Concrete – Complementary British Standard to BS EN 206-1 –

Part 1: Method of specifying and guidance for the specifier

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Summary of pages
This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 59 and a back cover.
Foreword

Publishing information
This part of BS 8500 is published by BSI and came into effect on 30 November 2006. It was prepared by Working Group B/517/1/WG20, Specification drafting, under the authority of Subcommittee B/517/1, Concrete production and testing, and Technical Committee B/517, Concrete and related products. A list of organizations represented on these committees can be obtained on request to their secretary.

Supersession
This part of BS 8500 supersedes BS 8500-1:2002, which is withdrawn.

Relationship with other publications
BS 8500 contains additional United Kingdom provisions to be used in conjunction with BS EN 206-1. Together they form a complete package for the specification, production and conformity of fresh concrete.

BS 8500 is published in the following parts:

- BS 8500-1, Method of specifying and guidance for the specifier;
- BS 8500-2, Specification for constituent materials and concrete.

Information about this document
This is a full revision of the standard, and introduces the following principal changes:

- changes to reflect changed guidance in BRE Special Digest 1 [1];
- revised guidance on resisting chloride-induced corrosion;
- extended guidance on recommended concrete quality in long life structures;
- changes resulting from the withdrawal of British Standards;
- reducing the strength class of the FND designated concretes to C25/30;
- new guidance on the chloride class for post-tensioned prestressed concrete;
- changes resulting from new European standards published since 2003;
- simplification of the cement and combination designations;
- presentational changes to ease the use of this standard;
- corrections.
Hazard warnings

WARNING. Where skin is in contact with fresh concrete, skin irritations are likely to occur owing to the alkaline nature of cement. The abrasive effects of sand and aggregate in the concrete can aggravate the condition. Potential effects range from dry skin, irritant contact dermatitis, to – in cases of prolonged exposure – severe burns. Take precautions to avoid dry cement entering the eyes, mouth and nose when mixing mortar or concrete by wearing suitable protective clothing. Take care to prevent fresh concrete from entering boots and use working methods that do not require personnel to kneel in fresh concrete. Unlike heat burns, cement burns might not be felt until some time after contact with fresh concrete, so there might be no warning of damage occurring. 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. Barrier creams may be used to supplement protective clothing but are not an alternative means of protection.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.
Introduction

The specifier is offered five approaches to the specification of concrete.

a) Designated concretes.

For many common applications, the simplest approach is to specify a designated concrete. Designated concretes were developed to make the specification of designed concretes simpler, complete and more reliable. While they do not cover every application nor do they permit the use of every potential concreting material, they are suitable for a wide range of housing, structural and other construction applications.

An essential part of the designated concrete concept is the requirement for the producer to hold current accredited production control and product conformity certification (see BS 8500-2) and therefore designated concretes are only applicable where third-party certification is selected as the option in specifying the concrete. Where the option selected is not to use a certified concrete, the method of designation/specification given in b), c) or d) below is used.

It is stressed that the reference to third-party certification does not make such a method of specification obligatory: it has been included with the support of industry bodies wishing to maintain the progress which has been achieved in quality levels as a result of such certification.

The environments to which the concrete is to be exposed are identified from A.2. Guidance on the selection of designated concrete is given in A.4 and the specification is drafted in accordance with 4.2.

b) Designed concretes.

Designed concretes are suitable for almost all applications. They may be used as an alternative to designated concrete and should be used where the requirements are outside of those covered by designated concretes, e.g.:

- where special cements or combinations are required, e.g. low heat of hydration;
- where the concrete is to be exposed to one of the chloride (XD) or sea water (XS) exposure classes;
- where lightweight or heavyweight concrete is required;
- where a strength class is required other than those covered by designated concrete;
- where strength is a requirement for the concrete and third-party certification is not required.

NOTE 1 Third-party certification is recommended for all concrete, including designated concrete.
The environments to which the concrete is to be exposed are identified from A.2. Using the intended working life and the minimum cover to reinforcement, the limiting values of composition are determined for each of the identified exposure classes using the guidance in A.4. The requirements for the concrete are selected from this composite of limiting values plus structural and fire considerations, and the specification is then drafted in accordance with 4.3.

c) **Prescribed concretes.**

This approach allows the specifier to prescribe the exact composition and constituents of the concrete. It is not permitted to include requirements on concrete strength, and so this option has only limited applicability.

Where a prescribed concrete is specified, the specifier is responsible for any initial testing to determine that the specified proportions will achieve the intended performance in the fresh and hardened states with an adequate margin (see BS EN 206-1:2000, 6.1). According to BS EN 206-1, the specifier is also responsible for ensuring that the specified proportions do not result in damaging alkali–silica reaction (ASR), but see A.8.1 for an alternative approach.

In general, it is better to specify using one of the performance options (designated or designed concrete), but there are a few situations where the prescribed concrete method of specification is appropriate. For example, with exposed aggregate finishes, uniformity of appearance is a key requirement. Having done trial mixes to confirm that the finished surface is as required and the mix satisfies the other required properties, e.g. strength, maximum w/c ratio, with an adequate margin, the concrete may then be specified as a prescribed concrete using the sources and proportions of constituent materials used in the approved trial mix.

The specification is drafted in accordance with 4.4.

d) **Standardized prescribed concretes.**

Standardized prescribed concretes are applicable for housing and similar construction where concrete is site-batched on a small site or obtained from a ready-mixed concrete producer who does not have accredited third-party certification. Guidance on the selection of standardized prescribed concrete is given in A.4.5 and the specification is drafted in accordance with 4.5.

Standardized prescribed concrete may be used as an alternative to the GEN series of designated concretes. As the concrete producer is unlikely to be known at the time of specification, the best approach in these situations is to specify a suitable designated concrete and the equivalent standardized prescribed concrete as alternatives.
e) **Proprietary concretes.**

This approach is appropriate where it is required that the concrete achieves a specific performance, using defined test methods. The proprietary concrete is selected in consultation with the concrete producer and the specification is drafted in accordance with **4.6**.

**NOTE 2** This method of specification might not be suitable for initial use in public procurement contracts if the specification, in effect, determines the concrete producer. BSI has not substantiated any claimed performance made for proprietary concrete by any producer.

The producer is not required to disclose full details of the mix constituents or composition to the specifier. Where the concrete is produced under third-party certification, the producer is required to substantiate to their third-party certification body that their proprietary concrete satisfies any performance requirements and limiting values that are specified or declared. Where the concrete is not under third-party certification, the producer is required to confirm that any performance requirements and limiting values that are specified or declared were satisfied and, on request, supply the relevant test data.

A performance approach to specifying self-compacting concrete is given in *The European Guidelines for self-compacting concrete – specification, production and use* [2]. This uses the proprietary method of specification and is written in a form that complements BS EN 206-1. In this case, the compressive strength class and limiting values are specified as if a designed concrete was being specified, but the properties of the fresh concrete are specified from the classes given in the *Guidelines*.

Within each approach to drafting the specification, there are a number of instances in which the specifier selects from the various options given in this part of BS 8500.

The Foreword to BS EN 206-1 sets out the context in which BS EN 206-1 operates in the context of European standards. As BS 8500 is the UK complementary standard to BS EN 206-1, the context in which BS 8500 operates is the same when BS 8500 is used within a suite of European standards. For a number of years, the European Standard design codes will co-exist with the current British Standard design codes. Using this standard with current British Standard design codes requires the designer to take account of:

- the different way of expressing strength, i.e. by strength class;
- the different ways of expressing workability, e.g. by consistence class;
- the different names for constituent materials;
- the different requirements or classes for constituent materials;
- the different format for specifying concrete;
- the new responsibilities of the concrete producer for conformity.

Guidance on using BS 8500 with BS 8110 is given in *How to use BS 8500 with BS 8110* [3].

An index is provided to aid the user of this standard.
1 Scope

This part of BS 8500 describes methods of specifying concrete and gives guidance for the specifier.

NOTE The guidance for the specifier is given in Annex A. This annex provides guidance on the concrete quality to specify for selected exposure classes, intended working life and nominal cover to normal reinforcement. It does not give guidance on stainless steel and non-metallic reinforcement. Guidance on nominal cover to reinforcement for structural and fire consideration is available in other publications, e.g. structural design codes of practice.

This part of BS 8500 complements BS EN 206-1. It provides United Kingdom national provisions where required or permitted by BS EN 206-1. It also covers materials, methods of testing and procedures that are outside the scope of BS EN 206-1, but within national experience.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of BS 8500. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 8500-2:2006, Concrete – Complementary British Standard to BS EN 206-1 – Part 2: Specification for constituent materials and concrete


BS EN 12350-1, Testing fresh concrete – Part 1: Sampling

BS EN 12350-2, Testing fresh concrete – Part 2: Slump test

BS EN 12350-5, Testing fresh concrete – Part 5: Flow table test

BS EN 12350-6, Testing fresh concrete – Part 6: Density

BS EN 12350-7, Testing fresh concrete – Part 7: Air content – Pressure methods

BS EN 12390-7, Testing hardened concrete – Part 7: Density of hardened concrete

ASTM C173, Standard test method for air content of freshly mixed concrete by the volumetric method

1) Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA. Tel: +610 832 9585. Fax: +610 832 9555. Website: http://www.astm.org.
3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this part of BS 8500, the terms and definitions given in BS EN 206-1 and the following apply.

3.1.1 cement content
mass of cement contained in a cubic metre of fresh, fully compacted concrete, expressed in kilograms per cubic metre (kg/m³)

NOTE Additions of Type II may be taken into account in respect of the cement content if the suitability is established (see BS EN 206-1:2000, 5.2.5.1 and BS 8500-2:2006, Table 1).

3.1.2 combination
restricted range of Portland cements and additions which, having been combined in the concrete mixer, count fully towards the cement content and water/cement ratio in concrete

NOTE A procedure for establishing the suitability of combinations is specified in BS 8500-2:2006, Annex A.

3.1.3 compressive strength class
classification comprising the type of concrete (normal-weight or lightweight), the minimum characteristic 150 mm diameter by 300 mm cylinder strength and the minimum characteristic 150 mm cube strength

3.1.4 design chemical class (DC-class)
designation used to describe a concrete quality capable of resisting the selected aggressive chemical environment for the concrete, provided that any specified additional protective measures (APMs) are correctly applied to the structure

NOTE See A.4.4 and BRE Special Digest 1[1].

3.1.5 designated concrete
concrete produced in accordance with BS 8500-2:2006, Clause 6 by a producer holding current accredited product conformity certification based on product testing and surveillance, coupled with approval of the producer’s quality system to BS EN ISO 9001

3.1.6 hydraulic gradient
difference in the hydrostatic head of water on opposite sides of a concrete element, in metres, divided by the section thickness, in metres

3.1.7 maximum aggregate size
largest aggregate size used in the concrete

NOTE The requirements for aggregate size in BS EN 12620 allow a small percentage to be retained on the upper sieve size.

3.1.8 minimum cover
depth of cover to reinforcement assumed for the purposes of durability design
3.1.9 **nominal cover**
depth of cover to reinforcement shown on the drawings comprising the minimum cover plus an allowance in design for deviation, $\Delta c$, to accommodate fixing precision

*NOTE* This allowance is typically in the range 5 mm to 15 mm for surfaces cast against formwork.

3.1.10 **proprietary concrete**
concrete for which the producer assures the performance subject to good practice in placing, compacting and curing and for which the producer is not required to declare the composition

3.1.11 **recycled aggregate (RA)**
aggregate resulting from the reprocessing of inorganic material previously used in construction

3.1.12 **recycled concrete aggregate (RCA)**
recycled aggregate principally comprising crushed concrete

3.2 **Symbols and abbreviations**
For the purposes of this part of BS 8500, the symbols and abbreviations given in BS EN 206-1:2000 and the following apply.

*NOTE 1* The abbreviations used to denote cement and combination types are given in Table A.6 and BS 8500-2:2006, Table 1.

ACEC aggressive chemical environment for concrete (see Table A.2 for its determination)

APM additional protective measure (see Table A.10 for the options)

BS EN European Standard published by BSI containing a national foreword and, where appropriate, national annexes

BS EN ISO International Standard that has been adopted as a European Standard published by BSI containing a national foreword and, where appropriate, national annexes

DC-(number) design chemical class used to classify the resistance of concrete to chemical attack

DS-(number) design sulfate class used to classify the sulfate or equivalent sulfate content of the site

FND(number of the DC-class) designation used for a series of designated concretes that are used in foundation applications

GEN(number) designation used for a series of designated concretes that are used for housing and similar applications

ggbs ground granulated blastfurnace slag

PAV(number) designation used for a series of designated concretes that are used in paving applications
4 Method of specifying

4.1 General

The specifier of the concrete shall ensure that all the relevant requirements for concrete properties are included in the specification given to the producer. The specification shall include any requirements for concrete properties that are needed for transportation after delivery, placing, compaction, curing or further treatment. The specification shall, if necessary, include any special requirements (e.g. for obtaining an architectural finish [4]).

The specifier shall take account of:

• the application of the fresh and hardened concrete;
• the method of placing;
• the method of compaction;
• the curing conditions;
• the dimensions of the element (the heat development);
• the environmental conditions to which the element is to be exposed;
• any requirements for exposed aggregate or tooled concrete finishes;
• any requirements related to the cover to reinforcement or minimum section width, e.g. maximum aggregate size;
• any further restrictions on the use of constituent materials with established suitability.

NOTE 1 Where types and classes of constituent materials and environmental conditions are not detailed in the specification, the producer will select constituent materials for the specified requirements only (see BS 8500-2:2006, 4.1).
Concrete shall be specified either as:
a) designated concrete conforming to BS 8500-2 (see 4.2); or
b) designed concrete conforming to BS 8500-2 (see 4.3); or
c) prescribed concrete conforming to BS 8500-2 (see 4.4); or
d) standardized prescribed concrete conforming to BS 8500-2 (see 4.5); or
e) proprietary concrete conforming to BS 8500-2 and a performance agreed between the specifier and the producer (see 4.6).

NOTE 2 Requirement for the concrete to conform to the appropriate clauses in BS 8500-2 invokes many general requirements for constituent materials, production and conformity and also requires the concrete to conform to the relevant requirements in BS EN 206-1 and the producer to comply with the relevant requirements in BS EN 206-1. Consequently conformity to BS 8500-2 includes conformity to BS EN 206-1.

When the specifier requires identity testing, this shall be carried out in accordance with:
• Annex B for slump, flow, air content and density of fresh concrete;
• Annex B for density of hardened concrete specimens;

4.2 Specification for designated concrete

4.2.1 General

The specification for designated concrete shall contain:
a) the basic requirements given in 4.2.2;
b) the additional requirements given in 4.2.3 where required.

NOTE 1 An appropriate designated concrete may be selected from the exposure class and intended working life given in Table A.3, Table A.8 and Table A.9. For housing and similar applications, an appropriate designated concrete may be selected by identifying from Table A.13 the application for which the concrete is to be used, or the application which most closely resembles it. Table A.14 may be used to check that the associated strength class is adequate for structural purposes.

For non-typical applications or to satisfy particular structural or other reasons, the designated concrete may be selected in accordance with the limiting values specified in BS 8500-2:2006, Clause 6.

