

Concrete

Part 1. Guide to specifying concrete

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

This British Standard, having been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 30 November 1990

© BSI 1990

The following BSI references relate to the work on this standard:
Committee reference CAB/4
Draft for comment 87/13759 DC

ISBN 0 580 18977 5

Amendments issued since publication

Amd. No.	Date	Text affected

Contents

	Page
Committees responsible	Inside front cover
Foreword	2
Guide	
0 Introduction	4
1 Scope	4
2 Definitions	4
3 Constituent materials of concrete	5
4 Durability of concrete	7
5 Other properties of hardened concrete	14
6 Properties of fresh concrete	14
7 Basis for specifying concrete	16
8 Sampling for compliance testing	19
9 Action to be taken in the event of non-compliance of the concrete with its specification	19
Tables	
1 Cements	6
2 Aggregates for general use	7
3 Admixtures	7
4 Limits of chloride content of concrete	8
5 Classification of exposure conditions	10
6 Guidance on mix design limits for durability of concrete made with normal weight aggregates of 20 mm nominal maximum size	12
7 Concrete exposed to sulphate attack	13
8 Adjustments to minimum cement contents for aggregates other than 20 mm nominal maximum size	14
9 Compressive strength grades	14
10 Flexural strength grades	14
11 Workabilities suitable for different uses of in situ concrete	15
12 Summary of different types of mix	16
13 Standard mixes suitable for general purposes	17
14 Equivalent grades for cement content and free water/cement ratio	18
15 Recommended minimum rates of sampling	19

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 2, 3 and 4, 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 circumstances, 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 on 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.

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.

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

Guide

0 Introduction

This Part of BS 5328 gives advice on the selection of the quality of concrete suitable for many general purposes not covered by British Standard specifications or codes of practice.

This Part of BS 5328 is primarily a guide for the specifier in choosing the appropriate materials and mix. It gives the range of constituent materials that can be used. It describes the properties of fresh and hardened concrete, with considerable emphasis on durability. Distinction is made between structural and non-structural concrete and between unreinforced, reinforced and prestressed concrete. Also included is guidance on sampling for strength compliance testing and action to be taken in the event of non-compliance.

Account is taken of standard specifications relating to ground granulated blastfurnace slag or pulverized-fuel ash used in composite cements or in equivalent combinations.

Purchasers ordering in accordance with this standard are advised to specify quality assurance requirements for materials or for concrete in their purchasing contracts to assure themselves that products specified in accordance with BS 5328 consistently achieve the required level of quality. Purchasers of ready-mixed concrete are advised to specify certification meeting the requirements of the National Accreditation Council for Certification Bodies, Category 2 for product conformity. They are similarly advised to specify that, where they are available, constituent materials should be obtained from suppliers operating quality systems in accordance with BS 5750.

1 Scope

This Part of BS 5328 gives guidance on the selection of materials for concrete and on the mixes to be specified to produce concrete having the required properties in the fresh and hardened state. It also gives guidance on sampling for strength compliance testing and action to be taken in the event of non-compliance.

NOTE. The titles of the publications referred to in this standard are listed on page 20.

2 Definitions

For the purposes of this Part of BS 5328 the definitions given in BS 6100 apply, together with the following.

2.1 batch

Quantity of concrete mixed in one cycle of operations of a batch mixer or the quantity of concrete conveyed ready-mixed in a vehicle or the quantity discharged during 1 min from a continuous mixer.

2.2 cement

Hydraulic binder that sets and hardens by chemical interaction with water and is capable of doing so under water.

NOTE. The cements covered by this standard are listed in table 1.

2.3 cement content

Mass of cement contained in a cubic metre of fresh, fully compacted concrete expressed in kg/m^3 .

2.4 certified average alkali content

The average of 25 consecutive determinations of equivalent alkali content carried out on samples each of which is representative of a day's production.

2.5 characteristic strength

That value of strength below which 5 % of the population of all possible strength measurements of the specified concrete are expected to fall.

2.6 density of fresh concrete

Mass of a quantity of compacted fresh concrete divided by its volume, expressed in kg/m^3 , determined in accordance with BS 1881 : Part 107.

NOTE. Compaction by the method described in BS 1881 : Part 107 is not appropriate for semi-dry concrete mixes.

2.7 lightweight concrete

Hardened concrete having an oven-dried density not greater than 2000 kg/m^3 .

2.8 normal-weight concrete

Hardened concrete having an oven-dried density greater than 2000 kg/m^3 but not exceeding 2600 kg/m^3 .

2.9 heavyweight concrete

Hardened concrete having an oven-dried density greater than 2600 kg/m^3 .

2.10 designed mix

Mix for which the purchaser is responsible for specifying the required performance and the producer is responsible for selecting the mix proportions to produce the required performance.

2.11 prescribed mix

Mix for which the purchaser specifies the proportions of the constituents and is responsible for ensuring that these proportions will produce a concrete with the performance required.

2.12 standard mix

Mix selected from the restricted list given in section 4 of BS 5328 : Part 2 : 1990 and made with a restricted range of materials.

2.13 free water/cement ratio

Ratio of the mass of free water (that is, excluding the water absorbed by the aggregate in a saturated surface dry condition) to the mass of cement in a concrete mix.

2.14 grade (of concrete)

Numerical value of 28 day characteristic compressive strength in N/mm^2 .

2.15 equivalent grade

Grade of concrete selected to provide reasonable assurance of complying with parameters such as minimum cement content or maximum free water/cement ratio.

NOTE. See 7.5.

2.16 laitance

Thin layer of water, cement and fine particles of aggregate that may form on the surface of concrete.

