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Part 4 : 1990

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Concrete

Part 4. Specification for the procedures to be used in sampling, testing and assessing compliance of concrete

ICS 91.100.30

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee (CAB/-) to Technical Committee CAB/4, upon which the following bodies were represented:

Association of Lightweight Aggregate Manufacturers
Association of Metropolitan Authorities
Association of Quality Pulverised Fuel Ash Suppliers
British Aggregate Construction Materials Industries
British Cement Association
British Civil Engineering Test Equipment Manufacturers' Association
British Precast Concrete Federation
British Ready Mixed Concrete Association
Building Employers' Confederation
Cement Admixtures Association
Cementitious Slag Makers Association
Concrete Society
County Surveyors' Society
Department of the Environment (Building Research Establishment)
Department of the Environment (Property Services Agency)
Department of Transport
Department of Transport (Transport and Road Research Laboratory)
Electricity Association
Federation of Civil Engineering Contractors
Institute of Concrete Technology
Institution of Civil Engineers
Institution of Highways and Transportation
Institution of Structural Engineers
Institution of Water and Environmental Management
Royal Institution of Chartered Surveyors
Sand and Gravel Association
Society of Chemical Industry

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Contents

Foreword

This Part of BS 5328 has been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee. This Part, together with BS 5328 : Parts 1, 2 and 3, is a revision of BS 5328 : 1981, which is withdrawn, and forms a comprehensive standard for the specification of concrete to which codes of practice and contractual documents can refer. It includes recommendations originating from, and complementing clauses in, BS 8110 : Part 1.

As this standard involves selection by the specifier from a number of options and, in certain instances, agreement on requirements between the purchaser and producer, any requirement for compliance with BS 5328 or any claim of compliance with it has to be qualified by reference to the selection and to any such agreements.

This standard covers the methods for specifying and producing concrete as a construction material up to the point of delivery into the construction. The standard is now in four Parts:

Part 1.	Guide to specifying concrete
Part 2.	Methods for specifying concrete mixes
Part 3.	Specification for the procedures to be used in producing and transporting concrete
Part 4.	Specification for the procedures to be used in sampling, testing and assessing compliance of concrete

Part 1 provides guidance to the specifier and purchaser of concrete on the selection of requirements for materials and concrete mixes. Part 2 provides a choice of methods by which the purchaser can convey the selected requirements to the producer. Part 3 specifies for the producer the procedures to be used in producing and transporting the concrete. Part 4 specifies the procedures to be used by the purchaser in sampling, testing and assessing concrete for compliance.

This standard provides methods for specifying concrete mixed on site or in a precast concrete factory and for the purchase and supply of ready-mixed concrete. It takes account of the distinct and different responsibilities of the purchaser and the producer. There are a number of instances in which the purchaser has to select from the various options given in this standard in order to specify the concrete required. The purchaser is responsible for passing on to the producer the requirements of the specifying body, e.g. the engineer's or architect's specification, together with any additional requirements. Throughout this standard the terms 'specify' and 'specification' are used in relation to both sets of requirements. There may be occasions where it is advantageous for economic or technical reasons to propose changes to the specification. In such cases the producer and purchaser should agree the proposed amendments for approval and sanction by the specifying body.

Precautions need to be taken when working with cement and wet concrete and attention is drawn to these in BS 5328 : Parts 3 and 4.

This standard covers concrete produced by normal methods, but it does not apply to precast concrete products where British Standard specifications contain the specification of the concrete. Many of the requirements of the standard, e.g. the use of materials and the control of production, apply equally to precast concrete and to in situ concrete. However, some of its requirements concerning the responsibilities of the purchaser and producer may not apply in the case of precast concrete. The specification of designated mixes is unlikely to be appropriate for factory produced precast concrete products.

Amendment number 4 takes account of the recent consensus reached by experts on provisions to resist damaging ASR in the UK. These recommendations are published in BRE Digest 330: 1999. The technical content of this amendment has been derived from these recommendations.

It is necessary for the purchaser to take into account the requirements of specialized codes of practice and any influences of the construction process. Provisions are made in this standard for the inclusion of any special requirements.

