BS 8500-1:2015

BSI Standards Publication

Concrete – Complementary British Standard to BS EN 206

Part 1: Method of specifying and guidance for the specifier

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 60, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 8500 is published by BSI Standards Limited, under licence by the British Standards Institution, and came into effect on 30 June 2015. 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

BS 8500-1:2015 supersedes BS 8500-1:2006+A1:2012, which will be withdrawn on 30 June 2015.

Relationship with other publications

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

BS 8500 is published in two parts:

- BS 8500-1, *Method of specifying and guidance for the specifier*; and
- 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 necessary to align with the publication of BS EN 206:2013;
- changes resulting from new or revised European Standards published since 2006;
- alignment with conformity assessment and accreditation policy in the United Kingdom;
- changes made to align the recommendations for seawater exposure with that of the British Standard for maritime structures: BS 6349-1-4;
- introduction of designated cement-bound concrete;
- modification of requirements for concrete to resist freezing and thawing;
- corrections and minor clarifications;
- requirements and guidance for consistence retention testing have been added to Annex B; and
- all references have been updated.

NOTE A new Annex (Annex D) has also been added to BS 8500-2:2015, which sets out where to find the BS 8500 provisions that cover BS EN 206 requirements that defer to provisions in the place of use.

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 can 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.

The requirement for third-party certification has been approved by the Standards Policy and Strategy Committee.

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 an appropriate level of product conformity certification. Although it is not usual practice for a British Standard to state that a legitimate claim of compliance is dependent on third-party conformity assessment, it is recognized that there is an identified market need for third-party conformity assessment of concrete. This is particularly true for those construction works such as housing and building where the user might not have any expertise in concrete specification and prefers to order on the basis of its application rather than specifying limiting values or prescribing composition. Where designated concrete is specified, it is on an elected basis, and having elected to specify a designated concrete then all its requirements, including those for third-party product conformity certification, are expected to be met. The inclusion of the requirement for third-party product conformity certification in this manner has been approved by the BSI Standards Policy and Strategy Committee.

Where the option selected is not to use a designated concrete, the method of 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** onwards. 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 can be used as an alternative to designated concrete and 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 product conformity certification (**3.1.14**) is not required.

*NOTE Product conformity certification (see **3.1.14**) is recommended for all concrete, including designed concrete, although it is not obligatory.*

The environments to which the concrete is to be exposed are identified in **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 achieve the intended performance in the fresh and hardened states with an adequate margin. According to BS EN 206, 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 can 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 product conformity certification (**3.1.14**). Guidance on the selection of standardized prescribed concrete is given in **A.4.7** and the specification is drafted in accordance with **4.5**.

Standardized prescribed concrete can 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 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 product conformity certification (see **3.1.13**), 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 product conformity 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.

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 sets out the context in which BS EN 206 operates in the context of European standards. As BS 8500 is the UK complementary standard to BS EN 206, the context in which BS 8500 operates is the same when BS 8500 is used within a suite of European standards.

1 Scope

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

Annex A of this British Standard provides guidance on the concrete quality to be specified 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. It provides United Kingdom national provisions where required or permitted by BS EN 206. It also covers materials, methods of testing and procedures that are outside the scope of BS EN 206, but within national experience.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASTM C173, *Standard test method for air content of freshly mixed concrete by the volumetric method* [1)]

BS 8500-2:2015, *Concrete – Complementary British Standard to BS EN 206 – Part 2: Specification for constituent materials and concrete*

BS EN 206:2013, *Concrete – Specification, performance, production and conformity*

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*

1) Available from ASTM, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA. Tel: +610 832 9585. Website: <http://www.astm.org> [last viewed 28 April 2015].

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

BS EN 12350-8, *Testing fresh concrete – Part 8: Self-compacting concrete – Slump-flow test*

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

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 and the following apply.

3.1.1 alkali content of concrete

value calculated from the mix proportions and the determined alkali contents of each of the constituents and used for verifying that the alkali content of concrete does not exceed the specified limit

3.1.2 cement or combination content

mass of cement or combination contained in a cubic metre of fresh, fully compacted concrete, expressed in kilograms per cubic metre (kg/m^3)

NOTE Additions of Type II may be taken into account in respect of the cement content if the suitability is established (see BS EN 206:2013, ***5.2.5.1*** *(2) and BS 8500-2:2015, Table 1).*

3.1.3 cement-bound concrete

concrete suitable for vibrating plate compaction or roller compaction to a target density

NOTE Cement-bound concrete that conforms to this British Standard is concrete comprised of any of the cements or combination listed in BS 8500-2:2015, Table 7, which have a maximum size of aggregate of 20 mm or 40 mm, and where the aggregate conforms to the grading shown in BS 8500-2:2015, Table 8.

3.1.4 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 The procedure in BS 8500-2:2015, Annex A for establishing the suitability of combinations conforms to the principles of the Equivalent Performance of Combinations Concept (EPCC) in BS EN 206:2013, ***5.2.5.4****.*

3.1.5 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

NOTE 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.

3.1.6 consistence retention time

specified time in excess of that required to place concrete, and at which there is a specified consistence (slump, flow and slump-flow) class or target value

3.1.7 crushed concrete aggregate (CCA)
aggregate obtained from crushed concrete

NOTE This was referred to as recycled concrete aggregate (RCA) in the previous version of this standard.

3.1.8 declared mean alkali content
alkali content of cement or addition, expressed as the sodium oxide equivalent (Na_2O eq), as declared by the cement or addition manufacturer

NOTE See BS 8500-2:2015, ***B.1****.*

3.1.9 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].*

3.1.10 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

3.1.11 maximum aggregate size
declared value of the coarsest fraction of aggregates actually 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.

3.1.12 minimum cover
depth of cover to reinforcement assumed for the purposes of durability design

3.1.13 nominal cover
depth of cover to reinforcement shown on the drawings comprising the minimum cover plus an allowance in design for deviation, Δc, to accommodate fixing precision

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

3.1.14 product conformity certification
certification, based on product testing and surveillance, and approved by an accredited third-party certification body in accordance with a documented quality system

NOTE 1 Users of this part of BS 8500 are advised to consider the desirability of quality system assessment and registration against BS EN ISO 9001 by an accredited third-party certification body. Many certification bodies have this as a requirement of their product conformity certification. Further information on the provisions for assessment, surveillance and certification of production control can be found in BS EN 206:2013, Annex C.

NOTE 2 Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

NOTE 3 Attention is drawn to the Department for Business, Innovation and Skills policy document, Conformity assessment and accreditation policy *[2].*

3.1.15 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

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

3.1.17 sodium oxide equivalent (Na_2O eq)
alkali content, as a percentage, calculated as: $\%Na_2O\ eq = \%Na_2O + 0.658\%K_2O$

3.2 Symbols and abbreviations

For the purposes this part of BS 8500, the symbols and abbreviations given in BS EN 206 and the following apply.

NOTE 1 The abbreviations used to denote cement and combination types are given in Table A.6 and BS 8500-2:2015, 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
CB (strength class)	designation used for a series of designated cement-bound concretes used for foundations, pavements, hardstandings and reinstatement of openings in highways
CCA	crushed concrete aggregate
DC-(number)	design chemical class used to classify the resistance of concrete to chemical attack
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
RA	recycled aggregate
RC (strength class)	designation used for a series of designated concretes that are used in reinforced and prestressed concrete applications
w/c	water/(cement or combination)
Δc	allowance in design for deviation of the cover to reinforcement *NOTE 2 This is the same as Δ_{cdev} used in BS EN 1992-1-1.*
$\Delta c_{dur,\gamma}$	additive safety element (for prestressing steel) given in the appropriate design code

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 (see The Concrete Society's Technical Report 52 [3]).

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 (in respect of 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; and
- 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 may select constituent materials for the specified requirements only (see BS 8500-2:2015, ***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 The 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 and the producer to comply with the relevant requirements in BS EN 206. Consequently, conformity to BS 8500-2 includes conformity to BS EN 206.

NOTE 3 The specification of a designated concrete includes the normative requirement for the producer to have product conformity certification with specified minimum requirements as set out in BS 8500-2:2015, Clause ***6****. Where such certification is not required, or where certification without minimum requirements is preferred, then the specifier has the option of specifying a designed, prescribed, standardized prescribed or proprietary concrete together with whatever level of product conformity certification is considered appropriate.*

When the specifier requires identity testing, this shall be carried out in accordance with:

1) Annex B of this British Standard for slump, flow, slump-flow, air content and density of fresh concrete;

2) Annex B of this British Standard for density of hardened concrete specimens; and

3) BS EN 206:2013, Annex B and **B.5** of this British Standard for compressive strength.

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**; and

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.9 and Table A.10. For housing and similar applications, an appropriate designated concrete may be selected by identifying from Table A.14 the application for which the concrete is to be used, or the application which most closely resembles it. Table A.15 and Table A.16 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 8500-2:2015, 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 product conformity certification and the certification body audits 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 206:2013, **8.4**), the product conformity certification body checks 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 specified largest value of the coarsest fraction of aggregate (D_{upper}) size when other than 20 mm; and

d) the class of consistence when other than CB, S3 for the GEN, FND and RC series, S3 for PAV2 or S2 for PAV1 [see Note 3 and Table A.14, footnote G)].