NOTE 2 Identity testing by the specifier or user is not necessary for designated concrete, as the producer is required to hold current accredited third-party certification and the certification body will audit the producer’s conformity control. Nevertheless identity testing is not precluded.

NOTE 3 Where the producer is required to inform the specifier and user of a non-conformity (see BS EN 206-1:2000, 8.4), the third-party certification body will check that this action has been taken.
4.2.2 Basic requirements

The specification for designated concrete shall contain:

a) a requirement to conform to BS 8500-2 (see Note 1);
b) an appropriate concrete designation (see Note 2);
c) the maximum aggregate size when other than 20 mm;
d) the class of consistence when other than S3 for the GEN, FND and RC series and S2 for the PAV series (see Note 3).

NOTE 1 The specification of the designated concrete by its designation, e.g. GEN3, is an instruction to the producer to conform to BS 8500-2, as appropriate.

NOTE 2 GEN concrete with relatively low cement or combination content might not be suitable for obtaining satisfactory cast and direct finished surfaces, nor for methods of placing, such as pumping. The suitability of such concrete should be discussed with the producer.

NOTE 3 The consistence class should be selected by the user of the concrete and passed to the specifier.

4.2.3 Additional requirements

In addition to the basic requirements (4.2.2), the specification for designated concrete shall contain any of the following additional requirements and provisions that are deemed to be necessary:

a) any restriction on the permitted range of cement and combination types, or any relaxation to permit type IVB-V cements or combinations (see Note 1);
b) any special requirements for the aggregates;
c) where RC20/25 to RC40/50 is specified, permission to use RA or RCA at more than a mass fraction of 20% of coarse aggregate or the exclusion of these aggregates from the specification;
d) accelerated or retarded set;
e) colour;
f) generic type and dosage of fibres where required;
g) any requirement for a different chloride class, i.e. where the following classes are not appropriate:
   • Cl 1,0 for the GEN series of designated concrete;
   • Cl 0,40 for other designated concretes for all cements and combinations except SRPC;
   • Cl 0,20 for SRPC;
h) any requirement for higher minimum air content, e.g. to allow for the effects of pumping (see Note 2).

NOTE 1 All the cement and combination types given in BS 8500-2:2006, Table 5 have the potential to provide adequate durability if the appropriate designated concrete is specified and the concrete is transported, placed, compacted and cured correctly. However, in a few instances there might be an advantage in selecting a particular type of permitted cement or combination, e.g. in massive sections to control heat development; in hot or cold weather (see A.9). For some designated concretes, cement and combination type IVB-V is subject to specific permission being given in the project specification.
NOTE 2 The minimum air content given in BS 8500-2:2006, Table 5 is based on the assumption that differences in the air content between the point of delivery and the point of placing are small. Where the distance between the point of discharge and the point of placing is large or the concrete is being pumped, it might be necessary to specify a higher air content.

4.3 Specification for designed concrete

4.3.1 General

NOTE 1 Guidance on the specification of designed concrete to resist identified exposure classes is given in A.4.

The specification for designed concrete shall contain:

a) the basic requirements given in 4.3.2;

b) the additional requirements given in 4.3.3 where required.

NOTE 2 For abbreviations to be used in specifications, see 3.2 and BS EN 206-1:2000, Clause 11.

4.3.2 Basic requirements

The specification for designed concrete shall contain (see Note 1 and Note 2):

a) a requirement to conform to BS 8500-2;

b) the compressive strength class;

c) the limiting values of composition, e.g. maximum w/c ratio, minimum cement content or the DC-class where appropriate;

d) where the DC-class has not been specified, the permitted cements and combinations (see Note 3);

e) the maximum aggregate size where a value other than 20 mm is required;

f) the chloride class where a class other than Cl 0.40 is required;

g) for lightweight concrete, the density class or target density;

h) for heavyweight concrete, the target density;

i) the class of consistence or, in special cases, a target value for consistence.

NOTE 1 BS EN 206-1 requires the exposure class or classes to be specified as a description for a set of concrete requirements given in national provisions. This part of BS 8500 requires the specification of designed concrete to contain limiting values or the DC-class, for the following reasons.

• Specification by exposure class is not appropriate where trade-off between cover to reinforcement and concrete quality is applied.

• Specification by exposure class is not suitable where the intended working life is other than “at least 50 years”, e.g. at least 100 years.

• Where there are multiple exposure classes, there can be a range of suitable concretes, e.g. one with air-entrainment and one without, and it is the specifier’s responsibility to select from these options.

• In chemically aggressive environments, the determination of the exposure class (ACEC-class) is only the first step in determining the concrete specification.
NOTE 2 Consideration should be given to specifying a requirement for the producer to operate an accredited quality system meeting the requirements of BS EN ISO 9001.

NOTE 3 The specifier may choose one or more groups using the broad designations given in Table A.6, select specific cement and combination types from BS 8500-2:2006, Table 1 or choose other cement and combination types not listed in these tables, e.g. Portland-composite cements, composite cements, Portland cement with two or more additions, cement or combinations with low heat of hydration. With designed concrete it is not normally necessary to specify the cement strength class, but where this is needed, it may be specified. Where the specification for a designed concrete does not state the cement and combination types to be used, the producer is required to select from those listed in BS 8500-2:2006, Table 1.

### 4.3.3 Additional requirements

In addition to the basic requirements (4.3.2), the specification for designed concrete shall contain any of the following additional requirements and provisions that are deemed to be necessary, specifying performance requirements and test methods as appropriate:

a) special types or classes of aggregate, e.g. for wear resistance or freeze-thaw resistance (see Note 1);

b) where the use of coarse RA is deemed acceptable, a statement that coarse RA is permitted and a requirement for the RA to conform to BS 8500-2:2006, 4.3, and at least the following additional requirements specific to the type of RA:
   - maximum acid-soluble sulfate;
   - method for determination of the chloride content;
   - classification with respect to alkali-aggregate reactivity;
   - method for determination of the alkali content;
   - any limitations on use in concrete, e.g. compressive strength classes, exposure classes;

c) restrictions on the use of certain aggregates;

d) generic type and dosage of fibres;

e) characteristics required to resist freeze-thaw attack, e.g. air content (see Note 2);

f) requirements for the temperature of the fresh concrete, where different from the lower limit in BS EN 206-1:2000, 5.2.8 or the upper limit in BS 8500-2:2006, 5.4;

g) strength development;

h) heat development during hydration;

i) retarded stiffening;

j) resistance to water penetration;

k) resistance to abrasion;

l) tensile splitting strength;
m) other technical requirements, e.g. requirements related to the achievement of a particular finish or special method of placing;

n) any “concerning effects” (see BS EN 206-1:2000, Note to A.4), together with the tests to be applied and the acceptability criteria.

NOTE 1 In these cases, BS EN 206-1:2000, 6.2.3 suggests that concrete composition to minimize damaging alkali–silica reaction is the responsibility of the specifier. However, BS 8500-2:2006, 5.2 requires the producer to take appropriate action in these cases (see A.8.1 for explanation).

NOTE 2 The minimum air content given in Table A.8 is the recommended minimum air content at the point of placing. Where the distance between the point of discharge and the point of placing is large or the concrete is being pumped, it might be necessary to specify a higher air content.

4.4 Specification for prescribed concrete

4.4.1 General

The specifier shall record the data linking the specified proportions to the intended performance.

Where necessary, these data shall be obtained by initial testing (see BS EN 206-1:2000, 6.1).

The specification shall contain proportions such that the risk of damaging alkali–silica reaction is minimized or a requirement for the producer to minimize the risk of damaging alkali–silica reaction (see A.8.1).

The specification for prescribed concrete shall contain:

a) the basic requirements given in 4.4.2;

b) the additional requirements given in 4.4.3 where required.

4.4.2 Basic requirements

The specification for prescribed concrete shall contain (see Note 1 and Note 2):

a) a requirement to conform to BS 8500-2;

b) the cement or combination type and standard strength class;

c) the cement or combination content;

d) the class of consistence or, in special cases, a target consistence;

e) the type and categories of the aggregate;

f) the maximum aggregate size and any limitations for grading;

g) in the case of lightweight or heavyweight concrete, the target density of the concrete or the maximum or minimum density of aggregate as appropriate;

h) the chloride class for the concrete or the maximum chloride content of the aggregate;

i) the type and quantity of admixture or addition, if any;

j) for characteristics that cannot be defined by other means, the sources of the constituents (see Note 3).
NOTE 1  Consideration should be given to specifying a requirement for the producer to operate an accredited quality system meeting the requirements of BS EN ISO 9001.

NOTE 2  The content of constituent materials should be given in terms of kilograms per cubic metre (kg/m³). The use of nominal proportions, e.g. 1:2:4, is deprecated. Annex C gives guidance on the cement contents to expect where nominal proportions have been used.

NOTE 3  Generally only the generic types of constituent material need be specified.

4.4.3 Additional requirements

In addition to the basic requirements (4.4.2), the specification for prescribed concrete shall contain any of the following additional requirements and provisions that are deemed to be necessary:

a)  a requirement to conform to BS 8500-2:2006, 5.2;
b)  the sources of some, or all, concrete constituents;
c)  additional requirements for aggregates, e.g. proportion of fine aggregate;
d)  requirements for the temperature of the fresh concrete where different from the lower limit in BS EN 206-1:2000, 5.2.8 or the upper limit in BS 8500-2:2006, 5.4;
e)  the target w/c ratio (see Note);
f)  other technical requirements.

NOTE  The specified value of the (target) w/c ratio should be 0.02 less than any required maximum value.

4.5 Specification for standardized prescribed concrete

4.5.1 General

The specification for standardized prescribed concrete shall contain:

a)  the basic requirements given in 4.5.2;
b)  the additional requirements given in 4.5.3 where required.

NOTE 1  The concrete may be selected using the guidance in A.4.5.

The materials and the mix proportions given in BS 8500-2:2006, Clause 9 shall be examined to determine whether restriction of the specification is necessary.

NOTE 2  The assessment of the concrete proportions by the concrete producer forms an essential part of the conformity requirements.

NOTE 3  Equivalent designated concretes should be specified as an alternative or accepted if offered by the producer. Guidance on the specification of designated concretes equivalent to standardized prescribed concretes is given in Table A.13.
4.5.2 **Basic requirements**  
The specification for standardized prescribed concrete shall contain:

a) a requirement to conform to BS 8500-2;

b) the description of the standardized prescribed concrete required, e.g. ST2;

c) the maximum aggregate size;

d) the slump class.

4.5.3 **Additional requirements**  
In addition to the basic requirements (4.5.2), the specification for standardized prescribed concrete shall contain any of the following additional requirements and provisions that are deemed to be necessary:

a) any restrictions on the types of cements or combinations permitted in BS 8500-2:2006, 9.2;

b) any restrictions on the types of aggregates permitted in BS 8500-2:2006, 9.2.

4.6 **Specification for proprietary concrete**

4.6.1 **General**  
The specification for proprietary concrete shall contain:

a) the basic requirements given in 4.6.2;

b) the additional requirements given in 4.6.3 where required.

*NOTE* For specifying self-compacting concrete, see A.5.

4.6.2 **Basic requirements**  
The specification for proprietary concrete shall contain:

a) a requirement to conform to BS 8500-2;

b) the name of the proprietary concrete and any other identification.

4.6.3 **Additional requirements**  
In addition to the basic requirements (4.6.2), the specification for proprietary concrete shall contain any of the following additional requirements or provisions that are deemed to be necessary:

a) if options are provided by the producer of the proprietary concrete, the required option;

b) a requirement for the producer to declare that the proprietary concrete conforms to any other requirements specified for the concrete;

*NOTE* Where any such declaration is not supported by accredited third-party certification, the specification should contain a requirement to provide evidence to justify such claims.

c) any other requirements.
5 Exchange of information

5.1 Information from the specifier or user of the concrete to the producer

In addition to the information described in BS EN 206-1:2000, 7.1, the following information shall be given by the specifier or user to the producer with the specification:

a) the intended method of placing and finishing the concrete;

b) where identity testing is not restricted to cases of doubt or random spot checks (see A.10), the type of test to be carried out, the volume of concrete in the assessment and the number of tests to be carried out on this volume of concrete;

c) whether a non-accredited laboratory is to be used for identity testing;

d) where appropriate, permission to transport the concrete to the point of delivery in a non-agitating vehicle.

NOTE The criteria for identity testing for slump, flow, air content and density are given in Annex B. The criteria for identity testing for strength are given in BS EN 206-1:2000, Annex B, and Annex B of the present part of BS 8500.

5.2 Information from the producer of the concrete to the specifier or user

In addition to the information described in BS EN 206-1:2000, 7.2, the specifier shall request from the producer whichever of the following information is deemed to be necessary (see Note 1):

a) the method used to minimize damaging alkali–silica reaction and, as appropriate:
   • details of service record;
   • verification of conformity;
   • relevant manufacturers’ guaranteed alkali limit or declared alkali content;

b) the type, composition and standard strength class of combination (see Note 2);

c) where porous flint aggregates are to be used in concrete requiring freeze-thaw resisting aggregates, a track record showing successful use for not less than 10 years in conditions of freezing and thawing;

d) the method of determination of the water absorption of fine lightweight aggregate;

e) where RA is to be incorporated into the concrete, its acid-soluble sulfate content, chloride content and alkali content;

f) where RA or RCA is to be incorporated into the concrete, the type of material and proportion to be used;

g) where RCA is to be used in exposure classes other than those given in BS 8500-2:2006, Table 3, evidence that the resulting concrete is suitable for the intended environment;
h) where the equivalent concrete performance concept is to be used, the producer’s proposals for determining equivalence and ensuring conformity;

i) where using one or more admixtures in addition to an air-entraining admixture, evidence of no adverse interactions, e.g. as required by BS 8500-2:2006, 4.5;

j) where proprietary concrete is to be supplied, relevant information on the performance of the concrete;

k) where the concrete is not under third-party certification, the test data on which the declaration of conformity was based (see Note 3).

NOTE 1 The producer is expected to provide this information on request.

NOTE 2 The provision of information covered by BS EN 206-1:2000, 7.2 with respect to additions, applies where the addition is being used under the k-value concept. Where used in a combination, the combination type is declared on the delivery ticket.

NOTE 3 Where the concrete is not under third-party product certification, the producer is required to confirm that the concrete was in conformity for the period of supply and, on request, supply the test data on which this confirmation was based (see BS 8500-2:2006, 12.1).
Annex A (informative)  

Guidance for the specifier

A.1 General

This annex provides guidance on the factors that should be taken into account prior to the selection of the method of specifying and the specification of requirements. The factors that are covered are:

- exposure classes related to environmental conditions (A.2);
- cover to reinforcement (A.3);
- resistance to identified exposure classes (A.4);
- selection of consistence (A.5);
- density (A.6);
- aggregate classes (A.7);
- internal degradation of concrete (A.8);
- temperature (A.9);
- conformity and identity testing (A.10).

BS EN 206-1 defines the term “specification” as the “final compilation of documented technical requirements given to the producer in terms of performance or composition”. It also recognizes that this specification can contain requirements for a number of different persons or bodies, e.g. architects, structural designers, contractors, etc. The architect and/or the structural designer compile the majority of the specification, but there are important aspects that have to be added by the user, e.g. a consistence that is suitable for the intended method of placing and finishing the concrete. The term “specifier” is reserved for the “person or body establishing the specification for the fresh and hardened concrete” (as defined in BS EN 206-1:2000, 3.1.37), i.e. the person or body who gives the specification to the producer.