A British standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

This corrigendum is issued to correct the error on pages 5, 7 and 8 in AMD 10367, issued in May 1999, as follows:

on page 5, in **3.7.1** c), the date should have been 1997 not 1990;

on page 7, in **3.13.1** c) and **3.14.1**, the date should have been 1997 not 1990;

on page 8, in the Note to **3.16.2** b), the second sentence should have read "Advice on the action to be taken in the event of such non-compliance is given in clause **10** of BS 5328 : Part 1 : 1997".

Summary of pages

This document comprises a front cover, an inside front cover, pages 1 to 8, an inside back cover and a back cover.

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Specification

0 Introduction

This Part of BS 5328 describes methods of sampling and testing of concrete, which have been specified in accordance with BS 5328 : Part 2, and defines, for both purchaser and producer, the compliance limits for the various tests that may be specified.

As an alternative to assessing compliance with cement content or water/cement ratio requirements by analysis, or observation of the batching, 'equivalent strength' grades are now given for which the strength compliance is deemed to satisfy a given minimum cement content and/or maximum free water/cement ratio.

Modifications have been made to the strength compliance requirements. The validity of the testing is now checked by applying a limit to the range of the two strength determinations, the mean of which constitutes the test result. For compressive strengths, requirements are given for the first two results and the first three results.

The use of superplasticizers to produce flowing concrete is accommodated by the inclusion of flow table compliance values. Sampling and testing of concrete for compliance should be specified to be carried out by organizations accredited by the National Measurement Accreditation Service (NAMAS) for the relevant test.

1 Scope

This Part of BS 5328 specifies the procedures to be followed when assessing the quality of concrete for compliance with a specification prepared in accordance with BS 5328 : Part 2.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 5328 the definitions given in BS 5328 : Part 1 and BS 6100 apply.

3 Sampling and testing

3.1 General

All sampling and testing of the constituent materials shall be carried out in accordance with the appropriate British Standard.

All sampling, curing and testing of the concrete, fresh or hardened, shall be carried out in accordance with the relevant Parts of BS 1881 unless stated otherwise in this Part of BS 5328.

Caution. When cement is mixed with water, alkali is released. Take precautions to avoid dry cement entering the eyes, mouth and nose when mixing cement or concrete by wearing suitable protective clothing. If cement or concrete enters the eye, immediately wash it out thoroughly with clean water and seek medical treatment without delay. Wash wet concrete off the skin immediately.

When sampling and testing for compliance are required to be quality assured, evidence of certification and any change in certification shall be provided on request.

The producer shall be afforded all reasonable opportunity and facility to inspect the sampling and testing regime employed by the purchaser.

3.2 Point and time of sampling

For the assessment of compliance of ready-mixed concrete, the point and time of sampling shall be at discharge from the producer's delivery vehicle or from the mixer when delivered into the purchaser's vehicle.

For the assessment of compliance of concrete supplied to the construction, the point and time of sampling shall be at delivery into the construction, unless agreed otherwise.

NOTE. Samples taken for assessing ready-mixed concrete may be used also for assessing compliance of concrete as supplied to the construction when either:

(a) concrete is discharged from the producer's vehicle directly into the construction; or

(b) effects due to time delays, ambient conditions, transport and handling between discharge from the producer's vehicle and delivery into the construction are agreed to be minimal; or

(c) adjustments to specified values have been agreed to take account of significant effects as under item (b). Such adjustments may be nominal or based on trials.

Similarly, samples taken at the point of production of concrete, whether ready-mixed, site mixed or factory precast, may be used to assess concrete supplied to the construction.

When concrete is sampled for compliance tests at the point of delivery into the construction, the purchaser shall ensure that the sampling is spread representatively within a single identified batch as produced, in accordance with BS 1881 : Part 101.

3.3 Compliance with concrete properties and mix proportions

When properties other than those mentioned in BS 5328 : Part 2 are specified (for example thermal conductivity or modulus of elasticity of concrete), the method of test, the compliance requirements and tolerances shall be specified or agreed in advance between the purchaser and producer.