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);

*NOTE 1 All the cement and combination types given in BS 8500-2:2015, Table 6 have the potential to provide adequate durability if the appropriate designated concrete is specified and the concrete is 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 types IVB-V, and IIIA with 56% to 65% ggbs, are subject to specific permission being given in the product specification.*

b) any special requirements for the aggregates;

NOTE 2 For example, the smallest value of D for the coarsest fraction of aggregate in the concrete, D_{lower}.

c) where RC20/25 to RC40/50 is specified, permission to use coarse RA, permission to use coarse CCA 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 and CB series of designated concrete;
- Cl 0,40 for other designated concretes for all cements and combinations except CEM I-SR 0 or 3;
- Cl 0,20 for CEM I-SR 0 or 3;

h) any requirement for higher minimum air content, e.g. to allow for the effects of pumping (see Note 3).

NOTE 3 The minimum air content given in BS 8500-2:2015, Table 6 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 if the concrete is being pumped, it might be necessary to undertake site trials to verify that the required minimum air content can be achieved at the point of placing and, where necessary, the minimum air content at the point of delivery should be specified accordingly.

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**; and

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 206:2013, Clause **11**.*

4.3.2 Basic requirements

The specification for designed concrete shall contain (see Note 2 and Note 3):

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;

NOTE 1 Combinations conforming to BS 8500-2:2015, Annex A count fully towards the minimum cement content.

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; and

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

NOTE 2 BS EN 206 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 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 8500-2:2015, 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 8500-2:2015, 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) conformity assessment, e.g. product conformity certification;

NOTE 1 Conformity assessment is a demonstration that what is being supplied meets the requirements specified or claimed. Conformity may be assessed by a body that is independent of any party interested in the outcome of the assessment (i.e. third-party conformity assessment), or may be carried out by any party interested in the outcome. Conformity assessment includes activities such *as testing, inspection and certifcation. Product conformity certification is a form of conformity assessment carried out by an accredited third-party conformity assessment body.*

b) special types or classes of aggregate, e.g. for wear resistance or freeze-thaw resistance;

NOTE 2 In these cases, BS EN 206:2013, ***6.2.3*** *suggests that concrete composition to minimize damaging alkali–silica reaction is the responsibility of the specifier. However, BS 8500-2:2015,* ***5.2*** *requires the producer to take appropriate action in these cases (see* ***A.8.1*** *for an explanation).*

c) 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 8500-2:2015, **4.3.6**, 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; and
- any limitations on use in concrete, e.g. compressive strength classes, exposure classes;

d) restrictions on the use of certain aggregates;

e) generic type and dosage of fibres;

f) characteristics required to resist freeze-thaw attack, e.g. air content;

NOTE 3 The minimum air content given in Table A.9 is based on the assumption that differences in 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 if the concrete is being pumped, it might be necessary to undertake site trials to verify that the required minimum air content can be achieved at the point of placing and where necessary the minimum air content at the point of delivery should be specified accordingly.

g) requirements for the temperature of the fresh concrete, where different from the lower limit in BS EN 206:2013, **5.2.9** or the upper limit in BS 8500-2:2015, **5.4**;

h) strength development;

i) heat development during hydration;

j) consistence retention time;

k) resistance to water penetration;

l) resistance to abrasion;

m) tensile splitting strength;

n) other technical requirements, e.g. requirements related to the achievement of a particular finish or special method of placing;

o) any "concerning effects", such as where concreting on the site is done under widely divergent temperature conditions, or if heat treatment is applied, the producer shall be informed about this, so that they can consider the concerning effects on the properties of the concrete and the need for any additional tests and the acceptability criteria.

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.

The specification shall contain either 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**; and

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; and

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 hold product conformity certification.

NOTE 2 The content of constituent materials should be given in terms of kilograms per cubic metre (kg/m^3). 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 8500-2:2015, **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 206:2013, **5.2.9** or the upper limit in BS 8500-2:2015, **5.4**;

e) the target w/c ratio (see Note); and

f) other technical requirements.

NOTE The specified value of the (target) w/c ratio should be 0.02 less than any required maximum value, e.g. 0.53 should be specified where 0.55 is required.

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**; and

b) the additional requirements given in **4.5.3**, where required.

*NOTE 1 The concrete may be selected using the guidance in **A.4.7**.*

The materials and the mix proportions given in BS 8500-2:2015, 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.14.

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; and

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 8500-2:2015, **9.2**; and

b) any restrictions on the types of aggregates permitted in BS 8500-2:2015, **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**; and

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; and

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; and

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 required to be provided by BS EN 206:2013, **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; and

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, slump-flow, air content and density are given in Annex B. The criteria for identity testing for strength are given in BS EN 206:2013, Annex B, and Annex B of this British Standard.

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

In addition to the information required to be provided in accordance with BS EN 206:2013, **7.2**, the specifier shall request from the producer whichever of the following information is deemed to be necessary:

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

a) the method used to minimize damaging alkali–silica reaction and, as appropriate:

- details of service record;
- verification of conformity; and
- alkali content of concrete in accordance with BS 8500-2:2015, Annex B;

b) the type, composition and standard strength class of combination;

*NOTE 2 The provision of information covered by BS EN 206:2013, **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.*

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 CCA or RA is to be incorporated into the concrete, the type of material and proportion to be used;

g) where CCA is to be used in exposure classes other than those given in BS 8500-2:2015, 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 8500-2:2015, **4.5**;

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

k) where the concrete is not under product conformity certification (**3.1.14**), the test data on which the declaration of conformity was based.

*NOTE 3 Where the concrete is not under product conformity certification (**3.1.14**), 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 8500-2:2015, **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**);
- concrete placing (**A.9**);
- conformity and identity testing (**A.10**);
- concrete for geotechnical works (**A.11**); and
- segregation and bleeding (**A.12**).

BS EN 206 defines the term "specification of concrete" 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. 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 206:2013, **3.1.1.18**), i.e. the person or body who gives the specification to the producer.

BS 8500 and BS EN 206 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 might, 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.

The guidance in this Annex is largely based on empirical evidence together with a limited amount of testing to identify those materials, and combinations of materials, most suitable for particular applications or the identified exposure classes related to environmental conditions (see **A.2**). This guidance is deemed to be sufficient for the majority of civil engineering and building works.

For particular applications, reference to alternate standards or specialist literature is desirable. For example, for concrete pavements, reference can be made to BS EN 13877-1 and BS EN 13877-2, and for Cement Bound Granular Mixtures (CBGM) for roads, airfields and other trafficked areas then BS EN 14227-1 might be appropriate. For agricultural buildings, BS 5502-21 and BS 5502-22 might be appropriate and for maritime works then BS 6349-1-4. BS EN 13369 covers common rules for precast concrete products and there might be further information in individual concrete product standards.

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** (1 of 3)

Class designation	Class description	Informative examples applicable in the United Kingdom
No risk of corrosion or attack (X0 class)		
X0	For concrete without reinforcement or embedded metal: all exposures except where there is freeze-thaw, abrasion or chemical attack	Unreinforced concrete surfaces inside structures Unreinforced concrete completely buried in soil classed as AC-1 and with a hydraulic gradient not greater than 5
	For concrete with reinforcement or embedded metal: very dry	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
Corrosion induced by carbonation (XC classes) A) *(where concrete containing reinforcement or other embedded metal is exposed to air and moisture)*		
XC1	Dry or permanently wet	Reinforced and prestressed concrete surfaces inside enclosed structures except voided superstructures and areas of structures with high humidity Reinforced and prestressed concrete surfaces permanently submerged in non-aggressive water
XC2	Wet, rarely dry	Reinforced and prestressed concrete surfaces permanently in contact with soil not containing chlorides B)
XC3 and XC4 (XC3/4)	Moderate humidity or cyclic wet and dry	External reinforced and prestressed concrete surfaces sheltered from, or exposed to, direct rain Reinforced and prestressed concrete surfaces subject to high humidity (e.g. poorly ventilated bathrooms, kitchens) Reinforced and prestressed concrete surfaces exposed to alternate wetting and drying Interior concrete surfaces of pedestrian subways not subject to de-icing salts, voided superstructures or cellular abutments Reinforced or prestressed concrete surfaces protected by waterproofing
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 seawater)*		
XD1	Moderate humidity	Concrete surfaces exposed to airborne chlorides Reinforced and prestressed concrete wall and structure supports more than 10 m horizontally from a carriageway Bridge deck soffits more than 5 m vertically above the carriageway Parts of structures exposed to occasional or slight chloride conditions
XD2	Wet, rarely dry	Reinforced and prestressed concrete surfaces totally immersed in water containing chlorides C) Buried highway structures more than 1 m below adjacent carriageway D)