BS 8500 and BS EN 206-1 take account of the distinct and different technical responsibilities of the specifier, producer and user. Where a body is responsible for more than one of these roles, internal procedures within that body are expected to allocate responsibilities for the various actions.

There can be occasions where it is advantageous for economic or technical reasons for the producer or user to propose changes to the specification. In such cases the proposer of the amendment needs to obtain approval from the specifier who may, in turn, seek the approval of the body responsible for the specific technical requirement, e.g. the designer.

Where designed concrete is specified in accordance with this part of BS 8500, the guidance on specification is given for defined materials with an established or accepted adequate performance in United Kingdom conditions. Some European Standards, e.g. BS EN 197-1, encompass a wide range of products, including several for which there is little experience of use in the United Kingdom. Until experience is gained, their use should be by agreement between the producer and specifier on a case-by-case basis. Some guidance on the performance of these products can be obtained by relative performance testing, as discussed in Concrete Society publication CS 109 [5].
A.2 Exposure classes related to environmental conditions

A.2.1 General

Environmental and ground conditions are classified as exposure classes in Table A.1 and Table A.2. Table A.1 gives a non-exhaustive list of examples applicable in the United Kingdom. There might be specific elements or structures where the exposure does not readily fit the descriptions in the exposure classes. In such situations, designers should use their own judgment for that application or seek specialist advice.

If the concrete is subject to more than one of the actions described in Table A.1, the environmental conditions to which it is subjected are expressed as a combination of exposure classes. However, where the concrete is subject to external chlorides and classified under the XD or XS exposure classes, it is not normally necessary for it to be classified under the carbonation-induced corrosion (XC) exposure class, as the recommended concrete qualities and cover to reinforcement are adequate to resist associated normal carbonation-induced corrosion.

The set of exposure classes given in Table A.1 and Table A.2 does not include exposure to abrasion. See BS 8204-2 for guidance on abrasion classes for floors.

For a given structural component, different concrete surfaces might be subject to different environmental actions.

### Table A.1 Exposure classes

<table>
<thead>
<tr>
<th>Class designation</th>
<th>Class description</th>
<th>Informative examples applicable in the United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No risk of corrosion or attack (X0 class)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X0</td>
<td>For concrete without reinforcement or embedded metal: all exposures except where there is freeze-thaw, abrasion or chemical attack For concrete with reinforcement or embedded metal: very dry</td>
<td>Unreinforced concrete surfaces inside structures Unreinforced concrete completely buried in soil classed as AC-1 and with a hydraulic gradient not greater than 5 Unreinforced concrete permanently submerged in non-aggressive water Unreinforced concrete surfaces in cyclic wet and dry conditions not subject to abrasion, freezing or chemical attack Reinforced concrete surfaces exposed to very dry conditions</td>
</tr>
<tr>
<td><strong>Corrosion induced by carbonation (XC classes) A)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XCl</td>
<td>Dry or permanently wet</td>
<td>Reinforced and prestressed concrete surfaces inside enclosed structures except areas of structures with high humidity Reinforced and prestressed concrete surfaces permanently submerged in non-aggressive water</td>
</tr>
<tr>
<td>XC2</td>
<td>Wet, rarely dry</td>
<td>Reinforced and prestressed concrete completely buried in soil classed as AC-1 and with a hydraulic gradient not greater than 5</td>
</tr>
</tbody>
</table>

A) Where concrete containing reinforcement or other embedded metal is exposed to air and moisture.
### Table A.1 Exposure classes (continued)

<table>
<thead>
<tr>
<th>Class designation</th>
<th>Class description</th>
<th>Informative examples applicable in the United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>XC3 and XC4</td>
<td>Moderate humidity or cyclic wet and dry</td>
<td>External reinforced and prestressed concrete surfaces sheltered from, or exposed to, direct rain&lt;br&gt;Reinforced and prestressed concrete surfaces subject to high humidity (e.g. poorly ventilated bathrooms, kitchens)&lt;br&gt;Reinforced and prestressed concrete surfaces exposed to alternate wetting and drying&lt;br&gt;Interior concrete surfaces of pedestrian subways not subject to de-icing salts, voided superstructures or cellular abutments&lt;br&gt;Reinforced or prestressed concrete beneath waterproofing</td>
</tr>
</tbody>
</table>

**Corrosion induced by chlorides other than from sea water (XD classes)\(^A\)**
*(where concrete containing reinforcement or other embedded metal is subject to contact with water containing chlorides, including de-icing salts, from sources other than from sea water)*

<table>
<thead>
<tr>
<th>Class designation</th>
<th>Class description</th>
<th>Informative examples applicable in the United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>XD1</td>
<td>Moderate humidity</td>
<td>Concrete surfaces exposed to airborne chlorides&lt;br&gt;Reinforced and prestressed concrete wall and structure supports more than 10 m horizontally from a carriageway&lt;br&gt;Bridge deck soffits more than 5 m vertically above the carriageway&lt;br&gt;Parts of structures exposed to occasional or slight chloride conditions</td>
</tr>
<tr>
<td>XD2</td>
<td>Wet, rarely dry</td>
<td>Reinforced and prestressed concrete surfaces totally immersed in water containing chlorides(^c)&lt;br&gt;Buried highway structures more than 1 m below adjacent carriageway</td>
</tr>
<tr>
<td>XD3</td>
<td>Cyclic wet and dry</td>
<td>Reinforced and prestressed concrete walls and structure supports within 10 m of a carriageway&lt;br&gt;Bridge parapet edge beams&lt;br&gt;Buried highway structures less than 1 m below carriageway level&lt;br&gt;Reinforced pavements and car park slabs</td>
</tr>
</tbody>
</table>

**Corrosion induced by chlorides from sea water (XS classes)\(^A, D\)**
*(where concrete containing reinforcement or other embedded metal is subject to contact with chlorides from sea water or air carrying salt originating from sea water)*

<table>
<thead>
<tr>
<th>Class designation</th>
<th>Class description</th>
<th>Informative examples applicable in the United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>XS1</td>
<td>Exposed to airborne salt but not in direct contact with sea water</td>
<td>External reinforced and prestressed concrete surfaces in coastal areas</td>
</tr>
<tr>
<td>XS2</td>
<td>Permanently submerged</td>
<td>Reinforced and prestressed concrete surfaces completely submerged and remaining saturated, e.g. concrete below mid-tide level(^c)</td>
</tr>
<tr>
<td>XS3</td>
<td>Tidal, splash and spray zones</td>
<td>Reinforced and prestressed concrete surfaces in the upper tidal zones and the splash and spray zones(^E)</td>
</tr>
</tbody>
</table>

**Freeze-thaw attack (XF classes)**
*(where concrete is exposed to significant attack from freeze-thaw cycles whilst wet)*

<table>
<thead>
<tr>
<th>Class designation</th>
<th>Class description</th>
<th>Informative examples applicable in the United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF1</td>
<td>Moderate water saturation without de-icing agent</td>
<td>Vertical concrete surfaces such as façades and columns exposed to rain and freezing&lt;br&gt;Non-vertical concrete surfaces not highly saturated, but exposed to freezing and to rain or water</td>
</tr>
<tr>
<td>XF2</td>
<td>Moderate water saturation with de-icing agent</td>
<td>Concrete surfaces such as parts of bridges, which would otherwise be classified as XF1, but which are exposed to de-icing salts either directly or as spray or run-off</td>
</tr>
</tbody>
</table>
### Table A.1 Exposure classes (continued)

<table>
<thead>
<tr>
<th>Class designation</th>
<th>Class description</th>
<th>Informative examples applicable in the United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF3</td>
<td>High water saturation without de-icing agent</td>
<td>Horizontal concrete surfaces, such as parts of buildings, where water accumulates and which are exposed to freezing Concrete surfaces subjected to frequent splashing with water and exposed to freezing</td>
</tr>
<tr>
<td>XF4</td>
<td>High water saturation with de-icing agent or sea water F)</td>
<td>Horizontal concrete surfaces, such as roads and pavements, exposed to freezing and to de-icing salts either directly or as spray or run-off Concrete surfaces subjected to frequent splashing with water containing de-icing agents and exposed to freezing</td>
</tr>
</tbody>
</table>

### Chemical attack (XA classes)
(Where concrete is exposed to chemical attack)

Use Table A.2 to determine the ACEC-class.

See BRE Special Digest 1 [1] for guidance on site investigation.

A) The moisture condition relates to that in the concrete cover to reinforcement or other embedded metal but, in many cases, conditions in the concrete cover can be taken as being that of the surrounding environment. This might not be the case if there is a barrier between the concrete and its environment (see A.3).

B) For concrete in soil classed as AC-2 or above or an element with a hydraulic gradient greater than 5, the ACEC class is used to determine the concrete quality and minimum cover to reinforcement (see A.4.4).

C) Reinforced and prestressed concrete elements where one surface is immersed in water containing chlorides and another is exposed to air are potentially a more severe condition, especially where the dry side is at a high ambient temperature. Specialist advice should be sought where appropriate, to develop a specification that is appropriate to the actual conditions likely to be encountered.

D) The rate of ingress of chloride into the concrete will depend on the concentration at its surface: brackish groundwater (chloride content less than 18 g/l) will be less severe than exposure to sea water.

E) Exposure XS3 covers a range of conditions. The most extreme conditions are in the spray zone. The least extreme is in the tidal zone where conditions can be similar to those in XS2. The recommendations given in this annex take into account the most extreme conditions within this class.

F) It is not normally necessary to classify in the XF4 exposure class those parts of structures located in the United Kingdom which are in frequent contact with the sea.
Table A.2  Classification of ground conditions

<table>
<thead>
<tr>
<th>Sulfate and magnesium</th>
<th>Design sulfate class</th>
<th>Natural soil</th>
<th>Brownfield</th>
<th>ACEC-class (design sulfate class)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2:1 water/soil extract</strong></td>
<td><strong>Groundwater</strong></td>
<td><strong>Total potential sulfate</strong></td>
<td><strong>Design sulfate class</strong></td>
<td><strong>Natural soil</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>SO₄²⁻ Mg (c) mg/l</strong></td>
<td><strong>SO₄²⁻ Mg (c) mg/l</strong></td>
<td><strong>SO₄²⁻ %</strong></td>
</tr>
<tr>
<td>&lt;500 —</td>
<td>&lt;400 —</td>
<td>&lt;0.24</td>
<td>DS-1</td>
<td>≥2.5 —</td>
</tr>
<tr>
<td>500 to 1500 —</td>
<td>400 to 1400 —</td>
<td>0.24 to 0.6</td>
<td>DS-2</td>
<td>&gt;3.5 —</td>
</tr>
<tr>
<td>1600 to 3000 —</td>
<td>1500 to 3000 —</td>
<td>0.7 to 1.2</td>
<td>DS-3</td>
<td>&gt;3.5 —</td>
</tr>
<tr>
<td>3100 to 6000 ≤1200</td>
<td>3100 to 6000 ≤1000</td>
<td>1.3 to 2.4</td>
<td>DS-4</td>
<td>≥3.5 —</td>
</tr>
<tr>
<td>3100 to 6000 &gt;1200 (c)</td>
<td>3100 to 6000 &gt;1000 (c)</td>
<td>1.3 to 2.4</td>
<td>DS-4m</td>
<td>Not found in UK natural ground</td>
</tr>
<tr>
<td>&gt;6000 ≤1200</td>
<td>&gt;6000 ≤1100</td>
<td>&gt;2.4</td>
<td>DS-5</td>
<td>≥3.5 —</td>
</tr>
<tr>
<td>&gt;6000 &gt;1200 (c)</td>
<td>&gt;6000 &gt;1100 (c)</td>
<td>≥2.4</td>
<td>DS-5m</td>
<td>Not found in UK natural ground</td>
</tr>
</tbody>
</table>

(a) “Brownfield” sites are those that might contain chemical residues remaining from previous industrial use or from imported wastes.
(b) Applies only to sites where concrete will be exposed to sulfate ions (SO₄²⁻), which can result from the oxidation of sulfides such as pyrite, following ground disturbance.
(c) The limit on water-soluble magnesium does not apply to brackish groundwater (chloride content between 12 g/l and 18 g/l). This allows these sites to be classified in the row above. This table does not cover sea water and stronger brines.
(d) An additional account is taken of hydrochloric and nitric acids by adjustment to sulfate content (see BRE Special Digest 1 [1]).
(e) For flowing water that is potentially aggressive to concrete owing to high purity or an aggressive carbon dioxide level greater than 15 mg/l, increase the ACEC class to AC-2x (see BRE Special Digest 1 [1]).
A.2.2 Environments related to corrosion of reinforcement

There are four environments related to corrosion of reinforcement: X0, XC, XD and XS (see Table A.1). If the concrete is reinforced or contains embedded metal, one of these exposure classes should be identified. Where concrete contains reinforcement, it is recommended that the X0 exposure class is only used where the relative humidity is very low (less than about 35%) and this condition is rarely found in practice. In most situations, exposure class XC1 will exist on its own. Where the concrete is classified as being exposed to environmental class XC1 on the basis of it being permanently wet, XC1 may be combined with freeze-thaw exposure class XF3. Exposure class XC2 can exist on its own in a buried foundation in soil classed as AC-1 or AC-1s where the hydraulic gradient is not greater than 5 and beyond the zone where freeze-thaw attack is a consideration. It can also exist in combination with exposure class XF3 and/or one of the chemically aggressive exposure classes. Exposure class XC3 (moderate humidity) has been combined with XC4 (cyclic wet and dry), because the recommendations for the concrete specification and cover to reinforcement are the same for XC3 and XC4.

A.2.3 Environments associated with unreinforced concrete

The classification of exposure for unreinforced concrete is limited to exposure classes X0, ACEC and/or XF. The XC, XD and XS classes are not applicable as they relate specifically to the risk of corrosion of reinforcement.

Exposure class X0 can exist only on its own. An aggressive chemical environment for concrete (ACEC class) can apply on its own or in combination with an XF exposure class. If the unreinforced concrete contains any embedded metal, it should be classified as reinforced and the appropriate limiting values associated with exposure classes XC, XD or XS should be selected.

See BS 8204-2 for guidance on abrasion classes for floors or BS EN 13813 for wear resistance by performance.

A.2.4 Environments leading to chemical attack including sulfate attack

Deterioration of concrete caused by chemical attack can be the result of contact with gases or solutions of many chemicals, but, in the ground, it is generally due to exposure to acidic solutions or to solutions of sulfate salts.

The limiting values for some of the exposure classes for chemical attack and some of the test methods in BS EN 206-1:2000, Table 2 vary significantly from previous United Kingdom practice. BRE Special Digest 1 [1] covers a wider range of environmental actions including mobile ground water, acids and some brownfield sites and consequently this approach to exposure class selection is recommended. Brownfield sites can contain unusual chemicals and might require special considerations that are outside the scope of this general guidance.
The method by which the exposure class for chemical attack from the ground is derived is given in BRE Special Digest 1. Consideration of the chemicals in the ground [the design sulfate class (DS-class)], the type (natural or brownfield) and the acidity of the ground, and the mobility of groundwater leads to an aggressive chemical environment for concrete class (ACEC class); see Table A.2.