3.4 Temperature of fresh concrete

When required, the temperature of the fresh concrete shall be measured in one of the following ways.

a) Within 2 min of taking the sample at delivery insert a type A 100 mm immersion thermometer having a range of −5 °C to +110 °C, graduated at each 1 °C and complying with BS 1704, in the sample to a depth of at least 100 mm. When steady conditions have been maintained for 1 min record the temperature to the nearest 1 °C.

b) Use an alternative form of temperature measurement which provides the same accuracy as given in item (a).

The measured concrete temperature shall not exceed any specified maximum value or fall below any specified minimum value.

3.5 Workability

The workability shall be within the following limits on the specified value as appropriate.

Slump		
(i) When sampled in accordance with BS 1881 : Part 101	±25 mm or ±⅓ of the specified value, whichever is the greater.	
(ii) When sampled in accordance with BS 1881 : Part 102	Specified value	Tolerance
	10 mm	+35 mm −10 mm
	25 mm	+35 mm −25 mm
	50 mm	±35
	75 mm and over	± [(⅓ specified slump) + 10 mm]

Limits for intermediate slumps shall be derived by interpolation.

Vebe time	±3 s or $\pm \frac{1}{5}$ of the specified value, whichever is the greater
Compacting factor	±0.03, where specified value is 0.90 or greater. ±0.04, where specified value is less than 0.90 but more than 0.80. ±0.05, where specified value is 0.80 or less.
Flow	Specified value ± 50 mm

3.6 Air content of fresh concrete

The total air content determined from individual samples of concrete taken at the point of delivery into the construction and representative of any given batch of concrete shall be the specified total value ±2.0 %. The mean total air content from any four consecutive determinations from separate batches shall be the specified value ±1.5 %.

NOTE 1. Total air content comprises entrained air plus entrapped air remaining after compaction.

NOTE 2. In certain forms of construction, e.g. airfield pavements, tolerances on the air content may need to be agreed between the purchaser and the producer.

NOTE 3. The method of measuring air content described in BS 1881 : Part 106 is not necessarily applicable to concrete made with lightweight aggregates, air-cooled blastfurnace slag, aggregates of high porosity, very stiff concrete which cannot be compacted by vibration alone or aerated concrete. Specialist advice should be sought from materials suppliers or other sources on the method of test when these are required.

3.7 Chloride content of fresh concrete

3.7.1 *Methods of calculation and test*

Unless otherwise specified and agreed between purchaser and producer, the method of calculation and test shall be based upon the chloride contents of the constituents and the composition of the concrete. The chloride content of each constituent used in the calculation shall be one of the following:

a) the measured value;

b) the value declared by the manufacturer;

c) the maximum value where specified in the British Standard for the constituent as appropriate (see **5.2.2** of BS 5328 : Part 1 : 1997).

The method of measuring chloride content under item (a) or (b) shall be as follows:

cement, ground granulated blastfurnace slag (ggbs) and pulverized-fuel ash (pfa)	BS 4550 : Part 2
aggregate	BS 812 : Part 117
admixture	BS 5075 : Part 1
water	**9.2** of BS 812 : Part 117 : 1988

The composition of the fresh concrete used in the calculation shall be either that declared as required under **3.1** of BS 5328 : Part 3 : 1990 or that obtained from observation of the batching or from examination of autographic records of the batching plant.

3.7.2 *Compliance*

When assessment of compliance is based on specified or declared values for chloride content of constituents and the declared or observed composition of the concrete, the calculated chloride content of the concrete expressed as the percentage of chloride ion by mass of cement shall not exceed the specified maximum value.

When assessment is based on measured values of chloride content of the fresh concrete or on analysis of fresh concrete for determination of composition, compliance rules shall be specified or agreed in advance by the purchaser and producer.

3.8 Requirements for the control of alkali content

3.8.1 *General*

Alkalis shall be expressed as the sodium oxide equivalent, Na_2O eq, using the equation:

$$Na_2O \text{ eq} = (Na_2O) + 0.658\ (K_2O)$$

The alkali content of a Portland cement or the Portland cement type component of other cements and combinations shall be expressed as either the guaranteed alkali limit or the declared mean alkali content as appropriate.

NOTE. Provided the guaranteed alkali limit of any ggbs and pfa does not exceed the relevant value given in **1.4** of BS 5328 : Part 2 : 1997 and the proportion of ggbs or pfa is $\geq$ 40 % or $\geq$ 25 % by mass of cement respectively, their alkali content is not taken into account when the alkali content of the cement or combination is determined.