Table A.1 **Exposure classes** (2 of 3)

XD3	Cyclic wet and dry	Reinforced and prestressed concrete walls and structure supports within 10 m of a carriageway Bridge parapet edge beams Buried highway structures less than 1 m below carriageway level Reinforced pavements and car park slabs E)
Corrosion induced by chlorides from sea water (XS classes) A) F) *(where concrete containing reinforcement or other embedded metal is subject to contact with sea water or airborne salt originating from sea water)*		
XS1	Exposed to airborne salt but not in direct contact with sea water	External reinforced and prestressed concrete surfaces in coastal areas
XS2	Permanently submerged	Reinforced and prestressed concrete surfaces completely submerged or remaining saturated, e.g. concrete below mid-tide level C)
XS3	Tidal, splash and spray zones	Reinforced and prestressed concrete surfaces in the upper tidal zones and the splash and spray zones G), including exposed soffits above sea water
Freeze-thaw attack (XF classes) *(where concrete is exposed to significant attack from freeze-thaw cycles whilst wet)*		
XF1	Moderate water saturation without de-icing agent	Vertical concrete surfaces such as façades and columns exposed to rain and freezing Non-vertical concrete surfaces not highly saturated, but exposed to freezing and to rain or water
XF2	Moderate water saturation with de-icing agent	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
XF3	High water saturation without de-icing agent	Horizontal or near horizontal concrete surfaces, which are exposed to freezing whilst wet Concrete surfaces subjected to frequent splashing with water and exposed to freezing
XF4	High water saturation with de-icing agent or sea water G)	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
Chemical attack (XA classes) *(where concrete is exposed to chemical attack)* *Chemical attack by aggressive ground (ACEC classes)*		
XA1	Slightly aggressive chemical environment	Concrete exposed to natural soil and ground water according to BS EN 206. These European exposure classes are not used in the UK where Table A.2 shall be used to determine the ACEC-class. See BRE Special Digest 1 [1] for guidance on site investigation.
XA2	Moderately aggressive chemical environment	
XA3	Highly aggressive chemical environment	
Chemical attack from seawater (XAS class) *(where concrete is exposed to chemical attack from seawater)*		
XAS H)	Exposed to sea water	Concrete surfaces in contact with sea water

Table A.1 **Exposure classes** (3 of 3)

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) Where the integrity of the waterproofing over the intended working life of the concrete surface it protects cannot be guaranteed or maintained then it may be prudent to assume XD1 or XS1 exposure class as appropriate. Soil may be classed as not containing chlorides if the chloride level is not greater than 275 mg/l. Higher limits might be applicable; seek specialist advice.

C) Reinforced and prestressed concrete elements where one surface is immersed in water containing chlorides and another is exposed to air are potentially in a more severe exposure 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) In deeply buried or fully submerged conditions, the availability of oxygen might be significantly restricted and consequently the risk of damage due to corrosion of reinforcement could be much reduced.

E) See **A.4.3** and **A.4.4** as reinforced pavements and car park slabs might be needed to resist freeze-thaw attack.

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

G) 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.

H) It is not normally necessary to classify the XF4 exposure classes to those parts of structures located in the United Kingdom which are in frequent contact with the sea.

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 exists 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, XAS 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. 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 as is the case for XAS exposure. 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.

Table A.2 **Aggressive chemical environment for concrete (ACEC) exposure classes** (1 of 2)

Sulfate and magnesium					**Design sulfate class**	**Natural soil**		**Brownfield** A)		**ACEC-class**
2:1 water/soil extract B)		**Groundwater** B)		**Total potential sulfate** C)		**Static water**	**Mobile water**	**Static water**	**Mobile water**	
SO_4 D) mg/l	Mg E) D) mg/l	SO_4 D) mg/l	Mg E) D) mg/l	SO_4 %		pH	pH	pH F)	pH F)	
						≥2.5	—	≥2.5	—	AC-1s
						—	>5.5	—	>6.5	AC-1 G)
<400	—	≤300	—	<0.24	DS-1	—	2.5 to 5.5	—	5.6 to 6.5	AC-2z
						—	—	—	4.5 to 5.5	AC-3z
						—	—	—	2.5 to 4.5	AC-4z
						>3.5	—	>5.5	—	AC-1s
						—	>5.5	—	>6.5	AC-2
500 to 1 500	—	400 to 1 400	—	0.24 to 0.6	DS-2	2.5 to 3.5	—	2.5 to 5.5	—	AC-2s
						—	2.5 to 5.5	—	5.6 to 6.5	AC-3z
						—	—	—	4.5 to 5.5	AC-4z
						—	—	—	2.5 to 4.5	AC-5z
						>3.5	—	>5.5	—	AC-2s
						—	>5.5	—	>6.5	AC-3
1 600 to 3 000	—	1 500 to 3 000	—	0.7 to 1.2	DS-3	2.5 to 3.5	—	2.5 to 5.5	—	AC-3s
						—	2.5 to 5.5	—	5.6 to 6.5	AC-4
						—	—	—	2.5 to 5.5	AC-5
						>3.5		>5.5	—	AC-3s
3 100 to 6 000	≤1 200	3 100 to 6 000	≤1 000	1.3 to 2.4	DS-4	—	>5.5	—	>6.5	AC-4
						2.5 to 3.5	—	2.5 to 5.5	—	AC-4s
						—	2.5 to 5.5	—	2.5 to 6.5	AC-5
								>5.5		AC-3s
3 100 to 6 000	>1 200 E)	3 100 to 6 000	>1 000 E)	1.3 to 2.4	DS-4m	Not found in UK natural ground			>6.5	AC-4m
								2.5 to 5.5		AC-4ms
									2.5 to 6.5	AC-5m
>6 000	≤1 200	>6 000	≤1 100	>2.4	DS-5	>3.5	—	>5.5	—	AC-4s
						2.5 to 3.5	W2.5	2.5 to 5.5	W2.5	AC-5
>6 000	>1 200 E)	>6 000	>1 100 E)	>2.4	DS-5m	Not found in UK natural ground		>5.5	—	AC-4ms
								2.5 to 5.5	W2.5	AC-5m

Table A.2 **Aggressive chemical environment for concrete (ACEC) exposure classes** (2 of 2)

A) "Brownfield" sites are those that might contain chemical residues remaining from previous industrial use or from imported wastes.

B) Characteristic values determined in accordance with BRE Special Digest 1 [1].

C) Applies only to sites where concrete is exposed to sulfate ions (SO_4), which can result from the oxidation of sulfides such as pyrite, following ground disturbance.

D) Values should be rounded to 100 mg/l.

E) 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 (see **A.4.6** and Table A.13) and stronger brines.

F) An additional account is taken of hydrochloric and nitric acids by adjustment to sulfate content (see BRE Special Digest 1 [1]).

G) 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-2z (see BRE Special Digest 1 [1]).

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 206:2013, 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 [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 [1], **B.2.2**, **B.4** and **B.5**).

Sea water is aggressive to concrete; see **A.4.6**.

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 (see The Concrete Society's Technical Report 51 [4]), 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; and
- 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, Δc, 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, Δc, 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 usually give the nominal cover, i.e. the minimum cover plus an allowance in design for deviation, Δc. The allowance should be chosen after consideration of the type of construction and the quality control measures (see BS EN 13670) that are to 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 its 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** gives the nominal cover to reinforcement in the form (minimum cover + Δc) mm (see Table A.3 (in general), Table A.4 and Table A.5).

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.4.5**), 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 depends 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 is only 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.4.5**.

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.4.5** and BRE Special Digest 1 [1]);
- the minimum cover to reinforcement (see, for example, Table A.4); and
- 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 normal-weight concrete and lightweight 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 1 BS 8500 includes three strength classes that are not given in BS EN 206. Class C6/8 is used in designated concrete CB6/8 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.

Table A.3 **Typical reinforced concrete applications in buildings (intended working life at least 50 years) for designated concretes**

Use	Exposure class	Nominal cover A) mm	Minimum designated concrete B)
Reinforced and prestressed concrete inside enclosed buildings except poorly ventilated rooms with high humidity	XC1	(15 + Δc)	RC20/25
External reinforced and prestressed vertical elements of buildings sheltered from, or exposed to, rain C)	XC3/XC4 + XF1	(20 + Δc) (25 + Δc) (30 + Δc)	RC40/50 RC30/37 RC28/35
Horizontal elements with high saturation without de-icing agent and subject to freezing while wet C)	XC3/XC4 + XF3	(20 + Δc) (25 + Δc) (30 + Δc)	RC40/50XF PAV2 PAV1
Reinforced or prestressed buried foundation in AC-1 where the hydraulic gradient is not greater than 5	XC2/AC-1	(25 + Δc) D)	RC25/30
C25/30 reinforced or prestressed buried foundation in AC-2 or more aggressive ground conditions	AC-2 to AC-5m	(25 + Δc) D)	See E)

A) Check the appropriate design code to see if it is recommended that the minimum cover to prestressing steel is adjusted by a factor $\Delta c_{dur,\gamma}$.