When selecting exposure classes for culverts, the water inside the culvert might be aggressive to concrete and different to the water in the ground outside the culvert (see BRE Special Digest 1:2005, B2.2, B.4 and B.5).

Sea water is aggressive to concrete; see A.4.4.

### A.3 Cover to reinforcement

The guidance in this annex applies to ordinary carbon steel reinforcement and prestressing steel. Guidance on cover to stainless steel is not given. The resistance of stainless steel to corrosion depends upon the type of stainless steel [6], and specialist guidance should be sought.

The selected minimum cover to reinforcement should take account of:

- the safe transmission of bond forces (see, for example, BS EN 1992-1-1);
- fire protection (see BS EN 1992-1-2);
- durability (see A.4);
- any additive safety element, e.g. for prestressing steel (see national annex to the appropriate design code);
- any reduction in cover due to the use of stainless steel;
- any reduction in cover due to the use of additional protection.

The maximum aggregate size is also related to the minimum cover to reinforcement, but this is normally selected after the minimum cover to reinforcement has been decided, based on the factors listed above.

The recommended values for minimum cover for durability have been chosen to give a low risk of the reinforcement becoming excessively corroded and requiring significant repairs before the end of the intended working life (design service life), on the assumptions that the designer has chosen a practical allowance for deviation, $\Delta c$, to add to the minimum value and that the level of workmanship on site is adequate to achieve the minimum cover.

The minimum covers to reinforcement given in A.4.2 (Table A.4 and Table A.5) are those recommended for durability. If the concrete is prestressed, the designer is expected to study the national annex of the appropriate design code to determine whether an additional safety element, i.e. increased minimum cover, is recommended. The national annex to the design code might also provide guidance on reductions in the minimum cover where stainless steel or additional protection is to be used. In all these cases, an allowance for deviation, $\Delta c$, should be added to the resulting minimum value to give the nominal cover to the reinforcement or prestressing steel.
Whilst design for durability is based on the minimum cover to reinforcement, the design drawings normally give the nominal cover, i.e. the minimum cover plus an allowance in design for deviation, $\Delta c$. The allowance should be chosen after consideration of the type of construction and the quality control measures (see DD ENV 13670-1) that will be implemented during construction. This allowance is typically in the range 5 mm to 15 mm. Where concrete is to be cast against the ground, a significantly higher allowance in design for deviation is required. In addition, BS EN 1992-1-1 and the UK National Annex provide guidance on appropriate values for other allowances, e.g. exposed aggregate finishes, that should be applied when relevant.

To avoid confusion, A.4.2 [Table A.3 (in general), Table A.4 and Table A.5] gives the nominal cover to reinforcement in the form (minimum cover + $\Delta c$) mm. However, for foundations in A.4.2 (Table A.3) and A.4.4 (Table A.9), the nominal cover has been given based on the recommendations in BS EN 1992-1-1 and the National Annex to BS EN 1992-1-1:2004.

*NOTE* BSI has informed CEN of a possible error in the use of the term “minimum cover” in EN 1992-1-1:2005, 4.4.1.3(4).

The recommendations given in this annex for concrete to resist freezing and thawing or chemical attack are such that when combined with forms of attack that lead to corrosion of reinforcement (exposure classes XC, XD and XS), the nominal cover to reinforcement need not be increased above that recommended to resist the XC, XD and XS exposures. However, when the additional protective measure APM4 (provide sacrificial layer) has been selected to resist chemical attack (see A.4.4), the nominal cover to reinforcement should be increased by the thickness of the sacrificial layer.

Certain types of permanent formwork have an in-use role of protecting the reinforcement from corrosion and such formwork may be taken into account when determining the cover to reinforcement. Account should be taken of the risk of any permanent formwork/water-proofing being damaged during use, and the consequences of such damage should not be disproportionate. Whether to take benefit from the “barrier” to reduce the concrete quality and/or the minimum cover to reinforcement will depend upon the particular situation and the proposed materials. This decision is left to the designer. Whether cover is needed to the stiffening nibs of the permanent formwork depends upon the particular material and the specific application.

Reliance should not be placed on formwork primarily used for construction purposes, but not removed, protecting the concrete throughout the intended working life.
A.4 Recommendations to resist the identified exposure classes

A.4.1 General

Design for durability should start at the concept design stage, continuing through the design, detailing, specification and execution phases, and will only be achieved in practice if the maintenance is carried out as planned. This annex covers only a part of this process, namely the determination of cover to reinforcement and concrete quality for structures to be built in the UK or similar environments. Such an approach to the provision of durability is adequate for most structures provided that the minimum cover to reinforcement is achieved in the structure and the concrete is properly specified, supplied, compacted and cured.

For more extreme environments, particularly where very long lives are required, consideration should be given to additional methods of protection such as corrosion-resistant reinforcement, surface protection and special admixtures. Guidance on additional protective measures for chemically aggressive environments is given in A.4.4.

The required concrete quality depends upon:

- the intended working life (see BS EN 1990);
  
  NOTE In BS EN 1990, the term used for the “intended working life” is the “design working life”. The terms may be treated as being synonymous.

- the environmental actions (see Table A.1 and Table A.2);

- any additional protective measures (APMs), particularly in the case of aggressive chemical exposure (see A.4.4 and BRE Special Digest 1 [1]);

- the minimum cover to reinforcement (see, for example, Table A.4);

- the structural requirements (see structural design codes for guidance, e.g. BS EN 1992-1-1).

A.4.2 Concrete properties and limiting values to resist corrosion of reinforcement

Table A.3 gives designated concretes that are suitable to resist carbonation-induced corrosion in normal building structures (intended working life at least 50 years). Designated concretes are not recommended for resisting chloride-induced corrosion (XD and XS exposure classes). Where a compressive strength class of C25/30 is insufficient for structural purposes, designated concretes cannot be used in foundations in exposure class AC-2 or higher and the designed concrete method of specification should be used.
Table A.4 and Table A.5 are for use where the designed concrete method of specification is preferred, and give concrete properties and limiting values to resist the XC, XD and XS exposure classes for intended working lives of at least 50 years and at least 100 years respectively. These tables are limited to durability considerations, and other considerations, e.g. fire, prestressing, might necessitate that higher requirements are specified.

Compressive strength classes are specified by a dual classification comprising the characteristic strength of 150 mm diameter by 300 mm length cylinders followed by the characteristic strength of 150 mm cubes, e.g. C20/25. BS 8500 treats the strength of concrete measured on 100 mm and 150 mm cubes as being identical and hence, in the UK, the dual classification applies also to 100 mm cubes.

NOTE BS 8500 includes three strength classes that are not given in BS EN 206-1:2000. Class C6/8 is used in designated concrete GEN0, and classes C28/35 (LC28/31) and C32/40 (LC32/35) are required for use in the specification of durability given in this part of BS 8500.

If lightweight concrete is required, the compressive strength class is replaced with a lightweight concrete compressive strength class with the same cylinder strength, e.g. C32/40 becomes LC32/35.

Resistance to chloride ingress is mainly dependent upon the cement or combination type and the w/c ratio, with aggregate quality being a secondary factor. Compressive strength is included as an indirect control on these parameters.
COMMENTARY ON CEMENTS AND COMBINATIONS

Cement is a single powder containing, for example, Portland cement and fly ash, supplied to the concrete producer and it is designated using the notation “CEM”. A combination is where the concrete producer combines Portland cement with, for example, fly ash at the concrete mixer and it is designated using the notation “C”. To be classified as a combination, the proportions of Portland cement and, for example, fly ash have to achieve minimum early and 28-day strength requirements as specified in BS 8500-2:2006, Annex A. BS 8500 treats cements and combinations as being technically equivalent.

Details of the cements and combinations recommended in these tables are given in Table A.6. In addition to these cements and combinations, there are others that have specialist uses or for which experience of their use in the UK is limited. No specific guidance on the application of these cements and combinations is provided in this British Standard. Such cements are not permitted to be used by a producer except where they are specified or agreed.

Table A.7 contains recommended minimum cement and combination contents for maximum aggregate sizes other than 20 mm.

The provisions given in Table A.4 and Table A.5 for the XS-exposures are adequate to cover associated normal UK sea water attack on the concrete. The provisions given in Table A.4 and Table A.5 do not take account of any associated freeze-thaw requirements (see A.4.3, Table A.8), aggressive chemicals other than sea water (see A.4.4) or abrasion (no guidance provided in this British Standard).
<table>
<thead>
<tr>
<th>Nominal cover b)</th>
<th>Compressive strength class where recommended, maximum water-cement ratio and minimum cement or combination content for normal-weight concrete c) with 20 mm maximum aggregate size b)</th>
<th>Cement/combination types</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>15 + A_c</td>
<td>20 + A_c</td>
</tr>
<tr>
<td></td>
<td>C20/25</td>
<td>C20/25</td>
</tr>
<tr>
<td>XC1</td>
<td>0.70</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>XC3/4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
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<td>—</td>
<td>—</td>
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<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**Corrosion induced by carbonation (XC exposure classes)**

<table>
<thead>
<tr>
<th>Corrosion induced by chlorides (XS from sea water, XD other than sea water)</th>
<th>Also adequate for any associated carbonation induced corrosion (XC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XD1</td>
<td>CEM I, II, IIA, IIB-S, SRPC</td>
</tr>
<tr>
<td>XS1</td>
<td>IIB-V, IIIA</td>
</tr>
<tr>
<td>XD2 or XS2</td>
<td>IIB, IVB-V</td>
</tr>
<tr>
<td>C40/50 (b) 0.45 360</td>
<td>CEM I, II, IIA, IIB-S, SRPC</td>
</tr>
<tr>
<td>C32/40 0.55 320</td>
<td>IIB-V, IIIA</td>
</tr>
<tr>
<td>C32/40 0.50 340</td>
<td>IIB, IVB-V</td>
</tr>
</tbody>
</table>

Bought by Mr Andrew Southward, Lakeland Pavers, on 06/07/2010 12:48 Latest version. Not to be distributed/networked. For multi-user access www.bsigroup.com/license © BSI
### Table A.4  Durability<sup>A</sup>) recommendations for reinforced or prestressed elements with an intended working life of at least 50 years (continued)

<table>
<thead>
<tr>
<th>Nominal cover&lt;sup&gt;B&lt;/sup&gt;)</th>
<th>15 + Δc</th>
<th>20 + Δc</th>
<th>25 + Δc</th>
<th>30 + Δc</th>
<th>35 + Δc</th>
<th>40 + Δc</th>
<th>45 + Δc</th>
<th>50 + Δc</th>
<th>Cement/comboination types</th>
</tr>
</thead>
<tbody>
<tr>
<td>XD3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CEM I, IIA, IIB-S, SRPC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C45/55&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C40/50&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C35/45&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>0.35&lt;sup&gt;F&lt;/sup&gt;) 380</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>C25/30</td>
<td>0.40 380</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C35/45&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>0.45 360</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C35/45&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>0.50 340</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>C25/30</td>
<td>0.40 380</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>C25/30</td>
<td>0.45 360</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.50 340</td>
</tr>
<tr>
<td>XS3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CEM I, IIA, IIB-S, SRPC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C45/55&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C40/50&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C35/45&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>0.35&lt;sup&gt;F&lt;/sup&gt;) 380</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>C25/30</td>
<td>0.40 380</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C35/45&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>0.45 360</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C35/45&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>0.50 340</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>C25/30</td>
<td>0.40 380</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C32/40&lt;sup&gt;E&lt;/sup&gt;)</td>
<td>C28/35</td>
<td>C25/30</td>
<td>0.45 360</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.50 340</td>
</tr>
</tbody>
</table>

A dash (—) indicates that greater cover is recommended.

<sup>A</sup>) Where appropriate, account should be taken of the recommendations to resist freeze-thaw damage (see A.4.3, Table A.8), aggressive chemicals (see A.4.4, Table A.11) and abrasion (no guidance provided).

<sup>B</sup>) Expressed as the minimum cover to reinforcement plus an allowance in design for deviation, c, e.g. to allow for workmanship. Check the appropriate design code to see whether it is recommended that the minimum cover to prestressing steel is adjusted by a factor Δc<sub>dur</sub>,γ<sup>C</sup>.

<sup>C</sup>) Also applies to heavyweight concrete. For lightweight concrete the maximum w/c ratio and minimum cement or combination content applies, but the compressive strength class needs to be changed to a lightweight compressive strength class (see BS EN 206-1:2000, Table A.8 and A.4.1, Note 2) on the basis of equal cylinder strength if designing to BS EN 1992.

<sup>D</sup>) For adjustments to cement content for different maximum size of aggregate, see Table A.7.

<sup>E</sup>) If the concrete is specified as being air entrained in accordance with the XF2 or XF4 recommendations in Table A.8, the minimum compressive strength class for corrosion induced by chlorides may be reduced to C28/35.

<sup>F</sup>) In some parts of the UK it is not possible to produce a practical concrete with a maximum w/c ratio of 0.35.
Table A.5  Durability \textsuperscript{A)} recommendations for reinforced or prestressed elements with an intended working life of at least 100 years

<table>
<thead>
<tr>
<th>Nominal cover b)</th>
<th>Compressive strength class where recommended, maximum water-cement ratio and minimum cement or combination content for normal-weight concrete c) with 20 mm maximum aggregate size d)</th>
<th>Cement/combination types</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>15 + Δc</td>
<td>25 + Δc</td>
</tr>
<tr>
<td>C20/25</td>
<td>0.70 240</td>
<td>0.70 240</td>
</tr>
<tr>
<td>C25/30</td>
<td>—</td>
<td>0.65 260</td>
</tr>
<tr>
<td>C30/37</td>
<td>—</td>
<td>C40/50</td>
</tr>
<tr>
<td>C32/40</td>
<td>—</td>
<td>C35/45</td>
</tr>
<tr>
<td>C35/45</td>
<td>—</td>
<td>C40/50</td>
</tr>
<tr>
<td>C40/50</td>
<td>—</td>
<td>C45/55</td>
</tr>
</tbody>
</table>

Corrosion induced by carbonation (XC exposure classes)