The alkali content of other constitutents e.g., admixtures etc., may be either the measured value, the specified maximum value given in the product standard or the guaranteed alkali limit.

3.8.2 ***Test methods for alkali contents***

Except for low alkali sulfate-resisting Portland cement conforming to BS 4027, the alkali content of a Portland cement or the Portland cement type component of other cements and combinations shall be determined by the method given in national annex **N.A.5.1** to BS EN 196 : Part 21 : 1992, or a secondary X-ray fluorescence method calibrated against the method.

The alkali content of a low alkali sulfate-resisting Portland cement conforming to BS 4027 shall be determined by the method given in BS EN 196 : Part 21, or a secondary X-ray fluorescence method calibrated against the method.

The alkali content of ggbs conforming to BS 6699 shall be determined by the method given in national annex **N.A.5.1** to BS EN 196 : Part 21 : 1992, or a secondary X-ray fluorescence method calibrated against the method.

The alkali content of pfa conforming to BS 3892 : Part 1 shall be determined by either of the methods given in **14.2** b) of BS 3892 : Part 1 : 1997.

The alkali content of the aggregates shall be determined from the chloride ion content. The chloride content of the aggregates measured by the method given in BS 812 : Part 117 shall be converted to a sodium oxide equivalent by multiplying the percentage of chloride ion by 0.76.

The chloride ion content of aggregates containing 0.01 % chloride ion by mass or more shall be determined at least once per production week in accordance with BS 812: Part 117. When the chloride ion content is less than 0.01 % it shall be regarded as nil, and routine testing is not required for the purposes of this conformity procedure.

The alkali content of admixtures shall be determined by the method given in BS EN 480-12.

The alkali content of non-potable water shall be determined by the methods given in BS 6068 : Part 2 : Section 2.42 for sodium and BS 6068 : Part 2 : Section 2.43 for potassium or by the method given in BS 6068 : Part 2 : Section 2.44 for both sodium and potassium.

3.8.3 ***Procedure***

Calculate the sum of the alkali contribution to the concrete from constituents other than the cement or combination (from their declared mix proportions and their determined alkali content) to establish if:

a) a limiting value for cement or combination content from either table 0A or table 0B of BS 5328 : Part 2 : 1997 applies, or;

b) an interpolated limiting value, between the values of table 0A and 0B applies.

3.9 Conformity to the requirement to minimize the risk of damaging alkali-silica reaction

3.9.1 ***Conformity by control of materials or alkali content***

Conformity is obtained where the conditions for no action are satisfied in accordance with any one of the following clauses in BS 5328 : Part 2 : 1997:

1.4.2

1.4.3

1.4.4

1.4.6

NOTE. In some of the clauses, conformity is based on the declared mean alkali content. Alkali contents of individual samples can be higher or lower than the declared mean value due to, for example, manufacturing and test variations. This has been taken into account when setting the limiting criteria.

3.9.2 Conformity by other methods

a) Any concrete that conforms to the guidance in BRE Digest 330 : 1997 or Concrete Society Report 30 : 1998 shall be deemed to conform to BS 5328.

b) Conformity to limits obtained from a well established service record for the particular cement and aggregate combination showing no history of cracking due to alkali-silica reaction.

3.10 Density of fresh concrete

Where minimum density of fresh concrete is specified, the mean of any four consecutive determinations in accordance with BS 1881 : Part 107 shall be not less than the specified value and any individual result shall be not less than 97.5 % of the specified value.

Where maximum density of fresh concrete is specified, the mean of any four consecutive determinations in accordance with BS 1881 : Part 107 shall be not more than the specified value and any individual result shall be not more than 102.5 % of the specified value.

3.11 Density of hardened concrete

Where minimum density of hardened concrete is specified, the mean of any four consecutive determinations in accordance with BS 1881 : Part 114 shall be not less than the specified value and any individual result shall be not less than 95 % of the specified value.

Where maximum density of hardened concrete is specified, the mean of any four consecutive determinations in accordance with BS 1881 : Part 114 shall be not more than the specified value and any individual result shall be not more than 105 % of the specified value.