B) See **A.4.7** (Table A.14) for details of the specification associated with the designation.

C) If IVB-V cements and combinations are to be specifically permitted under **4.2.3**a), increase the minimum cover by 5 mm.

D) The minimum allowance for deviation, Δc, should be at least 15 mm for concrete to be cast against blinding or prepared ground and at least 50 mm for concrete to be cast directly against soil. Where the ground contains chlorides, the nominal cover should comprise the recommended minimum cover for the associated XD or XS class plus an the allowance for deviation, Δc, and the more onerous limiting values for the concrete should be selected.

E) Provided that a minimum compressive strength class of C25/30 is adequate, use **A.4.5** (Table A.10) to determine the DC-class and replace the "DC-" with "FND" to obtain the designation of the appropriate designated concrete, e.g. "DC-3z" becomes "FND3Z". If a higher compressive strength class is required, specify a designed concrete using the required compressive strength class and the DC-class.

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.

NOTE 2 Cement is a single powder containing, for example, Portland cement clinker 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 8500-2:2015, Annex A. BS 8500 treats cements and combinations as being technically equivalent.

The use of additional quantities of fly-ash, ggbs, limestone fines or silica fume is not prohibited by the recommendations of Table A.4 and Table A.5 but these additional materials are not considered as part of the cement content and do not contribute to the w/c ratio.

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**), aggressive chemicals other than sea water (see **A.4.5**) or abrasion (no guidance provided in this British Standard).

Table A.4 **Durability[A] recommendations for reinforced or prestressed elements with an intended working life of at least 50 years** (1 of 3)

Nominal cover [B]	Compressive strength class [C], maximum w/c ratio and minimum cement or combination content for normal-weight concrete [D] with 20 mm maximum aggregate size [E]											Cement/combination types
mm	15 + Δc	20 + Δc	25 + Δc	30 + Δc	35 + Δc	40 + Δc	45 + Δc	50 + Δc	60 + Δc	70 + Δc	80 + Δc	
Corrosion induced by carbonation (XC exposure classes)												
XC1	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	All in Table A.6
XC2	—	—	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All in Table A.6
XC3/4	—	C40/50 0.45 340	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All in Table A.6 except IVB-V
	—	—	C40/50 0.45 340	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	IVB-V
Corrosion induced by chlorides other than sea water (XD exposure classes) *adequate for any associated carbonation induced corrosion (XC)*												
XD1	—	—	C40/50 0.45 360	C32/40 0.55 320	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	All in Table A.6
XD2	—	—	—	C40/50[F] 0.40 380	C32/40[F] 0.50 340	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	CEM I, IIA, IIB-S, CEM I-SR0, CEM I-SR3
	—	—	—	C35/45[F] 0.40 380	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA
	—	—	—	C32/40[F] 0.40 380	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIIB, IVB-V
XD3	—	—	—	—	—	C45/55[F] 0.35 [G] 380	C40/50[F] 0.40 380	C35/45[F] 0.45 360	C35/45[F] 0.45 360	C35/45[F] 0.45 360	C35/45[F] 0.45 360	CEM I, IIA, IIB-S, CEM I-SR0, CEM I-SR3
	—	—	—	—	—	C35/45[F] 0.40 380	C32/40[F] 0.45 360	C28/35 0.50 340	C28/35 0.50 340	C28/35 0.50 340	C28/35 0.50 340	IIB-V, IIIA
	—	—	—	—	—	C32/40[F] 0.40 380	C28/35 0.45 360	C25/30 0.50 340	C25/30 0.50 340	C25/30 0.50 340	C25/30 0.50 340	IIIB, IVB-V

Table A.4 **Durability[A)] recommendations for reinforced or prestressed elements with an intended working life of at least 50 years** (2 of 3)

Nominal cover [B)]	Compressive strength class [C)], maximum w/c ratio and minimum cement or combination content for normal-weight concrete [D)] with 20 mm maximum aggregate size [E)]											Cement/ combination types
mm	30 + Δc	35 + Δc	40 + Δc	45 + Δc	50 + Δc	55 + Δc	60 + Δc	65 + Δc	70 + Δc	75 + Δc	80 + Δc	
Corrosion induced by chlorides from sea water (XS exposure classes) *adequate for any associated carbonation induced corrosion (XC)*												
XS1	—	—	—	C45/55[F)] 0.35 [G)] 380	C40/50[F)] 0.40 380	C35/45[F)] 0.45 360	C32/40[F)] 0.50 340	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	CEM I, IIA, IIB-S
	C40/50[F)] 0.35 [G)] 380	C32/40[F)] 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA
	C35/45 [F)] 0.40 380	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	C32/40 [F)] 0.40 380	C25/30[H)] 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IV-B, IIIB
XS2	—	—	—	—	—	—	C45/55[F)] 0.35[G)] 380	C40/50[F)] 0.40 380	C40/50[F)] 0.40 380	C35/45[F)] 0.45 360	C32/40[F)] 0.50 340	CEM I, IIA, IIB-S
	—	—	C35/45[F)] 0.40 380	C32/40[F)] 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA
	—	C40/50[F)] 0.35 [G)] 380	C32/40[F)] 0.45 [G)] 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	—	C35/45[F)] 0.35 [G)] 380	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IV-B, IIIB
XS3	—	—	—	—	—	—	—	—	—	—	C45/55 0.35 [G)] 380	CEM I, IIA, IIB-S
	—	—	—	—	C40/50[F)] 0.35 [G)] 380	C35/45 [F)] 0.40 380	C32/40[F)] 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA
	—	—	—	C40/50[F)] 0.35[G)] 380	C32/40[F)] 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	—	—	—	C35/45[F)] 0.35[G)] 380	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IV-B, IIIB

Table A.4 **Durability[A)] recommendations for reinforced or prestressed elements with an intended working life of at least 50 years** (3 of 3)

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.9), aggressive chemicals (see **A.4.5**, Table A.12) and abrasion (no guidance provided).

B) Expressed as the minimum cover to reinforcement plus an allowance in design for deviation, Δc, 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 $\Delta c_{dur,\gamma}$.

C) Resistance to chloride ingress (XD and XS exposure classes) 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.

D) 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 **A.4.2**, Note, BS EN 206:2013, Table 13 and BS 8500-2:2015, Table 12) on the basis of equal cylinder strength if designing to BS EN 1992.

E) For adjustments to cement or combination content for different maximum size of aggregate, see Table A.7.

F) If the concrete is specified as being air entrained in accordance with the XF2 or XF4 recommendations in Table A.9, the minimum compressive strength class for corrosion induced by chlorides may be reduced to C28/35.

G) In some parts of the UK it is not possible to produce a practical concrete with a maximum w/c ratio of 0.35.

H) For IVB-V increase the strength class to C28/35.

Table A.5 **Durability[A] recommendations for reinforced or prestressed elements with an intended working life of at least 100 years** (1 of 3)

Nominal cover [B]	Compressive strength class [C], maximum w/c ratio and minimum cement or combination content for normal-weight concrete [D] with 20 mm maximum aggregate size [E]												Cement/ combination types
mm	15 + Δc	20 + Δc	25 + Δc	30 + Δc	35 + Δc	40 + Δc	45 + Δc	50 + Δc	55 + Δc	60 + Δc	70 + Δc	80 + Δc	
Corrosion induced by carbonation (XC exposure classes)													
XC1	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	All in Table A.6
XC2	—	—	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All in Table A.6
XC3/4	—	—	—	C40/50 0.45 340	C35/45 0.50 320	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All in Table A.6 except IVB-V
	—	—	—	—	C40/50 0.45 340	C35/45 0.50 320	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	IVB-V
Corrosion induced by chlorides other than sea water (XD exposure classes) *adequate for any associated carbonation induced corrosion (XC)*													
XD1	—	—	—	C45/55 0.40 380	C40/50 0.45 360	C35/45 0.50 340	C32/40 0.55 320	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	All in Table A.6
XD2	—	—	—	—	—	C35/45[F] 0.45 360	C32/40 0.50 340	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	CEM I, IIA, IIB-S, CEM I-SR0, CEM I-SR3
	—	—	—	—	—	C32/40[F] 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA
	—	—	—	—	—	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIIB, IVB-V
XD3	—	—	—	—	—	—	—	—	C45/55[F] 0.35 [G] 380	C40/50[F] 0.40 380	C35/45[F] 0.45 360	C35/45[F] 0.45 360	CEM I, IIA, IIB-S, CEM I-SR0, CEM I-SR3
	—	—	—	—	—	—	C40/50[F] 0.35 [G] 380	C35/45[F] 0.40 380	C32/40 [F] 0.45 360	C28/35 0.50 340	C25/30 0.50 320	C25/30 0.50 320	IIB-V, IIIA
	—	—	—	—	—	—	C32/40[F] 0.40 380	C28/35 0.45 360	C25/30 0.50 340	C25/30 0.50 320	C25/30 0.55 320	C25/30 0.55 320	IIIB, IVB-V