<table>
<thead>
<tr>
<th>XC1</th>
<th>C20/25</th>
<th>0.70 240</th>
<th>0.70 240</th>
<th>0.70 240</th>
<th>0.70 240</th>
<th>0.70 240</th>
<th>0.70 240</th>
<th>0.70 240</th>
<th>0.70 240</th>
<th>0.70 240</th>
</tr>
</thead>
<tbody>
<tr>
<td>XC2</td>
<td>C25/30</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
</tr>
<tr>
<td>XC3/4</td>
<td>C40/50</td>
<td>0.45 340</td>
<td>0.50 320</td>
<td>0.55 300</td>
<td>0.60 280</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
<td>0.65 260</td>
</tr>
<tr>
<td></td>
<td>C35/45</td>
<td>0.40 380</td>
<td>0.45 360</td>
<td>0.50 340</td>
<td>0.55 320</td>
<td>0.60 300</td>
<td>0.60 300</td>
<td>0.60 300</td>
<td>0.60 300</td>
<td>0.60 300</td>
</tr>
<tr>
<td></td>
<td>C30/37</td>
<td>0.35 340</td>
<td>0.40 320</td>
<td>0.45 300</td>
<td>0.50 280</td>
<td>0.55 260</td>
<td>0.60 240</td>
<td>0.65 220</td>
<td>0.65 200</td>
<td>0.65 180</td>
</tr>
<tr>
<td></td>
<td>C28/35</td>
<td>0.25 300</td>
<td>0.30 280</td>
<td>0.35 260</td>
<td>0.40 240</td>
<td>0.45 220</td>
<td>0.50 200</td>
<td>0.55 180</td>
<td>0.55 160</td>
<td>0.55 140</td>
</tr>
<tr>
<td></td>
<td>C25/30</td>
<td>0.20 280</td>
<td>0.25 260</td>
<td>0.30 240</td>
<td>0.35 220</td>
<td>0.40 200</td>
<td>0.45 180</td>
<td>0.50 160</td>
<td>0.55 140</td>
<td>0.55 120</td>
</tr>
<tr>
<td></td>
<td>C20/25</td>
<td>0.15 260</td>
<td>0.20 240</td>
<td>0.25 220</td>
<td>0.30 200</td>
<td>0.35 180</td>
<td>0.40 160</td>
<td>0.45 140</td>
<td>0.50 120</td>
<td>0.55 100</td>
</tr>
<tr>
<td></td>
<td>C15/20</td>
<td>0.10 240</td>
<td>0.15 220</td>
<td>0.20 200</td>
<td>0.25 180</td>
<td>0.30 160</td>
<td>0.35 140</td>
<td>0.40 120</td>
<td>0.45 100</td>
<td>0.50  80</td>
</tr>
<tr>
<td></td>
<td>C10/15</td>
<td>0.05 220</td>
<td>0.10 200</td>
<td>0.15 180</td>
<td>0.20 160</td>
<td>0.25 140</td>
<td>0.30 120</td>
<td>0.35 100</td>
<td>0.40  80</td>
<td>0.45  60</td>
</tr>
</tbody>
</table>

Corrosion induced by chlorides (XS from sea water, XD other than sea water)

Also adequate for any associated carbonation induced corrosion (XC)
### Table A.5  Durability \(^{A)}\) recommendations for reinforced or prestressed elements with an intended working life of at least 100 years (continued)

<table>
<thead>
<tr>
<th>Nominal cover (^{B)})</th>
<th>Compressive strength class where recommended, maximum water-cement ratio and minimum cement or combination content for normal-weight concrete (^{C)}) with 20 mm maximum aggregate size (^{D)})</th>
<th>Cement/comboination types</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>15 + (\Delta c)</td>
<td>25 + (\Delta c)</td>
</tr>
<tr>
<td>XD3</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>XS3</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
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<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

A dash (—) indicates that greater cover is recommended.

\(^{A)}\) Where appropriate, account should be taken of the recommendations to resist freeze-thaw damage (see \(A.4.3\), Table A.8), aggressive chemicals (see \(A.4.4\), Table A.11) and abrasion (no guidance provided).

\(^{B)}\) Expressed as the minimum cover to reinforcement plus an allowance in design for deviation, \(c\), e.g. to allow for workmanship. Check the appropriate design code to see whether it is recommended that the minimum cover to prestressing steel is adjusted by a factor \(\Delta c_{\text{dur}}\) or \(\gamma\).

\(^{C)}\) Also applies to heavyweight concrete. For lightweight concrete the maximum w/c ratio and minimum cement or combination content applies, but the compressive strength class needs to be changed to a lightweight compressive strength class (see BS EN 206-1:2000, Table A.8 and \(A.4.1\), Note 2) on the basis of equal cylinder strength if designing to BS EN 1992.

\(^{D)}\) For adjustments to cement content for different maximum size of aggregate, see Table A.7.

\(^{E)}\) If the concrete is specified as being air entrained in accordance with the XF2 or XF4 recommendations in Table A.8, the minimum compressive strength class for corrosion induced by chlorides may be reduced to C28/35.

\(^{F)}\) In some parts of the UK it is not possible to produce a practical concrete with a maximum w/c ratio of 0.35.
### Table A.6  Cement and combination types

<table>
<thead>
<tr>
<th>Broad designation</th>
<th>Composition</th>
<th>Comprises cement and combination types (see BS 8500-2:2006, Table 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEM I</td>
<td>Portland cement</td>
<td>CEM I</td>
</tr>
<tr>
<td>SRPC</td>
<td>Sulfate-resisting Portland cement</td>
<td>SRPC</td>
</tr>
<tr>
<td>IIA</td>
<td>Portland cement with 6% to 20% fly ash, ground</td>
<td>CEM II/A-L, CEM II/A-LL, CIIA-L, CIIA-LL, CEM II/A-S, CIIA-S, CEM II/A-V, CIIA-V, CEM II/A-D</td>
</tr>
<tr>
<td></td>
<td>granulated blastfurnace slag, limestone, or 6% to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10% silica fume (c)</td>
<td></td>
</tr>
<tr>
<td>IIB-S</td>
<td>Portland cement with 21% to 35% ground granulated</td>
<td>CEM II/B-S, CIIB-S</td>
</tr>
<tr>
<td></td>
<td>blastfurnace slag</td>
<td></td>
</tr>
<tr>
<td>IIB-V</td>
<td>Portland cement with 21% to 35% fly ash</td>
<td>CEM II/B-V, CIIB-V</td>
</tr>
<tr>
<td>IIIB-SR</td>
<td>Portland cement with 25% to 35% fly ash</td>
<td>CEM II/B-V+SR, CIIB-V+SR</td>
</tr>
<tr>
<td>IIA</td>
<td>Portland cement with 36% to 65% ground granulated</td>
<td>CEM III/A, CIIIA</td>
</tr>
<tr>
<td></td>
<td>blastfurnace slag</td>
<td></td>
</tr>
<tr>
<td>IIA+SR</td>
<td>Portland cement with 36% to 65% ground granulated</td>
<td>CEM III/A+SR (f), CIIIA+SR (f)</td>
</tr>
<tr>
<td></td>
<td>blastfurnace slag with additional requirements that</td>
<td></td>
</tr>
<tr>
<td></td>
<td>enhance sulfate resistance</td>
<td></td>
</tr>
<tr>
<td>IIIB+SR</td>
<td>Portland cement with 36% to 65% ground granulated</td>
<td>CEM III/B+SR (f), CIIB+SR (f)</td>
</tr>
<tr>
<td></td>
<td>blastfurnace slag</td>
<td></td>
</tr>
<tr>
<td>IVB-V</td>
<td>Portland cement with 36% to 55% fly ash</td>
<td>CEM IV/B(V), CIVB</td>
</tr>
</tbody>
</table>

---

**a)** There are a number of cements and combinations not listed in this table that may be specified for certain specialist applications. See BRE Special Digest 1 [1] for the sulfate-resisting characteristics of other cements and combinations. See IP 17/05 [7] for the use of high ggbs content cements and combinations in secant piling applications.

**b)** The use of these broad designations is sufficient for most applications. Where a more limited range of cement or combinations types is required, select from the notations given in BS 8500-2:2006, Table 1.

**c)** When IIA or IIA-D is specified, CEM I and silica fume may be combined in the concrete mixer using the k-value concept; see BS EN 206-1:2000, 5.2.5.2.3.

**d)** Where IIA is specified, IIA+SR may be used.

**e)** Inclusive of low early strength option (see BS EN 197-4 and the “L” classes in BS 8500-2:2006, Table A.1).

**f)** “+SR” indicates additional restrictions related to sulfate resistance. See BS 8500-2:2006, Table 1, footnote D.

**g)** Where IIIB is specified, IIIB+SR may be used.
The specifications for the RC-series of designated concretes include requirements for maximum w/c ratio and minimum cement or combination content, which makes specification easier and complete. However for designed concrete, conformity to the recommended compressive strength class will not necessarily ensure conformity to requirements for maximum w/c ratio or minimum cement or combination content. If a maximum w/c ratio or minimum cement content is required, it has to be specified. Failure to specify means that there is no requirement, as neither BS EN 206-1 nor BS 8500-2 have default values for designed concrete. The basic requirements detailed in 4.3 were selected to avoid this potential deficiency.

Models to predict concrete requirements for long-life structures in chloride environments do not give identical predictions, and extrapolating performance from existing structures also has many practical problems. Consequently there is a degree of uncertainty with the recommendations for an intended working life of at least 100 years in the chloride (XD) and sea water (XS) environments. Reliance solely on cover and concrete quality might not be the most economic solution. In these situations consideration may be given to using other techniques such as stainless steel or non-ferrous reinforcement, barriers, coatings and corrosion inhibitors, but these techniques also have their uncertainties. For guidance on these techniques see specialist literature, e.g. Concrete Society Technical Report 61 [8].

Table A.7  Minimum cement and combination contents with maximum aggregate sizes other than 20 mm

<table>
<thead>
<tr>
<th>Maximum w/c ratio</th>
<th>Minimum cement or combination content kg/m³</th>
<th>&gt;40 mm</th>
<th>14 mm</th>
<th>10 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.70</td>
<td>240</td>
<td>240</td>
<td>260</td>
<td>280</td>
</tr>
<tr>
<td>0.65</td>
<td>260</td>
<td>240</td>
<td>280</td>
<td>300</td>
</tr>
<tr>
<td>0.60</td>
<td>280</td>
<td>260</td>
<td>300</td>
<td>320</td>
</tr>
<tr>
<td>0.55</td>
<td>300</td>
<td>280</td>
<td>320</td>
<td>340</td>
</tr>
<tr>
<td></td>
<td>320</td>
<td>300</td>
<td>340</td>
<td>360</td>
</tr>
<tr>
<td>0.50</td>
<td>320</td>
<td>300</td>
<td>340</td>
<td>360</td>
</tr>
<tr>
<td></td>
<td>340</td>
<td>320</td>
<td>360</td>
<td>380</td>
</tr>
<tr>
<td>0.45</td>
<td>340</td>
<td>320</td>
<td>360</td>
<td>360</td>
</tr>
<tr>
<td></td>
<td>360</td>
<td>340</td>
<td>380</td>
<td>380</td>
</tr>
<tr>
<td>0.40</td>
<td>380</td>
<td>360</td>
<td>380</td>
<td>380</td>
</tr>
<tr>
<td>0.35</td>
<td>380</td>
<td>380</td>
<td>380</td>
<td>380</td>
</tr>
</tbody>
</table>
The concrete chloride class (the number in the classification being the maximum chloride ion by mass of cement or combination) needs to be specified for prescribed concrete, and for designated and designed concrete when the default chloride class does not apply. Concrete that is to be prestressed by pretensioning, and concrete containing reinforcement or other embedded metal that is to be heat-cured, should be specified as chloride class Cl 0,10. In post-tensioned prestressed concrete and unbonded prestressed concrete, no specific guidance is provided, as the appropriate chloride class will depend upon the particular exposure, type of structure and construction method. For internal post-tensioned office construction a chloride class of Cl 0,40 is appropriate. With strategic structures in severe chloride environments, e.g. bridges, a lower chloride class is appropriate; reference to the project specification should be made. Non-heat-cured reinforced concrete that contains ordinary carbon steel reinforcement or other embedded metal should be specified as chloride class Cl 0,40 except for concrete made with SRPC conforming to BS 4027, which should be specified as chloride class Cl 0,20, and concrete that will be subjected to significant amounts of external chloride, where a chloride class of Cl 0,30 might be appropriate.

The methods for measuring the chloride content of the constituent materials for concrete are specified in BS 8500-2:2006, and the method of determining the chloride content of fresh concrete is specified in BS EN 206-1:2000.

A.4.3 Concrete properties and limiting values to resist freeze-thaw attack

Table A.8 gives concrete properties and limiting values to resist the XF exposure classes. These recommended concrete qualities are suitable for an intended working life of both “at least 50 years” and “at least 100 years”.

When specifying concrete for pavements and hardstandings, consideration should be given to selecting the air-entrained option due to its superior freeze-thaw resistance. Guidance on suitable concrete qualities to provide an abrasion- and skid-resistant surface is not given in this British Standard. It should be noted that there are practical difficulties with entraining air into concrete with a compressive strength class of C35/45 or higher.

NOTE Pavements and hardstandings are often designed for a shorter intended working life than the “at least 50 years” guidance provided in this British Standard. This means that consideration could be given to relaxing the recommendations in Table A.4, but the recommendations in Table A.8 should not be relaxed.

In exposure classes XD2, XD3, XS1, XS2 and XS3, Table A.4 and Table A.5 permit a relaxation of the recommended minimum compressive strength class for corrosion induced by chlorides to C28/35 where the concrete is to be air entrained in accordance with Table A.8.
A.4.4 Concrete properties and limiting values to resist chemical attack

From the ACEC classification (see Table A.2), the intended working life and the hydraulic gradient, the quality of concrete, expressed as a design chemical class (DC-class), and the number of additional protective measures (APMs) should be selected using Table A.9. The APMs are listed in Table A.10. Table A.9 also gives lowest nominal cover recommended in the National Annex to BS EN 1992-1-1:2004.

BRE Special Digest 1 [1] gives full guidance that aids the selection of the DC-class and the relevant APMs. The DC-class or (FND) designated concrete specified to the producer should include any adjustments as the result of applying APM1 (enhanced concrete quality).
Table A.11 gives details of the limiting values associated with the specification of the DC-class. The recommendations in Table A.11 are adequate to resist carbonation-induced corrosion (XC2 exposure class) in fully buried reinforced concrete. The recommendations in Table A.11 for DC-2 and higher classes do not include a compressive strength class and this needs to be added to a designed concrete specification based on needs other than durability. Alternatively by specifying the equivalent FND designated concrete, the concrete will be supplied with a minimum compressive strength of C25/30. If, for structural reasons, a higher compressive strength class is needed, the designed concrete method of specification has to be used. In general fully buried concrete in the UK need not be designed to be freeze-thaw resisting.

Other than for brackish water (see Table A.2, footnote C), the recommendations in Table A.11 do not take account of conditions where chlorides are present in the soil or freeze-thaw resistance is required. In these situations the recommendations given in Table A.11 have to be compared with the recommendations given in Table A.4 or Table A.5 for resistance to chloride-induced corrosion and/or Table A.8 for freeze-thaw resistance, and the most onerous values, e.g. highest nominal cover, lowest maximum w/c ratio, have to be selected and specified.