3.12 Cement content or mix proportions by the analysis of fresh concrete

Where fresh concrete is to be analysed to determine the mix proportions, cement content or free water/cement ratio, the sampling and testing shall be carried out by a method specified in DD 83 or as otherwise agreed.

3.13 Minimum or maximum cement content

3.13.1 Where an equivalent grade (see **8.5** of BS 5328 : Part 1 : 1997) is permitted to be used to provide assurance of minimum cement content, the concrete shall be deemed to comply with the specified minimum cement content if the compressive strength results for the equivalent grade comply with the requirements of **3.16.2**.

3.13.2 Where compliance is assessed by observation of the batching or from examination of the autographic records of the batching plant, the mean of any four consecutive observed cement contents shall be not less than the specified minimum value or not greater than the specified maximum value and any individual observed cement content shall be not less than 95 % of the specified minimum value or not greater than 105 % of the specified maximum value.

3.13.3 Where compliance is assessed from the results of one of the analysis tests on the fresh concrete described in DD 83, the compliance limits shall be specified or agreed by the purchaser and producer based on the information given in DD 83.

3.14 Maximum free water/cement ratio

3.14.1 Where an equivalent grade (see **8.5** of BS 5328 : Part 1 : 1997) is permitted to be used to provide assurance of maximum free water/cement ratio, the concrete shall be deemed to comply with the specified maximum free water/cement ratio if the compressive strength results for the equivalent grade comply with the requirements of **3.16.2**.

3.14.2 Where compliance with the specified maximum free water/cement ratio is assessed by observation of the batching or from examination of the autographic records of the batching plant, allowance shall be made for the water in the aggregates and admixtures. The mean free water/cement ratio of any four consecutive observations shall be not greater than the specified maximum value and any individual observed free water/cement ratio shall be not more than 5 % greater than the value specified.

3.14.3 Where compliance with the specified maximum free water/cement ratio is assessed using workability test results, satisfactory evidence of the relationship between free water/cement ratio and workability for the materials used shall be available (see **3.5** of BS 5328 : Part 3 : 1990). Compliance with the maximum free water/cement ratio shall be deemed to be satisfied when the workability complies with **3.5** provided the materials are in compliance and the cement content is as declared (see clause **3** of BS 5328 : Part 3 : 1990).

3.14.4 Where compliance is assessed from the results of one of the analysis tests on the fresh concrete described in DD 83, the compliance limits shall be specified or agreed by the purchaser and producer based on the information given in DD 83.

3.15 Specified mix proportions (prescribed and standard mixes only)

3.15.1 When compliance is assessed by either observation of the batching, or examination of the autographic records of the batch weights used, an individual assessment of the mix proportions shall be within ± 5 % of the values specified and the mean of any four consecutive assessments of cement content shall be not less than the specified value. Account shall be taken of the adjustments permitted in **4.3.2** of BS 5328 : Part 3 : 1990.

3.15.2 Where compliance is assessed from the results of one of the analysis tests on the fresh concrete specified in DD 83, the compliance limits shall be specified or agreed by the purchaser and producer based on the information given in DD 83.

3.16 Strength (for designed mixes or where equivalent grade is used to assess compliance for minimum cement content or maximum free water/cement ratio)

3.16.1 *Sampling and testing*

Batches of concrete to be tested shall be selected at random and a sample obtained by taking a number of increments in accordance with BS 1881 : Part 101.

Two compressive strength test specimens for the selected age for compliance testing shall be prepared from the sample as described in BS 1881 : Part 108 and both the specimens shall be cured in one of the following ways:

a) for 28 days as described in BS 1881 : Part 111; or

b) by any other regime of curing specified or agreed between the producer and purchaser (e.g. 7 days, normal curing or accelerated curing at an elevated temperature (see BS 1881 : Part 112)) that will enable the strength at 28 days to be predicted.

On completion of the curing, the specimens shall be tested and the mean of the two results shall be taken as the test result.

When the difference between the two results divided by their mean exceeds 15 %, the test result shall be deemed invalid.

3.16.2 *Compressive strength*

When both the following conditions are met, the concrete complies with the specified compressive strength.

a) The mean strength determined from the first two, three or four consecutive test results, or from any group of four consecutive test results complies with the appropriate limits in column A of table 1.

b) Any individual test result complies with the appropriate limits in column B of table 1.