Table A.5 **Durability[A)] recommendations for reinforced or prestressed elements with an intended working life of at least 100 years** (2 of 3)

Nominal cover [B)]	Compressive strength class [C)], maximum w/c ratio and minimum cement or combination content for normal-weight concrete [D)] with 20 mm maximum aggregate size [E)]											Cement/combination types
mm	30 + Δc	35 + Δc	40 + Δc	45 + Δc	50 + Δc	55 + Δc	60 + Δc	65 + Δc	70 + Δc	75 + Δc	80 + Δc	
Corrosion induced by chlorides from sea water (XS exposure classes) *adequate for any associated carbonation induced corrosion (XC)*												
XS1	—	—	—	—	—	—	—	C45/55[F)] 0.35 [G)] 380	C40/50[F)] 0.40 380	C35/45[F)] 0.45 360	C32/40[F)] 0.50 340	CEM I, IIA, IIB-S
	—	C40/50[F)] 0.35 [H)] 380	C40/50[F)] 0.35 [G)] 380	C35/45[F)] 0.40 380	C32/40[F)] 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA
	—	—	C35/45[F)] 0.40 380	C32/40[F)] 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB V ≥25% fly ash, IIIA ≥46% ggbs
	—	—	C32/40[F)] 0.45 380	C28/35 0.45 360	C25/30 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIIB
	—	—	C35/45 [F)] 0.40 380	C30/37 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IVB-V
XS2	—	—	—	—	—	—	—	—	—	—	—	CEM I, IIA, IIB-S
	—	—	—	—	C40/50[F)] 0.35 [G)] 380	C35/45[F)] 0.40 380	C32/40[F)] 0.45 360	C28/35 0.50 340	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA
	—	—	—	C40/50[F)] 0.35 [G)] 380	C35/45[F)] 0.40 380	C32/40[F)] 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB V ≥25% fly ash, IIIA ≥46% ggbs
				C35/45[F)] 0.35 [G)] 380	C32/40[F)] 0.40 380	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IVB-V, IIIB
XS3	—	—	—	—	—	—	—	—	—	—	—	CEM I, IIA, IIB-S
	—	—	—	—	—	—	C40/50[F)] 0.35 [H)] 380	C40/50[F)] 0.35 [G)] 380	C35/45[F)] 0.40 380	C32/40[F)] 0.45 360	C28/35 0.50 340	IIB-V, IIIA
	—	—	—	—	—	—	C40/50[F)] 0.35 [G)] 380	C35/45[F)] 0.40 380	C32/40[F)] 0.45 360	C25/30 0.55 320	C25/30 0.55 320	IIB V ≥25% fly ash, IIIA ≥46% ggbs
	—	—	—	—	—	—	C35/45[F)] 0.35 [G)] 380	C32/40[F)] 0.40 380	C28/35 0.45 360	C20/25 0.55 320	C20/25 0.55 320	IVB-V, IIIB

Table A.5 **Durability[A)] recommendations for reinforced or prestressed elements with an intended working life of at least 100 years** (3 of 3)

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.9), aggressive chemicals (see **A.4.5**, Table A.12) and abrasion (no guidance provided).

B) Expressed as the minimum cover to reinforcement plus an allowance in design for deviation, Δc, 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 $\Delta c_{dur,\gamma}$.

C) Resistance to chloride ingress (XD and XS exposure classes) 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.

D) 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 **A.4.2**, Note, BS EN 206:2013, Table 13 and BS 8500-2:2015, Table 12) on the basis of equal cylinder strength if designing to BS EN 1992.

E) For adjustments to cement or combination content for different maximum size of aggregate, see Table A.7.

F) If the concrete is specified as being air entrained in accordance with the XF2 or XF4 recommendations in Table A.9, the minimum compressive strength class for corrosion induced by chlorides may be reduced to C28/35.

G) In some parts of the UK it is not possible to produce a practical concrete with a maximum w/c ratio of 0.35.

H) For pre-cast, pre-tensioned concrete only.

Table A.6 **Cement and combination types**A)

Broad designation B)	**Composition**	**Comprises cement and combination types (see BS 8500-2:2015, Table 1)**
CEM I	Portland cement	CEM I
CEM I-SR0	Sulfate-resisting Portland cement	CEM I-SR 0
CEM I-SR 3		CEM I-SR 3
IIA	Portland cement with 6% to 20% fly ash, ground granulated blastfurnace slag, limestone, or 6% to 10% silica fume C)	CEM II/A-L, CIIA-L, CEM II/A-LL, CIIA-LL, CEM II/A-S, CIIA-S, CEM II/A-V, CIIA-V, CEM II/A-D
IIB-S	Portland cement with 21% to 35% ground granulated blastfurnace slag	CEM II/B-S, CIIB-S
IIB-V	Portland cement with 21% to 35% fly ash	CEM II/B-V,CIIB-V
IIB+SR	Portland cement with 25% to 35% fly ash	CEM II/B-V+SR, CIIB-V+SR
IIIA D)	Portland cement with 36% to 65% ground granulated blastfurnace slag	CEM III/A, CIIIA
IIIA+SR	Portland cement with 36% to 65% ground granulated blastfurnace slag with additional requirements that enhance sulfate resistance	CEM III/A+SR E), CIIIA+SR E)
IIIB F)	Portland cement with 66% to 80% ground granulated blastfurnace slag	CEM III/B, CIIIB
IIIB+SR	Portland cement with 66% to 80% ground granulated blastfurnace slag with additional requirements that enhance sulfate resistance	CEM III/B+SR E), CIIIB+SR E)
IVB-V G)	Portland cement with 36% to 55% fly ash	CEM IV/B-V, CIVB-V

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 [5] 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 8500-2:2015, 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 206:2013, **5.2.5.2.3**.

D) Where IIIA is specified, IIIA+SR may be used.

E) "+SR" indicates additional restrictions on the chemical composition of cement or ggbs related to sulfate resistance. See BS 8500-2:2015, Table 1, footnote D.

F) Where IIIB is specified, IIIB+SR may be used.

G) IVA cements and combinations with a siliceous fly ash should be classified as II-V.

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

Limiting values given for 20 mm maximum aggregate size		Maximum aggregate size		
Maximum w/c ratio	**Minimum cement or combination content kg/m³**	**≥40 mm**	**14 mm**	**10 mm**
0.70	240	240	260	280
0.65	260	240	280	300
0.60	300	280	320	340
0.60	280	260	300	320
0.55	300	280	320	340
	320	300	340	360
0.50	320	300	340	360
	340	320	360	380
0.45	340	320	360	360
	360	340	380	380
0.40	380	360	380	380
0.35	380	380	380	380

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 does 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 should be specified. Failure to specify means that there is no requirement, as neither BS EN 206 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 [6].

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.

Table A.8 gives recommended chloride classes for particular concrete uses containing reinforcing steel. No guidance is given for galvanized reinforcing steel, epoxy-coated reinforcing steel, corrosion resistant reinforcing steel or any non-steel reinforcement.

Table A.8 **Recommended chloride classes for concrete containing steel reinforcement or high tensile steel wire or strand for prestressing**

Concrete use	**Chloride class**	**Maximum chloride ion content (% mass of cement or combination)**
Pre-tensioned pre-stressed concrete Heat-cured concrete containing steel reinforcement or other embedded metal	Cl 0,10	0.10
Non heat-cured concrete containing steel reinforcement or other embedded metal that is subjected to significant amounts of external chloride, such as in XS or XD exposure classes	Cl 0,30	0.30
Non heat-cured concrete containing steel reinforcement subject to XC exposure classes Post-tensioned concrete in XC1 exposure class [A)], e.g. internal post-tensioned office construction	Cl 0,40	0.40
Unreinforced concrete containing no embedded metal other than corrosion-resistant lifting devices	Cl 1,0	1.0

[A)] No guidance is given for post-tensioned pre-stressed concrete in other exposure classes, or for unbounded pre-stressed concrete. The appropriate chloride class depends on the particular exposure, type of structure and construction method.

The methods for measuring the chloride content of the constituent materials for concrete are specified in BS 8500-2:2015, **5.3** and the method of determining the chloride content of fresh concrete is specified in BS EN 206:2013, **5.2.8**.

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

Table A.9 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".

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 for XF2 or XF4 where the concrete is to be air entrained in accordance with Table A.9.

A.4.4 Concrete for pavements and hardstandings

Most external pavements and hardstandings are subject to XF4 exposure. When specifying concrete for pavements and hardstandings, consideration should be given to selecting the air-entrained option due to its superior freeze-thaw resistance. However, there may be practical difficulties with entraining air into concrete with a compressive strength class of C35/45 or higher.

Pavements and hardstandings are often designed for a shorter intended working life than the "at least 50 years" guidance provided in this British Standard. Consideration may be given to relaxing the recommendations in Table A.4, but the recommendations in Table A.9 should not be relaxed.

For heavy duty external paving the recommended slump class is S3 but depending on the area of the pavement, method of placing, compaction, finishing and supervision it might be appropriate to specify a different slump class, e.g. S2 or S1.