Where the recommendations given for DC-2 to DC-4m control the concrete specification, the DC-class should be specified and not the limiting values. This approach to specification allows producers to use the cements and combinations they stock to produce concrete of the required durability. In all cases, it is necessary to specify the compressive strength class and any other appropriate requirements. Alternatively, where a compressive strength class of C25/30 is adequate, an equivalent FND designated concrete may be specified.
Table A.9  Selection of the nominal cover and DC-class or designated concrete and the number of APM for in-situ concrete elements\(^{A)}\) where the hydraulic gradient due to groundwater is five or less\(^{B), C), D)}\)

<table>
<thead>
<tr>
<th>ACEC-class</th>
<th>Lowest nominal cover (^{b)}), mm</th>
<th>Intended working life(^ {F)})</th>
<th>At least 50 years(^ {i), h)})</th>
<th>At least 100 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-1s, AC-1</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-1 (RC25/30 if reinforced)</td>
<td>DC-1 (RC25/30 if reinforced)</td>
<td></td>
</tr>
<tr>
<td>AC-2s, AC-2</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-2 (FND2)</td>
<td>DC-2 (FND2)</td>
<td></td>
</tr>
<tr>
<td>AC-2z</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-2z (FND2z)</td>
<td>DC-2z (FND2z)</td>
<td></td>
</tr>
<tr>
<td>AC-3s</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-3 (FND3)</td>
<td>DC-3 (FND3)</td>
<td></td>
</tr>
<tr>
<td>AC-3z</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-3z (FND3z)</td>
<td>DC-3z (FND3z)</td>
<td></td>
</tr>
<tr>
<td>AC-3</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-3 (FND3)</td>
<td>DC-3 + one APM of choice, FND3 + one APM of choice, DC-4 or FND4</td>
<td></td>
</tr>
<tr>
<td>AC-4s</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-4 (FND4)</td>
<td>DC-4 (FND4)</td>
<td></td>
</tr>
<tr>
<td>AC-4z</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-4z (FND4z)</td>
<td>DC-4z (FND4z)</td>
<td></td>
</tr>
<tr>
<td>AC-4</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-4 (FND4)</td>
<td>DC-4 + one APM from APM2 to APM5, or FND4 + one APM from APM2 to APM5</td>
<td></td>
</tr>
<tr>
<td>AC-4ms</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-4m (FND4m)</td>
<td>DC-4m (FND4m)</td>
<td></td>
</tr>
<tr>
<td>AC-4m</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-4m (FND4m)</td>
<td>DC-4m + one APM from APM2 to APM5, or FND4m + one APM from APM2 to APM5</td>
<td></td>
</tr>
<tr>
<td>AC-5z</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-4z (FND4z) + APM3 (^{k})</td>
<td>DC-4z (FND4z) + APM3 (^{k})</td>
<td></td>
</tr>
<tr>
<td>AC-5</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-4 (FND4) + APM3 (^{k})</td>
<td>DC-4 (FND4) + APM3 (^{k})</td>
<td></td>
</tr>
<tr>
<td>AC-5m</td>
<td>50(^{i)}, 75(^{j})</td>
<td>DC-4m (FND4m)+ APM3 (^{k})</td>
<td>DC-4m (FND4m) + APM3 (^{k})</td>
<td></td>
</tr>
</tbody>
</table>

\(^{A)}\) For guidance on precast concrete products, see BRE Special Digest 1 [1].

\(^{B)}\) Where the hydraulic gradient across a concrete element is greater than 5, one step in DC-class or one APM over and above the number indicated in the table should be applied except where the original provisions included APM3. Where APM3 is already required, or has been selected, an additional APM is not necessary.

\(^{C)}\) A section thickness of 140 mm or less should be avoided in in-situ construction but where this is not practicable, apply one step higher DC-class (designated concrete) or an additional APM except where the original provisions included APM3. Where APM3 is already required, or has been selected, an additional APM is not necessary.

\(^{D)}\) Where a section thickness greater than 450 mm is used and some surface chemical attack is acceptable, a relaxation of one step in DC-class (designated concrete) may be applied. For reinforced concrete, the cover should be sufficiently thick to allow for estimated surface degradation during the intended working life.

\(^{E)}\) Where the ground contains chlorides, the nominal cover should comprise the recommended minimum cover for the associated XD or XS class plus an allowance for deviation, \(\Delta c\), of at least 25 mm for concrete to be cast against blinding and at least 50 mm for concrete to be cast directly against soil, and the more onerous limiting values for the concrete should be selected.

\(^{F)}\) Designated concrete classes are given in parentheses.

\(^{G)}\) Foundations of low-rise housing that has an intended working life of “at least 100 years” may be constructed with concrete selected from the column headed “at least 50 years”.

\(^{H)}\) Structures with an intended working life of “at least 50 years” but for which the consequences of failure would be relatively serious, should be classed as having an intended working life of “at least 100 years” for the selection of the DC-class (designated concrete) and APM.

\(^{I)}\) For concrete cast against blinding.

\(^{J)}\) For concrete cast directly against the soil.

\(^{K)}\) Where APM3 is not practical, select an alternative APM.

Table A.10  Additional protective measures (APMs)

<table>
<thead>
<tr>
<th>Option code</th>
<th>APM</th>
</tr>
</thead>
<tbody>
<tr>
<td>APM1</td>
<td>Enhanced concrete quality</td>
</tr>
<tr>
<td>APM2</td>
<td>Use of controlled permeability formwork</td>
</tr>
<tr>
<td>APM3</td>
<td>Provide surface protection</td>
</tr>
<tr>
<td>APM4</td>
<td>Provide sacrificial layer</td>
</tr>
<tr>
<td>APM5</td>
<td>Address drainage of site</td>
</tr>
</tbody>
</table>
Where concrete is to be in contact with sea water, it needs to be of a sufficient quality to resist sea water attack. The recommendations to resist reinforcement corrosion induced by sea water (see Table A.4 and Table A.5) provide concretes with adequate resistance to the chemical attack on the concrete by sea water. Where unreinforced concrete is to be in contact with sea water, the maximum w/c ratio should not be more than and minimum cement or combination content should be not less than that given in Table A.12.

Table A.11  Limiting values of composition and properties for concrete where a DC-class is specified

<table>
<thead>
<tr>
<th>DC-class</th>
<th>Max. w/c ratio</th>
<th>Min. cement or combination content (kg/m³) for max. aggregate size</th>
<th>Cement and combination types</th>
<th>Grouping used in BRE SD1: 2005 [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>40 mm 20 mm 14 mm 10 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC-1 A)</td>
<td>—</td>
<td>340 360 380 380</td>
<td>IIB-V+SR, IIIA+SR, IIIB+SR, IVB-V</td>
<td>D, E, F</td>
</tr>
<tr>
<td></td>
<td>0.55</td>
<td>300 320 340 360</td>
<td>CEM I, SRPC, IIA-D, IIA-Q, IIA-S, IIA-V, IIB-V, IIIA, IIIIB</td>
<td>D, E, F</td>
</tr>
<tr>
<td>DC-2</td>
<td>0.45</td>
<td>340 360 380 380</td>
<td>IIA-L or LL ≥42.5</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>0.40</td>
<td>360 380 380 380</td>
<td>IIA-L or LL 32,5</td>
<td>C</td>
</tr>
<tr>
<td>DC-2z</td>
<td>0.55</td>
<td>300 320 340 360</td>
<td>All in Table A.6</td>
<td>A to G</td>
</tr>
<tr>
<td>DC-3</td>
<td>0.45</td>
<td>340 360 380 380</td>
<td>IIB-V+SR</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>0.40</td>
<td>360 380 380 380</td>
<td>IIB-V</td>
<td>E</td>
</tr>
<tr>
<td>DC-3z</td>
<td>0.50</td>
<td>320 340 360 380</td>
<td>All in Table A.6</td>
<td>A to G</td>
</tr>
<tr>
<td>DC-4</td>
<td>0.45</td>
<td>340 360 380 380</td>
<td>IIB-V+SR</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td>0.35</td>
<td>380 380 380 380</td>
<td>IIB-V, IIIA+SR, SRPC</td>
<td>D, G</td>
</tr>
<tr>
<td>DC-4z</td>
<td>0.45</td>
<td>340 360 380 380</td>
<td>All in Table A.6</td>
<td>A to G</td>
</tr>
<tr>
<td>DC-4m</td>
<td>0.45</td>
<td>340 360 380 380</td>
<td>IIB-V+SR</td>
<td>F</td>
</tr>
</tbody>
</table>

A) If the concrete is reinforced or contains embedded metal, the minimum concrete quality for 20 mm maximum aggregate size is C25/30, 0.65, 260 or designated concrete RC25/30.

Where concrete is to be in contact with sea water, it needs to be of a sufficient quality to resist sea water attack. The recommendations to resist reinforcement corrosion induced by sea water (see Table A.4 and Table A.5) provide concretes with adequate resistance to the chemical attack on the concrete by sea water. Where unreinforced concrete is to be in contact with sea water, the maximum w/c ratio should not be more than and minimum cement or combination content should be not less than that given in Table A.12.

Table A.12  Limiting values of composition for unreinforced concrete in contact with sea water

<table>
<thead>
<tr>
<th>Max. w/c ratio</th>
<th>Min. cement or combination content (kg/m³) for max. aggregate size</th>
<th>Cement and combination types A)</th>
<th>Indicative compressive strength class B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 mm 20 mm 14 mm 10 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.55</td>
<td>280 300 320 340</td>
<td>CEM I, SRPC, IIA, IIB-S</td>
<td>(C28/35)</td>
</tr>
<tr>
<td>0.55</td>
<td>280 300 320 340</td>
<td>IIB-V, IIB-V+SR, IIIA, IIIA+SR</td>
<td>(C25/30)</td>
</tr>
<tr>
<td>0.55</td>
<td>280 300 320 340</td>
<td>IIB, IIB+SR, IVB-V</td>
<td>(C20/25)</td>
</tr>
</tbody>
</table>

A) See Table A.6.
B) This is an indicative compressive strength class and not a recommended minimum compressive strength class for durability; see A.4.2.

For the avoidance of deterioration due to sulfates within the original concrete, see A.7.4 and A.8.2. For the avoidance of damaging alkali–silica reaction, see A.8.1.
A.4.5 Guidance on the selection of concrete for housing and other applications

Table A.13 provides guidance on the selection of designated concrete and standardized prescribed concrete in housing and other applications, together with a recommended consistence class. See Table A.3 for reinforced concrete applications of designated concretes. The associated compressive strength classes, limiting values and default slump classes for designated concrete are given in Table A.14. For standardized prescribed concrete the compressive strength classes given in Table A.15 may be assumed for structural design purposes. The proportions of standardized prescribed concretes were selected to give assurance that in most cases they will produce concrete of the indicated characteristic strength. However, where strength or durability is important, a designated or designed concrete should be specified.

Other than blinding or similar applications, standardized prescribed concretes should not be used where the presence of sulfates or other aggressive chemicals in the groundwater, the ground or any adjacent material give a ACEC classification higher than AC-1 (see A.2.4). For more aggressive sulfate or other aggressive chemical conditions, the concrete should be specified as a designated (FND) concrete if a C25/30 compressive strength class is adequate, a designed concrete for other compressive strength classes, or, if there is no compressive strength requirement, a prescribed concrete. It should be noted that standardized prescribed concrete produced using sulfate-resisting cement is not intended to produce sulfate-resisting concrete.

Cast in-situ concrete for house drives and similar external areas is liable to attack by freezing and thawing, which is made worse by the use of de-icing salts. Where these conditions are likely to occur, it is recommended that the concrete contains entrained air. Air-entrainment is not permitted in standardized prescribed concrete (see BS EN 206-1:2000, 5.2.1), but is within the scope of designated concretes (see Table A.14) and designed concrete.

ST1 and ST2 concrete should not be specified where the concrete is to contain reinforcement or embedded metal, as the chloride class for these concretes is Cl 1,0.

Table A.13 contains recommendations for both designated and standardized prescribed concretes. Where the specifier wishes to permit a choice between using either small-scale mixing on site or ready-mixed concrete, both approaches (as alternatives) should be included in the specification.
Table A.13  Guidance on the selection of designated and standardized prescribed concrete in housing and other applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Designated concrete</th>
<th>Standardized prescribed concrete</th>
<th>Recommended consistence class</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unreinforced foundations and associated works requiring DC-1 concrete</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blinding and mass concrete fill</td>
<td>GEN1</td>
<td>ST2</td>
<td>S3 (c)</td>
</tr>
<tr>
<td>Strip footings</td>
<td>GEN1</td>
<td>ST2</td>
<td>S3 (c)</td>
</tr>
<tr>
<td>Mass concrete foundations</td>
<td>GEN1</td>
<td>ST2</td>
<td>S3 (c)</td>
</tr>
<tr>
<td>Trench fill foundations</td>
<td>GEN1</td>
<td>ST2</td>
<td>S4</td>
</tr>
<tr>
<td>Drainage works to give immediate support</td>
<td>GEN1</td>
<td>ST2</td>
<td>S1</td>
</tr>
<tr>
<td>Other drainage works</td>
<td>GEN1</td>
<td>ST2</td>
<td>S3 (c)</td>
</tr>
<tr>
<td>Oversite below suspended slabs</td>
<td>GEN1</td>
<td>ST2</td>
<td>S3 (c)</td>
</tr>
<tr>
<td><strong>Unreinforced foundations requiring DC-2 to DC-4 concrete</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC-2</td>
<td>FND2</td>
<td>N/A</td>
<td>S3 (c), D)</td>
</tr>
<tr>
<td>DC-2z</td>
<td>FND2Z</td>
<td>N/A</td>
<td>S3 (c), D)</td>
</tr>
<tr>
<td>DC-3</td>
<td>FND3</td>
<td>N/A</td>
<td>S3 (c), D)</td>
</tr>
<tr>
<td>DC-3z</td>
<td>FND3Z</td>
<td>N/A</td>
<td>S3 (c), D)</td>
</tr>
<tr>
<td>DC-4</td>
<td>FND4</td>
<td>N/A</td>
<td>S3 (c), D)</td>
</tr>
<tr>
<td>DC-4z</td>
<td>FND4Z</td>
<td>N/A</td>
<td>S3 (c), D)</td>
</tr>
<tr>
<td>DC-4m</td>
<td>FND4M</td>
<td>N/A</td>
<td>S3 (c), D)</td>
</tr>
<tr>
<td><strong>General applications</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kerb bedding and backing</td>
<td>GEN0</td>
<td>ST1</td>
<td>S1</td>
</tr>
<tr>
<td><strong>Floors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>House floors with no embedded metal (see Note 2 to 4.2.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Permanent finish to be added, e.g. a screed or floating floor</td>
<td>GEN1</td>
<td>ST2</td>
<td>S2</td>
</tr>
<tr>
<td>• No permanent finish to be added, e.g. carpeted</td>
<td>GEN2</td>
<td>ST3</td>
<td>S2</td>
</tr>
<tr>
<td>Garage floors with no embedded metal</td>
<td>GEN3</td>
<td>ST4</td>
<td>S2</td>
</tr>
<tr>
<td>Wearing surface: light foot and trolley traffic</td>
<td>RC25/30</td>
<td>ST4</td>
<td>S2</td>
</tr>
<tr>
<td>Wearing surface: general industrial</td>
<td>RC32/40</td>
<td>N/A</td>
<td>S2</td>
</tr>
<tr>
<td>Wearing surface: heavy industrial E)</td>
<td>RC40/50</td>
<td>N/A</td>
<td>S2</td>
</tr>
<tr>
<td><strong>Paving</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>House drives and domestic parking</td>
<td>PAV1</td>
<td>N/A</td>
<td>S2 (c)</td>
</tr>
<tr>
<td>Heavy-duty external paving with rubber tyre vehicles E)</td>
<td>PAV2</td>
<td>N/A</td>
<td>S2 (c), F)</td>
</tr>
</tbody>
</table>