NOTE. It should be recognized that even for well controlled continuous production, statistical analysis of strength data will give a small probability that a result indicates a non-compliance with criteria (a) or (b). Advice on the action to be taken in the event of such non-compliance is given in clause **10** of BS 5328 : Part 1 : 1997.

3.16.3 *Flexural strength*

When both the following conditions are met, the concrete complies with the specified flexural strength.

a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.

b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2.

NOTE. It should be recognized that even for well controlled continuous production, statistical analysis of strength data will give a small probability that a result indicates a non-compliance with criteria (a) or (b). Advice on the action to be taken in the event of such non-compliance is given in clause **10** of BS 5328 : Part 1 : 1997.

Table 1. Characteristic compressive strength compliance requirements

Specified grade	group of test results	A	B
		The mean of the group of test results exceeds the specified characteristic compressive strength by at least:	Any individual test result is not less than the characteristic compressive strength less:
		N/mm^2	N/mm^2
C20 and above	first 2	1	3
	first 3	2	3
	any consecutive 4	3	3
C7.5 to C15	first 2	0	2
	first 3	1	2
	any consecutive 4	2	2

3.17 Quantity of concrete represented by strength test results

The quantity of concrete represented by a group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches. Similarly, the first two or three results shall be taken as representing all the intervening batches. For the individual test result requirements given in column B of table 1, or in item (b) of **3.16.3**, only the particular batch from which the sample was taken shall be at risk.

If the purchaser fails to specify the mean rate of sampling (see BS 5328 : Part 2), or fails to operate the specified rate, the maximum quantity of concrete that four consecutive test results represent shall be limited to 60 m^3.

Publications referred to

BSI publications

BS 812	Testing aggregates Part 117 Method for determination of water-soluble chloride salts
BS 1704	Specification for solid-stem general purpose thermometers
BS 1881	Testing concrete Part 101 Method of sampling fresh concrete on site Part 102 Method for determination of slump Part 106 Methods for determination of air content of fresh concrete Part 107 Method for determination of density of compacted fresh concrete Part 108 Method for making test cubes from fresh concrete Part 111 Method of normal curing of test specimens (20 °C method) Part 112 Methods of accelerated curing of test cubes Part 114 Methods for determination of density of hardened concrete
BS 3892	Pulverized-fuel ash Part 1 Specification for pulverized-fuel ash for use with Portland cement
BS 4027	Specification for sulfate-resisting Portland cement
BS 4550	Methods of testing cement Part 2 Chemical tests
BS 5075	Concrete admixtures Part 1 Specification for accelerating admixtures, retarding admixtures and water reducing admixtures
BS 5328	Concrete Part 1 Guide to specifying concrete Part 2 Methods for specifying concrete mixes Part 3 Specification for the procedures to be used in producing and transporting concrete
BS 6068	Water quality Part 2 Physical chemical and biochemical methods Section 2.42 Determination of sodium and potassium: determination of sodium by atomic absorption spectrometry Section 2.43 Determination of sodium and potassium: determination of potassium by atomic absorption spectrometry Section 2.44 Determination of sodium and potassium: determination of sodium and potassium by flame emission spectrometry
BS 6100	Glossary of building and civil engineering terms
BS 6699	Specification for ground granulated blastfurnace slag for use with Portland cement
BS 8110	Structural use of concrete Part 1 Code of practice for design and construction
DD 83	Assessment of the composition of fresh concrete
BS EN 196	Methods of testing cement Part 21 Determination of the chloride, carbon dioxide and alkali content of cement
BS EN 480	Admixtures for concrete, mortar and grout. Test methods Part 12 Determination of the alkali content of admixtures

Other publications

[1] BRE Digest 330[1)] Alkali–silica reaction in concrete, 1999

[2] Concrete Society Technical Report No. 30[2)], Alkali-silica reaction — minimizing the risk of damage to concrete, 1998

[1)] Available from Building Research Establishment, Garston, Watford WD2 7JR.

[2)] Available from Concrete Society, 3 Eatongate, 112 Windsor Road, Slough SL1 2JA.

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London
W4 4AL