This standard does not provide any guidance on how to achieve abrasion- or skid-resistant surfaces. For detailed guidance, specific to pavements and hardstandings, see specialist literature, e.g. Concrete Society Technical Report 66 [7].

Table A.9 **Limiting values for composition and properties of concrete to resist freezing and thawing (XF exposures)**

Exposure class	Min. strength class	Max. w/c ratio	Min. air content A) and min. cement or combination content (kg/m³) for max. aggregate size				Other require-ments	Cements and combinations	Alternative designated concrete
			32 mm or 40 mm	20 mm	14 mm	10 mm			
XF1	C25/30	0.60	4.0 260	4.5 280	5.5 300	6.5 320	—	All in Table A.6	PAV1 and RC28/35
	C28/35 or LC28/31	0.60	— 260	— 280	— 300	— 320	—		
XF2	C25/30	0.60	4.0 260	4.5 280	5.5 300	6.5 320	—	All in Table A.6	PAV1 and RC32/40
	C32/40 or LC32/35	0.55	— 280	— 300	— 320	— 340	—		
XF3	C25/30	0.60	4.0 260	4.5 280	5.5 300	6.5 320	Freeze-thaw resisting aggregates B)	All in Table A.6 excluding cement and combination type IVB-V	PAV1 and RC40/50XF
	C40/50 or LC40/44	0.45	— 320	— 340	— 360	— 360			
XF4	C28/35	0.55	4.0 280	4.5 300	5.5 320	6.5 340	Freeze-thaw resisting aggregates B)	All C) in Table A.6 excluding cement and combination type IVB-V	PAV2 D) and RC40/50XF
	C40/50 or LC40/44	0.45	— 320	— 340	— 360	— 360			

A) See BS 8500-2:2015, **4.5** for requirements relating to the use of air-entraining admixtures.

B) See **A.7.6** and BS 8500-2:2015, **4.3.2**.

C) Cements or combinations containing more than a mass fraction of 55% ggbs might not be suitable for the wearing surfaces of pavement concrete due to the possibility of surface scaling in the top few millimetres.

D) As the requirements for PAV2 concrete cover a range of exposure conditions, not just XF4 exposure, the limiting values for composition and properties are more onerous than those given in this Table. See **A.4.3** for guidance.

A.4.5 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 additional protective measure (APM) should be selected using Table A.10. The APMs are listed in Table A.11. Table A.10 also gives lowest nominal cover recommended in the National Annex to BS EN 1992-1-1.

BRE Special Digest 1 [1] gives full guidance that aids the selection of the DC-class and the relevant APM. 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.10 **Selection of the nominal cover and DC-class or designated concrete and APM for in-situ concrete elements[A)] in contact with the ground where the hydraulic gradient due to groundwater is five or less[B) C) D)]**

ACEC-class	Lowest nominal cover [E)], mm	Intended working life [F)]	
		At least 50 years[G) H)]	At least 100 years
AC-1s, AC-1	(25 + Δc)	DC-1 (RC25/30 if reinforced)	DC-1 (RC25/30 if reinforced)
AC-2s, AC-2	(25 + Δc)	DC-2 (FND2)	DC-2 (FND2)
AC-2z	(25 + Δc)	DC-2z (FND2Z)	DC-2z (FND2Z)
AC-3s	(25 + Δc)	DC-3 (FND3)	DC-3 (FND3)
AC-3z	(25 + Δc)	DC-3z (FND3Z)	DC-3z (FND3Z)
AC-3	(25 + Δc)	DC-3 (FND3)	DC-3 + one APM of choice, FND3 + one APM of choice, DC-4 or FND4
AC-4s	(25 + Δc)	DC-4 (FND4)	DC-4 (FND4)
AC-4z	(25 + Δc)	DC-4z (FND4Z)	DC-4z (FND4Z)
AC-4	(25 + Δc)	DC-4 (FND4)	DC-4 + one APM from APM2 to APM5, or FND4 + one APM from APM2 to APM5
AC-4ms	(25 + Δc)	DC-4m (FND4M)	DC-4m (FND4M)
AC-4m	(25 + Δc)	DC-4m (FND4M)	DC-4m + one APM from APM2 to APM5, or FND4m + one APM from APM2 to APM5
AC-5z	(25 + Δc)	DC-4z (FND4Z) + APM3 [I)]	DC-4z (FND4Z) + APM3 [I)]
AC-5	(25 + Δc)	DC-4 (FND4) + APM3 [I)]	DC-4 (FND4) + APM3 [I)]
AC-5m	(25 + Δc)	DC-4m (FND4M) + APM3 [I)]	DC-4m (FND4M) + APM3 [I)]

[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, whilst retaining any requirement for APM. For reinforced concrete, the cover should be sufficiently thick to allow for estimated surface degradation during the intended working life.

[E)] The minimum allowance for deviation, Δc, should be at least 15 mm for concrete to be cast against blinding or prepared ground and at least 50 mm for concrete to be cast directly against soil. For concrete initially cast against formwork before coming into contact with the ground this allowance is typically 5 mm to 15 mm. Where the ground contains chlorides, the nominal cover should comprise the recommended minimum cover for the associated XD or XS class plus an the allowance for deviation, Δc, 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)] Where APM3 is not practical, select an alternative APM.

Table A.11 **Additional protective measures (APMs)**

Option code	APM
APM1	Enhanced concrete quality
APM2	Use of controlled permeability formwork
APM3	Provide surface protection
APM4	Provide sacrificial layer
APM5	Address drainage of site

Table A.12 gives details of the limiting values associated with the specification of the DC-class. The recommendations in Table A.12 are adequate to resist carbonation-induced corrosion (XC2 exposure class) in fully buried reinforced concrete. The recommendations in Table A.12 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 is 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 should 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 E), the recommendations in Table A.12 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.12 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.9 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.12 **Limiting values of composition and properties for concrete where a DC-class is specified**

DC-class	Max. w/c ratio	Min. cement or combination content (kg/m³) for max. aggregate size				Cement and combination types	Grouping used in BRE SD1:2005 [1]
		≥40 mm	20 mm	14 mm	10 mm		
DC-1 A)	—	—	—	—	—	All in Table A.6	A to G
DC-2	0.55	300	320	340	360	IIB-V+SR, IIIA+SR, IIIB+SR, IVB-V	D, E, F
	0.50	320	340	360	380	CEM I, CEMI-SR0, CEMI-SR3, IIA-D, IIA-Q, IIA-S, IIA-V, IIB-S, IIB-V, IIIA, IIIB	A, G
	0.45	340	360	380	380	IIA-L or LL ≥42,5	B
	0.40	360	380	380	380	IIA-L or LL 32,5	C
DC-2z	0.55	300	320	340	360	All in Table A.6	A to G
DC-3	0.50	320	340	360	380	IIIB+SR	F
	0.45	340	360	380	380	IVB-V	E
	0.40	360	380	380	380	IIB-V+SR, IIIA+SR, CEMI-SR0, CEMI-SR3	D, G
DC-3z	0.50	320	340	360	380	All in Table A.6	A to G
DC-4	0.45	340	360	380	380	IIIB+SR	F
	0.40	360	380	380	380	IVB-V	E
	0.35	380	380	380	380	IIB-V+SR, IIIA+SR, CEMI-SR0, CEMI-SR3	D, G
DC-4z	0.45	340	360	380	380	All in Table A.6	A to G
DC-4m	0.45	340	360	380	380	IIIB+SR	F

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.

A.4.6 Guidance on the selection of concrete exposed to sea water

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.13.

For the avoidance of deterioration due to sulfates within the original concrete, see **A.7.5** and **A.8.2**. For the avoidance of damaging alkali–silica reaction, see **A.8.1**. Limiting values for composition and properties of unreinforced concrete subject to sea water and abrasion are given in BS 6349-1-4.

Table A.13 **Limiting values of composition for unreinforced concrete in contact with sea water (exposure class XAS)**

Max. w/c ratio	Min. cement or combination content (kg/m³) for max. aggregate size				Cement and combination types A)	Indicative compressive strength class B)
	≥40 mm	20 mm	14 mm	10 mm		
0.55	280	300	320	340	CEMI, CEMI-SR0, CEMI-SR3, IIA,IIB-S	(C28/35)
0.55	280	300	320	340	IIB-V, IIB-V+SR, IIIA, IIIA+SR	(C25/30)
0.55	280	300	320	340	IIIB, IIIB+SR, IVB-V	(C20/25)

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**.

A.4.7 Guidance on the selection of concrete for housing and other applications

Table A.14 provides guidance on the selection of designated concrete and standardized prescribed concrete in housing and other applications, together with a recommended consistence class where applicable. 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.15 and a summary of the requirements for designated cement-bound concrete is given in Table A.16. For standardized prescribed concrete the compressive strength classes given in Table A.17 may be assumed for structural design purposes. The proportions of standardized prescribed concretes were selected to give assurance that in most cases they 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 within the scope of designated concretes (see Table A.14) and designed concrete. Air entraining admixtures are not permitted in standardized prescribed concrete (see BS 8500-2:2015, **9.2**).