A) Concrete containing embedded metal should be treated as reinforced.
B) See Table A.3 for designated concretes for reinforced foundations and reinforced concrete.
C) This is the default slump class for this designated concrete.
D) For trench fill, the recommended consistence class is S4.
E) For extreme applications, e.g. foundry floors and busy public roads, specialist advice should be sought.
F) Depends on method of placing.
<table>
<thead>
<tr>
<th>Concrete designation</th>
<th>Min. strength class</th>
<th>Default slump class</th>
<th>Max. w/c ratio</th>
<th>Min. cement or combination content (kg/m³) for 20 mm max. aggregate size</th>
<th>Cement and combination types</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN0</td>
<td>C6/8</td>
<td>S3</td>
<td></td>
<td>120</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>GEN1</td>
<td>C8/10</td>
<td>S3</td>
<td></td>
<td>180</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>GEN2</td>
<td>C12/15</td>
<td>S3</td>
<td></td>
<td>200</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>GEN3</td>
<td>C16/20</td>
<td>S3</td>
<td></td>
<td>220</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>RC20/25</td>
<td>C20/25</td>
<td>S3</td>
<td>0.70</td>
<td>240</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>RC25/30</td>
<td>C25/30</td>
<td>S3</td>
<td>0.65</td>
<td>260</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>RC28/35</td>
<td>C28/35</td>
<td>S3</td>
<td>0.60</td>
<td>280</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>RC30/37</td>
<td>C30/37</td>
<td>S3</td>
<td>0.55</td>
<td>300</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>RC32/40</td>
<td>C32/40</td>
<td>S3</td>
<td>0.55</td>
<td>300</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>RC35/45</td>
<td>C35/45</td>
<td>S3</td>
<td>0.50</td>
<td>320</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>RC40/50</td>
<td>C40/50</td>
<td>S3</td>
<td>0.45</td>
<td>340</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>RC40/50XF</td>
<td>C40/50</td>
<td>S3</td>
<td>0.45</td>
<td>340</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA, IV-B-V</td>
</tr>
<tr>
<td>PAV1</td>
<td>C25/30 (c)</td>
<td>S2</td>
<td>0.60</td>
<td>280</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA</td>
</tr>
<tr>
<td>PAV2</td>
<td>C28/35 (c)</td>
<td>S2</td>
<td>0.55</td>
<td>300</td>
<td>CEM I, IIA, II-B-S, II-B-V, IIIA</td>
</tr>
<tr>
<td>FND2</td>
<td>C25/30</td>
<td>S3</td>
<td>0.55</td>
<td>320</td>
<td>II-B-V+SR, IIIA+SR, II-B-SR, IV-B-V</td>
</tr>
<tr>
<td>FND3</td>
<td>C25/30</td>
<td>S3</td>
<td>0.50</td>
<td>340</td>
<td>CEM I, SRPC, II-S, II-V, IIIA, IIIB</td>
</tr>
<tr>
<td>FND3Z</td>
<td>C25/30</td>
<td>S3</td>
<td>0.45</td>
<td>360</td>
<td>II-A-L or LL ≥ class 42.5</td>
</tr>
<tr>
<td>FND4</td>
<td>C25/30</td>
<td>S3</td>
<td>0.40</td>
<td>380</td>
<td>II-A-L or LL class 32.5</td>
</tr>
<tr>
<td>FND4Z</td>
<td>C25/30</td>
<td>S3</td>
<td>0.45</td>
<td>360</td>
<td>All in Table A.6</td>
</tr>
<tr>
<td>FND4M</td>
<td>C25/30</td>
<td>S3</td>
<td>0.45</td>
<td>360</td>
<td>All in Table A.6</td>
</tr>
</tbody>
</table>

A) See BS 8500-2:2006, Clause 6 for the full set of requirements for designated concretes.

B) Only if specifically permitted under 4.2.3a).

C) The concrete is required by BS 8500-2 to contain an air-entraining admixture to give a minimum air content by volume of 3.0%, 3.5% or 5.5% with aggregate of 40 mm, 20 mm and 10 mm maximum aggregate size respectively at delivery.
A.5 Selection of consistence

The consistence of fresh concrete should be suitable for the conditions of handling and placing so that after compaction, concrete surrounds all reinforcement, tendons and ducts and completely fills the formwork. Table A.16 provides guidance on the consistence expressed as slump \([S(number)]\) and flow \([F(number)]\) classes appropriate to different uses. Where the concrete is laid on a slope, a lower slump class than that given in Table A.16 might be necessary.

Consistence should be specified by using one of the classes in BS EN 206-1:2000, Table 3 to Table 6 or, in special cases, by a target value. Where self-compacting concrete is required, guidance may be obtained from specialist literature. For example, the classes in The European Guidelines for self-compacting concrete – specification, production and use [2] may be specified and that document cited for conformity criteria and test methods.

It is normally the responsibility of the user of the fresh concrete to make the selection of consistence and inform the specifier of the requirements. The specifier should add this requirement to the specification.
A.6 Density

The density of lightweight concrete should be specified by density class (see BS EN 206-1:2000, Table 9) or by target value. The density of normal-weight and heavyweight concrete can only be specified as a target value.

NOTE 1 It is not normally necessary to specify density with normal-weight concrete.

Where target density is specified, it should be expressed in kilograms per cubic metre (kg/m³) normally on an oven-dry basis. In special circumstances density may be specified in other moisture conditions, e.g. fresh density or the density on demoulding.

NOTE 2 For structural design purposes, the in-situ density will be higher than the oven-dry density. See BS EN 1991-1-1 for guidance.

A.7 Guidance on aggregate classes

A.7.1 General

Generally, aggregates should conform to the British Standards listed in BS 8500-2:2006, 4.3. In making reference to aggregates conforming to these standards, there might be a need to specify or approve certain characteristics including size, grading, impurities, durability and other properties.

a) BS EN 12620 and BS EN 13055-1 cover the use of natural, manufactured and recycled aggregates. BS 8500-2 imposes additional requirements on recycled aggregates. Neither of these standards uses the term “secondary” aggregates, but such aggregates are covered by these standards, albeit under a different name.

b) The specification of normal-weight and heavyweight aggregates should follow the recommendations given in PD 6682-1.

c) Some minimum requirements for aggregates are included in BS 8500-2:2006, 4.3 and in most situations, additional requirements for aggregates are not necessary. This subclause has placed additional requirements on lightweight aggregates so that when lightweight designed concrete is specified, further requirements on the lightweight aggregate are not normally necessary.

BS 8500 uses the simpler term “maximum aggregate size” to mean the “maximum nominal upper aggregate size” (the term used in BS EN 206-1) and it is acceptable to specify the maximum aggregate size as 10 mm, 20 mm or 40 mm as appropriate. In these cases the nominal upper aggregate size used in the concrete will be 4/10 mm, 10/20 mm and 20/40 mm respectively. It should be noted that BS EN 12620 permits a small proportion of the aggregate to be larger than the nominal upper aggregate size.
The maximum aggregate size has to be selected and specified. This depends upon the minimum cover to reinforcement, the minimum section dimension and the spacing between bars, particularly at laps (see A.3). Aggregates with a maximum aggregate size of 20 mm (10/20 mm) and 10 mm (4/10 mm) conforming to the grading requirements in BS EN 12620 are widely available in the United Kingdom. Another size that is available in certain locations is 40 mm (20/40 mm). For most work, a maximum aggregate size of 20 mm is suitable. Where there are no restrictions to the flow of concrete into sections, a maximum aggregate size of 40 mm should be specified.

NOTE If 40 mm aggregate is not available, the producer may offer a maximum aggregate size of 20 mm as an alternative.

In concrete elements with thin sections, closely spaced reinforcement or small cover to reinforcement, a maximum aggregate size of 10 mm is recommended. Further guidance on the grading requirements and particle size distribution is given in PD 6682-1.

Where appearance is important, the aggregate should not contain surface-marring materials such as pyrites; see BS EN 12620:2002, G.4. The producer should be informed where appearance is important to ensure that appropriate aggregates can be selected.

Aggregate type can affect the fire resistance provided by the concrete. The selection of aggregates with lower thermal expansion such as lightweight aggregates or limestone can be advantageous. Aggregates with low coefficients of thermal expansion are also beneficial in reducing the risk or extent of early-age thermal cracking.

A.7.2 Aggregates for wear resistance

There is a default requirement in BS 8500-2:2006, 4.3 for the Los Angeles coefficient category of coarse normal-weight and heavyweight aggregate to be not greater than LA40 as classified in BS EN 12620 or the suitability of the aggregate to be established by testing. Where needed, a different value may be specified. Aggregates having Los Angeles coefficient values above 40 might also perform satisfactorily in normal concrete but their compressive strength and, if reinforced, shear strength performance should be established in concrete trials before use.

Current guidance on industrial floors (see Concrete Society Technical Report 34 [9]) does not recommend a higher abrasion resistance, i.e. a lower LA category, as it is not expected that the coarse aggregate will be exposed.

For wear resistance specified by performance, see BS EN 13813.
A.7.3 Drying shrinkage of aggregates

Most aggregates have low moisture movements. Aggregates having high moisture movements, such as some dolerites and basalts, and gravels containing these rocks, produce concrete having an above average initial drying shrinkage. Where the drying shrinkage exceeds certain values, this can result in deterioration of exposed concrete, cracking and excessive deflections of reinforced concrete. A method of test is given in BS EN 1367-4. It should be noted that the BS EN 1367-4 test actually measures the drying shrinkage of a standard concrete containing the aggregate under test, not the specific drying shrinkage of the aggregate. Guidance on design recommendations for satisfactory use of high drying shrinkage aggregates in concrete for structures is given in BRE Digest 357 [10].

There is a default requirement in BS 8500-2:2006, 4.3 for coarse aggregates to produce a drying shrinkage that is not greater than 0.075% when tested in accordance with BS EN 1367-4. Verification by testing is required for aggregate types listed as being susceptible to high drying shrinkage in BRE Digest 357 [10] or an unfamiliar type. Where the concrete is not expected to dry in service or the design has taken account of the high drying shrinkage, the specifier may delete this requirement.

A.7.4 Sulfates in aggregates

After hardening of the concrete, excessive amounts of mobile sulfate from aggregates or other constituents in concrete can cause expansion and disruption. To prevent this, specifications for many constituent materials put limits on the sulfate level. Where appropriate BS 8500-2:2006, 4.3 has included for aggregates limits on the acid-soluble sulfate content, which were taken from superseded BS aggregate standards or, in the case of recycled concrete aggregates, from recent research [11].

Within the United Kingdom, sulfate problems caused by natural aggregates are rare. However, world-wide there are natural aggregates with sulfate levels of sufficient magnitude to cause disruption of concrete. Where the source of aggregate is new or is suspected of containing sulfate, tests on the aggregates for sulfate content prior to acceptance are advised.

NOTE As no tests exist to determine mobile sulfate content, it is usual to measure the acid-soluble sulfate contents of the aggregates. The relationship between such measurements and the mobile sulfate content of the hardened concrete is variable and therefore no universal sulfate limit can sensibly be applied to concrete. For example, a 4% or 5% limit on concrete would exclude many lightweight and blast furnace slag aggregates with long histories of satisfactory use.
A.7.5 Freeze-thaw resistance

COMMENTARY ON POROUS FLINT AGGREGATES
The magnesium sulfate test if used on porous flint aggregate concrete is likely to indicate that the concrete is unsuitable for use in freeze-thaw conditions, which conflicts with decades of experience of successful use in practice.

In exposure classes XF3 and XF4, it is recommended that the aggregates are specified as freeze-thaw resisting. In BS 8500-2:2006, 4.3, requirements are given in terms of a performance in the magnesium sulfate soundness test carried out in accordance with BS EN 1367-2. Such a test is not sufficiently discriminating when used on certain porous flint aggregates and the only guide in this case is experience with concrete made with the aggregate in question after several years’ exposure to freeze-thaw conditions.

A.7.6 Lightweight aggregates

BS EN 13055-1 covers a wide range of lightweight aggregate types and uses, including some not within the scope of BS EN 206-1:2000. Where structural lightweight concrete is to be used, BS 8500-2:2006, 4.3 specifies requirements for the lightweight aggregate. These are:

- an acid-soluble sulfate content not more than 1% when measured in accordance with BS EN 1744-1;
- for furnace bottom ash or clinker, a loss-on-ignition not more than 10% when measured in accordance with BS EN 1744-1;
- where concrete is to be placed in XF3 or XF4 exposure conditions, data demonstrating adequate freeze-thaw resistance when used in concrete.

Lightweight aggregate concrete might require initial testing in accordance with BS EN 206-1:2000, Annex A.

A.8 Internal degradation of concrete

A.8.1 Alkali–aggregate reaction

Alkali–silica reaction is the more common form of alkali–aggregate reaction and the only form that is known to have affected structures in the United Kingdom. Dry concrete is not prone to cracking by alkali–silica reaction, as it needs an external source of water to develop sufficiently to cause cracking.

For designated, designed and standardized prescribed concretes, the producer is required to take action to minimize damaging alkali–silica reaction (see BS 8500-2:2006, 5.2). If the producer follows the guidance given in BRE Digest 330 [12], this will be deemed to have satisfied the requirement to minimize damaging alkali–silica reaction. These actions apply regardless of whether the concrete will be in a dry environment. Whilst BS EN 206-1:2000, Note 1 to 6.2.3 states that where special types and classes of aggregate are specified, the concrete composition to minimize damaging alkali–silica reaction is the responsibility of the specifier, the view within BSI was that this is an impractical requirement to place on the specifier. For example, if the specifier specifies a polished stone value for wear resistance, they will have no knowledge of what rock type will be used and the producer could select a greywacke which is classified as being highly reactive. The producer, not the specifier, has all the information to be able to minimize the risk of damaging alkali–silica reaction. Consequently, BS 8500-2:2006, 5.2 requires the producer to take action to minimize the risk of damaging alkali–silica reaction for designated, designed and standardized prescribed concrete even when special types and classes of aggregate are specified.
The designed concrete method of specification permits the specification of "other technical requirements". This includes different provisions for minimizing the risk of damaging alkali–silica reaction. If the concrete is to remain in a dry environment, the specifier may specify no requirements. On the other hand, if the concrete is to be in contact with a significant external source of alkalis, the specifier might wish to specify more onerous requirements.

BS EN 206-1:2000, 6.1 states that for prescribed concrete, the specifier is responsible for ensuring that the specified composition will not be prone to damaging alkali–silica reaction. Due to the general nature of most prescribed concrete specifications, e.g. cement type and strength class, aggregates conforming to a standard, it is not normally practical for the specifier to check that damaging alkali–silica reaction will not occur. The practical solution is to include in the specification the additional requirement in 4.4.3a) of this part of BS 8500, which requires the producer to take action to minimize the risk of damaging alkali–silica reaction. If this creates problems for the producer, they are expected to inform the specifier.

In some of the sets of recommendations to minimize the risk of damaging alkali–silica reaction given in BRE Digest 330 [12], conformity is based on the declared mean alkali content of a cement or the CEM I component of a combination. 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.

When assessing new types of aggregates for use in concrete, all forms of alkali–aggregate reaction should be considered.

A.8.2 Delayed ettringite formation
Where the heat of hydration or accelerated curing is likely to take the concrete temperature above 70 °C, the potential for delayed ettringite formation should be considered. The state of knowledge on delayed ettringite formation and advice on its avoidance is given in BRE Information Paper IP11/01 [13].

