelines and Code of Practice.

APPENDIX A - TYPICAL CERTIFICATE

We ……..

hereby certify that the blast furnace slag cement supplied to ……

……..

at ……..

between the …….. and ……

has been manufactured and tested in accordance with the requirements of WIS No. 4-13-01: Issue 1. Specification for blast furnace slag cement for in situ lining of water mains, published by FWR/WRc.

Our company has/does not have* third party certification in respect of this specification.

*Delete as applicable.

Signed: ……..

On behalf of: ……

On: ……..