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.14 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.14 **Guidance on the selection of designated and standardized prescribed concrete in housing and other applications**

Application[A) B)]	Designated concrete	Standardized prescribed concrete	Recommended consistence class
Unreinforced foundations [B)] ***and associated works requiring DC-1 concrete***			
Blinding and mass concrete fill	GEN1	ST2	S3 [C)]
Strip footings	GEN1	ST2	S3[C)]
Mass concrete foundations	GEN1	ST2	S3[C)]
Trench fill foundations	GEN1	ST2	S4
Drainage works to give immediate support	GEN1	ST2	S1
Other drainage works	GEN1	ST2	S3[C)]
Oversite below suspended slabs	GEN1	ST2	S3 [C)]
Unreinforced foundations requiring DC-2 to DC-4 concrete [B)]			
DC-2	FND2	N/A	S3[C) D)]
DC-2z	FND2Z	N/A	S3[C) D)]
DC-3	FND3	N/A	S3[C) D)]
DC-3z	FND3Z	N/A	S3[C) D)]
DC-4	FND4	N/A	S3[C) D)]
DC-4z	FND4Z	N/A	S3[C) D)]
DC-4m	FND4M	N/A	S3[C) D)]
General applications			
Kerb bedding and backing	GEN0	ST1	S1
Floors			
House floors with no embedded metal (see Note 2 to **4.2.2**)			
• Permanent finish to be added, e.g. a screed or floating floor	GEN1	ST2	S2
• No permanent finish to be added, e.g. carpeted	GEN2	ST3	S2
House and garage ground floor slabs			
Fully nominally reinforced, either ground bearing, suspended or over sub-floor voids [E)]	RC28/35	ST5	S2
Garage floors not designed as suspended and not reinforced [E)]	GEN3	ST4	S2
Wearing surface: light foot and trolley traffic	RC25/30	ST4	S2
Wearing surface: general industrial	RC32/40	N/A	S2
Wearing surface: heavy industrial [F)]	RC40/50	N/A	S2
Paving and roadbase			
House drives and domestic parking	PAV1	N/A	S2 [C)]
Heavy-duty external paving with rubber tyre vehicles [F)]	PAV2	N/A	S3[C) G)]
Cement-bound concrete, used for foundations and reinstatement of openings in highways			
Reinstating base (roadbase) for flexible/composite roads and footways	CB16/20	N/A	N/A

[A)] Concrete containing embedded metal should be treated as reinforced. PAV2 is suitable for reinforced ground supported pavements exposure class XD3. See **A.4.3**.

[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)] See NHBC Technical Standards 2.1 [8].

[F)] For extreme applications, e.g. foundry floors and busy public roads, specialist advice should be sought.

[G)] Depends on method of placing and finishing.

Table A.15 **Summary of requirements for designated concretes**[A)]

Concrete designation	Min. strength class	Default slump class	Max. w/c ratio	Min. cement or combination content (kg/m³) for 20 mm max. aggregate size	Cement and combination types
GEN0	C6/8	S3	—	120	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
GEN1	C8/10	S3	—	180	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
GEN2	C12/15	S3	—	200	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
GEN3	C16/20	S3	—	220	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
RC20/25	C20/25	S3	0.70	240	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
RC25/30	C25/30	S3	0.65	260	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V [B)]
RC28/35	C28/35	S3	0.60	280	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V [B)]
RC30/37	C30/37	S3	0.55	300	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V [B)]
RC32/40	C32/40	S3	0.55	300	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V [B)]
RC35/45	C35/45	S3	0.50	320	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V [B)]
RC40/50	C40/50	S3	0.45	340	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V [B)]
RC40/50XF	C40/50	S3	0.45	340	CEM I, IIA, IIB-S, IIB-V, IIIA [C)]
PAV1	C28/35 [D)]	S2	0.55	300	CEM I, IIA, IIB-S, IIB-V, IIIA [C)]
PAV2	C32/40 [D)]	S3	0.45	340	CEM I, IIA, IIB-S, IIB-V, IIIA [C)]
FND2	C25/30	S3	0.55	320	IIB-V+SR, IIIA+SR, IIIB+SR, IVB-V
			0.50	340	CEM I, CEMI-SR0, CEMI-SR3, II-S, II-V, IIIA, IIIB
			0.45	360	IIA-L or LL class 42,5
			0.40	380	IIA-L or LL class 32,5
FND2Z	C25/30	S3	0.55	320	All in Table A.6
FND3	C25/30	S3	0.50	340	IIIB+SR
			0.45	360	IVB-V
			0.40	380	IIB-V+SR, IIIA+SR, CEMI-SR0, CEMI-SR3
FND3Z	C25/30	S3	0.50	340	All in Table A.6
FND4	C25/30	S3	0.45	360	IIIB+SR
			0.40	380	IVB-V
			0.35	380	IIB-V+SR, IIIA+SR, CEMI-SR0, CEMI-SR3
FND4Z	C25/30	S3	0.45	360	All in Table A.6
FND4M	C25/30	S3	0.45	360	IIIB+SR

A) See BS 8500-2:2015, Clause **6** for the full set of requirements for designated concretes.

B) Only if specifically permitted under **4.2.3**a).

C) With a maximum proportion of ggbs of 55% unless a higher proportion is specifically permitted in accordance with **4.2.3**a).

D) The concrete shall contain an air-entraining admixture to give a minimum air content by volume of 4.0%, 4.5%, 5.5% or 6.5% with aggregate of 40 mm, 20 mm, 14 mm, and 10 mm maximum aggregate size respectively at delivery.

Table A.16 **Summary of requirements for designated cement-bound concrete**

Concrete designation	Min. strength class A)	Min. cement or combination content B) %	Cement and combination type
CB6/8	C6/8	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB8/10	C8/10	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB12/15	C12/15	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB16/20	C16/20	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB20/25	C20/25	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB25/30	C25/30	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB28/35	C28/35	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB30/37	C30/37	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB32/40	C32/40	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB35/45	C35/45	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
CB40/50	C40/50	3	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V

A) The characteristic compressive strength at 28 days of cylinders or cubes made in accordance with BS EN 13286-51 and tested in accordance with BS EN 12390-3.

B) Aggregate grading for cement-bound concrete as given BS 8500-2:2015, Table 8.

Table A.17 **Standardized prescribed concretes and indicative strengths**

Standardized prescribed concrete	Strength class that may be assumed for structural design	Characteristic compressive cube strength at 28 days that may be assumed for structural design N/mm^2
ST1	C6/8	8
ST2	C8/10	10
ST3	C12/15	15
ST4	C16/20	20
ST5	C20/25	25

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.18 provides guidance on the consistence expressed as slump [S(number)], flow [F(number)] and slump-flow [SF(number)] classes appropriate to different uses. Where the concrete is laid on a slope, a lower slump class than that given in Table A.18 might be necessary.

Consistence should be specified by using one of the classes in BS EN 206:2013, Table 3, Table 5 or Table 6. Where there are particular compaction, viscosity, passing ability or segregation resistance requirements then one of the classes in BS EN 206:2013, Table 4, Table 7, Table 8, Table 9, Table 10 or Table 11 should be specified. In special cases, a target value instead of a consistence class might be appropriate. 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.

Table A.18 **Consistence suitable for different uses of in-situ concrete**

Use of concrete	Form of compaction	Consistence class	
		Normal-weight concrete	**Lightweight concrete**
Cement-bound for reinstatement or base	Tamping, vibrotamper, vibrating plate or roller, roller-compaction	—	—
Kerb bedding and backing	Tamping	S1	—
Floors and hand placed pavements	Poker or beam vibration	S3	S2
Large or industrial floors		S3	S3
Machine placed pavements	Poker or beam vibration	S3	—
Strip footings	Poker or beam vibration and/or tamping	S4	—
Mass concrete foundations		S3	—
Blinding		S3	—
Normal reinforced concrete in slabs, beams, walls and columns		S3	S3
Sliding formwork construction		S2	S2
Pumped concrete		S3	F5
Vacuum processed concrete		S3	S3
Trench fill	Self-weight compaction	S4	—
In-situ piling		S4	—
Self-compacting concrete for applications such as congested reinforcement or intricate formwork	Self-weight compaction	SF2	SF2

A.6 Density

The density of lightweight concrete should be specified by density class (see BS EN 206:2013, Table 14) 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/m^3) 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 is 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 standards listed in BS 8500-2:2015, **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 8500-2:2015, **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.

A.7.2 Aggregate size

The maximum permitted aggregate size should be specified as D_{upper}. This normally permits the producer to provide concrete with a smaller maximum aggregate size, e.g. concrete specified as 20 mm maximum aggregate size may be supplied with a maximum aggregate size of 20 mm, 14 mm or 10 mm. Where either 14 mm or 10 mm is not acceptable the specifier should also specify a lower limit to the specified maximum aggregate size, D_{lower}, e.g. D_{upper} = 20 mm and D_{lower} = 14 mm or D_{lower} = 10 mm as required.