A.9 Temperature
A.9.1 General
BS 8500-2 requires concrete to be delivered within 2 h after the time of loading where transported in truck mixers or agitators or within 1 h after the time of loading where non-agitating equipment is used, unless a shorter time is specified or a longer time permitted by the specifier. These limits are sufficient for normal UK temperatures.
A.9.2 Work in cold weather

In cold weather, consideration should be given to:

- prevention of freezing of the immature concrete;
- extended stiffening times, which can lead to increased formwork pressures and delays in finishing;
- low rates of concrete strength development, which can lead to delays in subsequent construction operations such as striking formwork.

As part of the overall approach to working in cold weather, consideration should be given to taking steps such as insulation of the fresh concrete. The following steps modify the concrete in ways that can help counter the effects of cold weather:

a) increasing the cement or combination content to increase the heat of hydration and early strength;

b) changing the cement or combination type within the permitted range of types to one with a higher heat of hydration at low temperatures, e.g. Portland cement;

c) using admixtures that reduce the setting time and/or increase the rate of strength gain;

d) specifying a minimum temperature of fresh concrete greater than that given in BS EN 206-1:2000, 5.2.8.

NOTE This might require some of the mix constituents or the concrete to be heated. If steam is used to heat the concrete this is taken into account when checking the maximum w/c ratio criterion.

A.9.3 Work in hot weather

In hot weather consideration should be given to:

- avoiding reductions in the working life of the fresh concrete due to loss of mix water by evaporation and accelerated hydration;
- preventing a high temperature rise in the concrete element which could lead to unacceptable levels of early-age thermal cracking, reductions in the ultimate quality of the concrete and delayed ettringite formation.

In hot weather, the stability of the entrained air content is reduced at placing temperatures above about 30 °C and so a maximum temperature of 30 °C should be specified.

The following steps modify the concrete in ways that can help counter the effects of hot weather:

a) using admixtures to retard the hydration and/or increase the initial workability. A retarder will not compensate for stiffening by moisture loss;

b) using a cement or combination that has a low heat evolution;

c) specifying a maximum temperature of fresh concrete less than that given in BS 8500-2:2006, 5.4.
High temperatures increase the rate at which the concrete loses consistence. A potential solution is to specify shorter times of transport, but in many site situations this is an impractical option. A better solution is to use a retarder to slow chemical stiffening and to agree with the producer a means by which the consistence may be adjusted on site under the responsibility of the producer to compensate for loss of water by evaporation.

A.10 Conformity and identity testing

BS EN 206-1 permits conformity to the specified compressive strength class to be based on test data from 100 mm cubes. The required value of the minimum characteristic strength based on 100 mm cubes is specified in BS 8500-2:2006, 12.2.

The producer need only use one shape and size of specimen for conformity testing, either cylinders or cubes (see BS EN 206-1:2000, 5.5.1.1). The specimen shape and size to be tested is selected by the concrete producer and declared (see BS EN 206-1:2000, 5.5.1.2). In the United Kingdom this is likely to be the 100 mm cube.

BS EN 206-1 requires the concrete producer to operate a defined conformity control procedure and to inform the specifier and user of any non-conformity that was not obvious at the time of delivery. Testing by the user or specifier is not part of the conformity control procedure. However, the concept of identity testing is introduced for cases where there is doubt over the concrete quality or for spot checks. Whenever there is doubt over a particular batch of concrete, identity testing of that batch is recommended.

To give the specifier independent assurance that the concrete conforms to the specification and that non-conformities are reported correctly, a requirement for the concrete producer to hold accredited third-party certification is strongly recommended where the specifier and the producer are not the same party. Where the producer does not hold accredited third-party certification, independent identity tests by the specifier’s representative are recommended. BS EN 206-1 requires the producer to inform the specifier and user of any non-conformity and the contract specification should require such notifications to be passed by the specifier to other interested parties, e.g. the designer.

Requirements for identity testing for slump, flow, air content and density on individual batches of concrete are given in Annex B.

Requirements for identity testing for compressive strength are given in BS EN 206-1:2000, Annex B for two to six test results and in Annex B of this part of BS 8500 for more than six test results. Annex B of this part of BS 8500 also clarifies how identity testing for compressive strength should be undertaken.
Prior to contract, where identity testing is not restricted to cases of doubt or random spot checks, BS EN 206-1 requires the specifier to define the type of test, the volume of concrete in the assessment and the number of tests on this volume of concrete, and to give this information to the producer. Experience of using BS EN 206-1 has shown that this is an impractical requirement, as the volumes of concrete might not be known prior to contract. In such situations, it is adequate to inform the producer that identity testing will be undertaken on volumes of concrete still to be defined using the criteria in BS EN 206-1 and BS 8500. For clarity of application, it is better to have clearly identified volumes of concrete, e.g. the concrete in a floor slab. The volume of concrete should be selected so that no more than six identity tests are undertaken on any volume of concrete, because BS EN 206-1 only gives rules for two to six results. Where more than six results are obtained, they will have to be split into groups of six non-overlapping results in accordance with B.5 for assessment of whether the concrete came from a conforming population. The specifier is responsible for organizing any identity testing.

The results used in a volume of concrete should represent a relatively short chronological period to minimize the risk of including a step change in quality. BS EN 206-1 requires the producer to maintain a certain strength margin above the specified characteristic strength. This can result in abrupt changes of strength which could be reflected in results from identity testing. Any failure to satisfy the identity testing criterion should be discussed with the producer prior to requiring any other action to be taken.

Annex B (normative) Identity testing for slump, flow, air content, density and additional requirements for compressive strength

B.1 Point and time of sampling

For identity testing of ready-mixed concrete, the point and time of sampling shall be one of the following:

a) at discharge from the producer’s delivery vehicle;

b) at the mixer when delivered into the user’s vehicle;

c) at the point of placing into the construction where the effects due to time delays, ambient conditions, transport and handling between discharge from the producer’s vehicle and delivery into the construction are agreed with the producer to be minimal;

d) at the point of placing into the construction where adjustments to specified values have been agreed with the producer to take account of significant effects as under item c). Such adjustments may be nominal or based on trials.
B.2 Slump and flow testing

B.2.1 Sampling
The sampling shall be either:
• in accordance with BS EN 12350-1; or
• measured using a spot sample obtained from the initial discharge, if concrete is delivered in a truck mixer or agitating equipment. The spot sample shall be taken after a discharge of approximately 0.3 m³ by taking six increments from the moving stream of the concrete in accordance with BS EN 12350-1.

The sample shall be remixd on a non-absorbent surface and tested for slump or flow.

B.2.2 Method of test
Slump shall be measured in accordance with BS EN 12350-2. Flow shall be measured in accordance with BS EN 12350-5.

B.2.3 Identity criteria for the slump of an individual batch
If the measured slump meets the requirements specified in Table B.1 or is within the tolerances specified in Table B.2, the identity test confirms that the batch conforms to BS EN 206-1 with respect to consistence.

Table B.1 Identity criteria for slump specified as a slump class
Dimensions in millimetres

<table>
<thead>
<tr>
<th>Specified slump class</th>
<th>Requirement</th>
<th>For composite samples taken in accordance with BS EN 12350-1</th>
<th>For spot samples taken from initial discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Not less than</td>
<td>Not more than</td>
</tr>
<tr>
<td>S1</td>
<td>0</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>S2</td>
<td>40</td>
<td>110</td>
<td>30</td>
</tr>
<tr>
<td>S3</td>
<td>90</td>
<td>170</td>
<td>80</td>
</tr>
<tr>
<td>S4</td>
<td>150</td>
<td>230</td>
<td>140</td>
</tr>
<tr>
<td>S5</td>
<td>210</td>
<td>—</td>
<td>200</td>
</tr>
</tbody>
</table>

Table B.2 Identity criteria for slump specified as a target value
Dimensions in millimetres

<table>
<thead>
<tr>
<th>Specified target slump</th>
<th>Tolerance</th>
<th>For composite samples taken in accordance with BS EN 12350-1</th>
<th>For spot samples taken from initial discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤40</td>
<td>−20, +30</td>
<td>−30, +40</td>
<td></td>
</tr>
<tr>
<td>50 to 90</td>
<td>−30, +40</td>
<td>−40, +50</td>
<td></td>
</tr>
<tr>
<td>≥100</td>
<td>−40, +50</td>
<td>−50, +60</td>
<td></td>
</tr>
</tbody>
</table>
B.2.4 Identity criteria for the flow of an individual batch

If the measured flow meets the requirements specified in Table B.3 or is within the tolerances specified in Table B.4, the identity test confirms that the batch conforms to BS EN 206-1 with respect to consistence.

Table B.3 Identity criteria for flow specified as a flow class
Dimensions in millimetres

<table>
<thead>
<tr>
<th>Specified flow class</th>
<th>Requirement</th>
<th>For composite samples taken in accordance with BS EN 12350-1</th>
<th>For spot samples taken from initial discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not less than</td>
<td>Not more than</td>
<td>Not less than</td>
</tr>
<tr>
<td>F1</td>
<td>200</td>
<td>370</td>
<td>200</td>
</tr>
<tr>
<td>F2</td>
<td>330</td>
<td>440</td>
<td>320</td>
</tr>
<tr>
<td>F3</td>
<td>400</td>
<td>510</td>
<td>390</td>
</tr>
<tr>
<td>F4</td>
<td>470</td>
<td>580</td>
<td>460</td>
</tr>
<tr>
<td>F5</td>
<td>540</td>
<td>650</td>
<td>530</td>
</tr>
<tr>
<td>F6</td>
<td>610</td>
<td>—</td>
<td>600</td>
</tr>
</tbody>
</table>

Table B.4 Identity criteria for flow specified as a flow value
Dimensions in millimetres

<table>
<thead>
<tr>
<th>Specified flow class</th>
<th>Requirement</th>
<th>For composite samples taken in accordance with BS EN 12350-1</th>
<th>For spot samples taken from initial discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not more than A</td>
<td>Not more than A</td>
<td>Not more than A</td>
</tr>
<tr>
<td>All values</td>
<td>−50</td>
<td>+60</td>
<td>−60</td>
</tr>
</tbody>
</table>

A) The measured flow shall not differ from the specified target value by more than the amount shown.

B.3 Air content

B.3.1 Sampling

The sample shall be a composite sample taken in accordance with BS EN 12350-1.

B.3.2 Method of test

The air content shall be measured in accordance with BS EN 12350-7 for normal-weight and heavyweight concretes and in accordance with ASTM C173 for lightweight concrete.

B.3.3 Identity criteria for air content of an individual batch

No test result shall be more than 0.5% below the specified minimum air content or more than 5% above the specified minimum air content.

B.4 Density

B.4.1 Sampling

The sample shall be a composite sample taken in accordance with BS EN 12350-1.
B.4.2 Method of test

The density of fresh concrete shall be measured in accordance with BS EN 12350-6 and the density of hardened concrete shall be measured in accordance with BS EN 12390-7.

B.4.3 Identity criteria for density of hardened concrete

The density of non air-entrained normal and non air-entrained lightweight hardened concrete shall be not more than \( \pm 130 \text{ kg/m}^3 \) from the specified target value. The density of non air-entrained lightweight concrete shall be not more than 30 kg/m\(^3\) outside the specified class limits. The density of non air-entrained heavyweight concrete shall be not more than 130 kg/m\(^3\) below the specified target value.

B.5 Additional requirements for compressive strength

Identity testing shall be based on composite samples as defined in BS EN 12350-1. Each concrete shall be assessed individually. Within each defined volume of concrete, the individual results shall first be assessed against criterion 2 given in BS EN 206-1:2000, Annex B, Table B.1. Any result that appears to be an outlier shall be investigated to determine whether it is a valid result. Invalid results shall not be included in the calculation of the mean strength. The mean strength of all the valid results in the volume of concrete shall be calculated and the result compared with BS EN 206-1:2000, Annex B, Table B.1, criterion 1 if there are two to six results in the volume of concrete. Where there are more than six results in the volume of concrete, the results shall be split into non-overlapping groups of six results taken in chronological sequence. BS EN 206-1:2000, Annex B, Table B.1, criterion 1 shall be applied to each of the groups of six results and, where applicable, the last group with less than six results.
Annex C (informative)  

Expected cement content with nominal proportions

Table C.1 gives the target cement content to expect where concrete has been specified in terms of nominal proportions batched by volume. Where the producer’s proposals indicate cement contents lower than the values in Table C.1, the specifier should require the producer to provide evidence justifying the lower cement contents.

NOTE Where nominal proportions are by mass, the cement contents are significantly greater than the values given in Table C.1.

Table C.1  
Target cement contents for nominal proportions

<table>
<thead>
<tr>
<th>Nominal proportions</th>
<th>Target cement content A) kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1:2</td>
<td>480</td>
</tr>
<tr>
<td>1:1:3</td>
<td>350</td>
</tr>
<tr>
<td>1:2:4</td>
<td>275</td>
</tr>
<tr>
<td>1:2:5</td>
<td>225</td>
</tr>
<tr>
<td>1:3:6</td>
<td>190</td>
</tr>
<tr>
<td>1:4:8</td>
<td>150</td>
</tr>
<tr>
<td>4:1 all in</td>
<td>330</td>
</tr>
<tr>
<td>5:1 all in</td>
<td>290</td>
</tr>
<tr>
<td>6:1 all in</td>
<td>250</td>
</tr>
<tr>
<td>7:1 all in</td>
<td>220</td>
</tr>
<tr>
<td>8:1 all in</td>
<td>195</td>
</tr>
<tr>
<td>9:1 all in</td>
<td>175</td>
</tr>
<tr>
<td>10:1 all in</td>
<td>160</td>
</tr>
<tr>
<td>12:1 all in</td>
<td>135</td>
</tr>
<tr>
<td>14:1 all in</td>
<td>120</td>
</tr>
<tr>
<td>15:1 all in</td>
<td>115</td>
</tr>
<tr>
<td>18:1 all in</td>
<td>95</td>
</tr>
<tr>
<td>20:1 all in</td>
<td>85</td>
</tr>
</tbody>
</table>

A) Where the producer proposes to use lower values, these lower values should be justified.
Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 4027, Specification for sulfate-resisting Portland cement

BS 8110-1, Structural use of concrete – Part 1: Code of practice for design and construction

BS 8204-2, Screeds, bases and in-situ floorings – Part 2: Concrete wearing surfaces – Code of practice

PD 6682-1, Aggregates – Part 1: Aggregates for concrete – Guidance on the use of BS EN 12620

DD ENV 13670-1, Execution of concrete structures – Part 1: Common


BS EN 197-1, Cement – Part 1: Composition, specifications and conformity criteria for common cements

BS EN 1367-2, Tests for thermal and weathering properties of aggregates – Part 2: Magnesium sulfate test

BS EN 1367-4, Tests for thermal and weathering properties of aggregates – Part 4: Determination of drying shrinkage

BS EN 1744-1, Tests for chemical properties of aggregates – Part 1: Chemical tests

BS EN 1990, Eurocode – Basis of structural design


BS EN 12620:2002, Aggregates for concrete

BS EN 13055-1, Lightweight aggregates – Part 1: Lightweight aggregates for concrete and mortar

BS EN 13813, Screed materials and floor screeds – Properties and requirements

BS EN ISO 9001, Quality management systems – Requirements
Other publications


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5) Available from The Concrete Bookshop, 4 Meadows Business Park, Station Approach, Blackwater, Camberley, Surrey GU17 9AB, UK. Tel: 01276 608778. Website: http://www.concretebookshop.com.
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