2.17 producer

Person or authority entering a contract to supply concrete.

NOTE. For example, a producer of ready-mixed or precast concrete supplying a contractor or a contractor supplying a client.

2.18 purchaser

Person or authority entering a contract to buy concrete.

NOTE. For example, a client purchasing from a contractor or a contractor purchasing from a subcontractor or material supplier.

2.19 ready-mixed concrete

Concrete mixed in a stationary mixer or in a truck-mixer and supplied in the fresh condition to the purchaser either at the site or into the purchaser's vehicles.

2.20 time of loading

Time of first contact between cement and aggregates or, when the latter are surface dry, between cement and added water.

3 Constituent materials of concrete**3.1 Choice and approval of materials**

3.1.1 Materials used should satisfy the requirements for the safety, structural performance, durability and appearance of the finished structure, taking full account of the environment to which it will be subjected. In selecting the materials to be used, account should be taken of the cumulative effect of impurities, the construction process, the likely standards of supervision and workmanship and the possible technical and cost implications of using non-standard materials.

3.1.2 Where non-standard materials are used, there should be satisfactory data on their suitability and assurance of quality control. Records of the details and performance of such materials should be maintained.

3.1.3 Account should be taken of possible interactions between the materials used.

3.2 Cements

3.2.1 Generally, cements should comply with the British Standards listed in table 1. Other cements or other combinations of Portland cement with ground granulated blastfurnace slag (ggbs) and pulverized-fuel ash (pfa) may be used provided that there are satisfactory data on their suitability, such as performance tests on concrete containing them.

Other British Standards may restrict the type of cement to be used in particular cases.

3.2.2 Where used for special purposes, the cement may need to have additional requirements specified. For example, for certain classes of sulphate resistance it is necessary to stipulate the proportions of ggbs or pfa in composite cements and combinations.

3.2.3 Not all standard cements are suitable for all uses in concrete. For example, for structural concrete, high alumina cement complying with BS 915 should not normally be permitted.

3.3 Aggregates

3.3.1 Generally, aggregates should comply with the British Standards listed in table 2. In making reference to aggregates complying with these standards, there may be a need to specify or approve certain characteristics including size, grading, impurities, durability and other properties. Other aggregates may be used provided there are satisfactory data on the properties of concrete made with them.

3.3.2 For most work, 20 mm aggregate is suitable. Where there are no restrictions to the flow of concrete into sections, 40 mm or larger sized aggregate should be permitted. In concrete elements with thin sections, closely spaced reinforcement or small cover, consideration should be given to the use of 10 mm nominal maximum size.

3.3.3 Separate coarse and fine aggregates should be used in concrete of grades C20 (see 5.1) and above. Either separate coarse and fine aggregates or all-in aggregate may be used in concrete of grades C15 and below.

3.3.4 Most aggregates have low moisture movement (e.g. flint, quartzite, limestone). Aggregates having a high moisture movement, such as some dolerites and basalts, and gravels containing these rocks, produce concrete having an

above average initial drying shrinkage. When the drying shrinkage exceeds certain values this can result in deterioration of exposed concrete and excessive deflections of reinforced concrete.

Classification of these aggregates is given in BS 812 : Part 120 and guidance on design recommendations for their satisfactory use in structures is given in BRE Digest 35.

3.3.5 The elastic modulus of concrete depends on the types of aggregate used and the compressive strength of the concrete.

3.3.6 Where appearance is important, the aggregate should not contain surface-marring materials such as pyrites (see appendix B of BS 882 : 1984).

3.3.7 Where high strength concrete is required, the source as well as the type of aggregate may need careful selection based on results of previous use or of trial mixes.

Table 1. Cements

Type	Standard
Portland cements	
Ordinary (OPC)	BS 12
Rapid hardening (RHPC)	BS 12
Low-heat (LHPC)	BS 1370
Sulphate-resisting (SRPC)	BS 4027
Low-alkali sulphate-resisting (LASRPC)	BS 4027
Cements containing ground granulated blastfurnace slag (ggbS) or pulverized-fuel ash (pfa)	
Portland blastfurnace (PBFC)	BS 146
Low-heat Portland blastfurnace	BS 4246
Portland pulverized-fuel ash (PPFAC)	BS 6588
Pozzolanic cement with pulverized-fuel ash as pozzolana	BS 6610
Combinations manufactured in the concrete mixer from Portland cement and ggbS or pfa	Combination of which the proportions and properties comply with
OPC with ggbS complying with BS 6699	BS 146
	BS 4246
OPC with pfa complying with BS 3892 : Part 1	BS 6588
	BS 6610
Other cements	
High alumina cement (HAC) ^{1) 2)}	BS 915
Supersulphated cement (SSC) ¹⁾	BS 4248
Modified Portland cements, e.g. coloured, ultra-high early strength, water-repellent, hydrophobic	Complying with the physical properties for ordinary Portland cement in BS 12

¹⁾ High alumina cement complying with BS 915 or supersulphated cement complying with BS 4248 should not be mixed with any other type of cement in the production of concrete (see 3.2.3).

²⁾ High alumina cement should be used with caution. The hydrated cement undergoes chemical changes, including a process known as conversion, which lead to loss of concrete strength and reduced resistance to aggressive chemicals. The precise way in which conversion occurs and the effects on concrete properties depend on the initial free water/cement ratio, the temperature and/or humidity of the concrete during curing and throughout its subsequent life. Guidance on the correct use of high alumina cement should be sought from the manufacturers and current specialized publications.

NOTE. Not all cements may be readily available. For example supersulphated cement has not been produced in Britain since 1969, and specifiers should check their availability.