Where no reduction below the specified maximum aggregate size is permitted, the value of D_{lower} should be the same as D_{upper}, e.g. D_{upper} = 20 mm and D_{lower} = 20 mm. D_{lower} need not be specified if there is no requirement to limit the lowest acceptable maximum aggregate size.

NOTE 1 The term D_{max} is used by the producer to declare the maximum aggregate size provided.

It is acceptable to specify the D_{upper} as 10 mm, 14 mm, 20 mm or 40 mm as appropriate. In these cases the nominal upper aggregate size used in the concrete is 4/10 mm, 6/14 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 should 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 2 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.

The producer is free to select for the concrete D_{upper}, D_{lower} or any size in between and declare this size on the delivery ticket as D_{max}, defined in BS EN 206 as “declared value of *D* of the coarsest fraction of aggregates actually used in the concrete”.

A.7.3 Aggregates for resistance to fragmentation and wear

There is a default requirement in BS 8500-2:2015, **4.3** for the Los Angeles coefficient category of coarse normal-weight and heavyweight aggregate to be not greater than LA_{40} 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 is exposed.

For wear resistance specified by performance, see BS EN 13813.

A.7.4 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 8500-2:2015, **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.7.5 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 8500-2:2015, **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 (see DETR 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 blastfurnace slag aggregates with long histories of satisfactory use.

A.7.6 Freeze-thaw resistance

*COMMENTARY ON **A.7.6***

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 8500-2:2015, **4.3.2**, 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.7.7 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. Where structural lightweight concrete is to be used, BS 8500-2:2015, **4.3** specifies requirements for the lightweight aggregate. These are:

a) an acid-soluble sulfate content not more than 1% when measured in accordance with BS EN 1744-1;

b) for furnace bottom ash or clinker, a loss-on-ignition not more than 10% when measured in accordance with BS EN 1744-1;

c) 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 206:2013, Annex A.

A.7.8 Aggregates for visual concrete

The presence of materials in aggregates, such as iron pyrites, particles of coal and lightweight contaminators can mar the surface of the concrete. Where the appearance of the concrete is important, a knowledge of the aggregate source and of similar work that has been carried out with the aggregate in question can be more helpful than setting any particular limits on the content of such contaminators. Any limits should be agreed between the purchaser and supplier.

A.7.9 Aggregate for fire resistance and low thermal expansion

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 might be advantageous. Aggregates with low coefficients of thermal expansion are also beneficial in reducing the risk or extent of early-age thermal cracking.

A.7.10 Crushed concrete aggregate (CCA) and recycled aggregate (RA)

A.7.10.1 Coarse CCA and RA

Coarse CCA and coarse RA conforming to BS 8500-2 may be used in designed concrete up to a maximum strength class C40/50. Coarse CCA obtained by crushing hardened concrete of known composition that has not been in use and not contaminated during storage and processing may be used in any strength class.

Coarse CCA and coarse RA conforming to BS 8500-2 may be used in designed concrete in exposure classes X0, XC1, XC2, XC3/XC4, XF1 and DC-1. These aggregates may be used in other exposure classes provided it has been demonstrated that the resulting concrete is suitable for the intended environment, e.g. freeze-thaw resisting, sulfate-resisting.

Coarse CCA and coarse RA conforming to BS 8500-2 may be used in designated concrete RC20/25 to RC40/50 but the proportion is limited to not more than a mass fraction of 20% of coarse aggregate unless specified otherwise.

While some requirements for coarse RA are specified in BS 8500-2 they are insufficient to form an adequate specification. As the potential composition of RA is so wide, the additional specification requirements should be assessed on a case-by-case basis taking into account the specific composition of the RA. In particular the project specification for RA should include:

a) maximum acid-soluble sulfate;

b) method for determination of the chloride content;

c) classification with respect to alkali–aggregate reactivity;

d) method for determination of the alkali content; and

e) any limitations on use in concrete.

A.7.10.2 Fine CCA and RA

Although provisions for the use of fine CCA and fine RA are not given in BS 8500 this does not preclude their use where it is demonstrated that, due to the source of material, significant quantities of deleterious materials are not present and their use has been specified or permitted.

NOTE 1 Clean fine CCA is suitable for use in concrete. However, it is known that some concrete elements have been coated with gypsum plaster, and on crushing most of this gypsum plaster finishes in the fine CCA. Gypsum plaster is known to increase the sulfate content of the concrete and this can increase the risk of delayed ettringite formation (see BRE Information Paper IP 11/01 [12]) and there are great difficulties in detecting localized high volumes of sulfate. For these reasons, the use of fine CCA is left to the project specification, which can take account of the particular source of CCA.

NOTE 2 Some fine RA might also be suitable for use in concrete, but because of the wide range of composition and lack of detailed information, generic requirements cannot be given at present. The comment above on gypsum in fine CCA also applies to some sources of fine RA.

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, standardized prescribed and proprietary concretes, the producer is required to take action to minimize damaging alkali–silica reaction (see BS 8500-2:2015, **5.2**). If the producer follows the guidance given in BS 8500-2:2015, Annex B, this is deemed to have satisfied the requirement to minimize damaging alkali–silica reaction. These actions apply regardless of whether the concrete is in a dry environment. Whilst BS EN 206:2013, 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, this can be a difficult requirement to place on the specifier. For example, if the specifier specifies a polished stone value for wear resistance, they have no knowledge of what rock type is 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 when special types and classes of aggregate are specified to minimize the risk of damaging alkali–silica reaction.

Consequently, BS 8500-2:2015, **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 206:2013, **6.1** states that for prescribed concrete, the specifier is responsible for ensuring that the specified composition is not prone to damaging alkali–silica reaction. Due to the general nature of most prescribed concrete specifications, e.g. type and strength class of cement, aggregates conforming to a standard, it is not normally practical for the specifier to check that damaging alkali–silica reaction does not occur. The practical solution is to include in the specification the additional requirement in **4.4.3**a) 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 BS 8500-2:2015, Annex B, conformity is based on the declared mean alkali content of a cement or 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 IP 11/01 [12].

A.9 Concrete placing

A.9.1 Time limits

Concrete should be placed into its final position as soon as practicable. Extended delays in placing can lead to a significant loss of consistence with time making it impossible to place with satisfactory compaction. Where there is an extended delay between the placement of one layer of concrete and the following layer then there may be a cold joint between layers. For this to occur the delay should be sufficient for the lower layer to develop an initial set or harden. The time for this to occur depends on the concrete temperature, cement type, mix proportions, the use of admixtures with set retarding properties and consistence of the concrete.

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.

Where required, the specification of a maximum time between placing layers of concrete should take account of the likely temperature of the concrete, cement type, mix proportions, the use of admixtures with set retarding poperties and consistence of the concrete.

NOTE With the use of retarding admixtures the set may be delayed for 12 h or more. Where placed concrete remains compactable by vibration then the continued placement of concrete does not produce a cold joint.

A.9.2 Work in cold weather

In cold weather, consideration should be given to:

a) prevention of freezing of the immature concrete;

b) extended stiffening times, which can lead to increased formwork pressures and delays in finishing; and

c) 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:

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

2) 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;

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

4) specifying a minimum temperature of fresh concrete greater than that given in BS EN 206:2013, **5.2.9**.

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:

a) avoiding reductions in the working life of the fresh concrete due to loss of mix water by evaporation and accelerated hydration; and

b) 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 concrete temperature of 30 °C should be specified.

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

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

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

3) specifying a maximum temperature of fresh concrete less than that given in BS 8500-2:2015, **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 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 8500-2:2015, **12.2**.

The producer need only use one shape and size of specimen for conformity testing, either cylinders or cubes (see BS EN 206:2013, **5.5.1.1**). The specimen shape and size to be tested is selected by the concrete producer and declared (see BS EN 206:2013, **5.5.1.2**). In the United Kingdom this is likely to be the 100 mm cube.

BS EN 206 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. 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 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, slump-flow, air content and quality or for spot checks. density on individual batches of concrete are given in Annex B. Requirements for identity testing for compressive strength are given in BS EN 206:2013, 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 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 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 is to be undertaken on volumes of concrete still to be defined using the criteria in BS EN 206 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 specifier is responsible for organizing any identity testing. The identity criteria are set for one to six non-overlapping results in accordance with BS EN 206:2013, **B.3**. Where there are more than six results then the BS EN 206:2013, **B.3**, criterion 1 is applied to each group of six results and, where applicable, the last group with less than six results in accordance with **B.5** of this British Standard.

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 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.

A.11 Concrete for geotechnical works

BS EN 206:2013, Annex D contains optional additional requirements for specification and conformity of designed concrete for special geotechnical works.

*NOTE The UK view is that these additional requirements are not necessary as the framework for specifying concrete for any application is contained within BS EN 206:2013, Clause **6**.*

A.12 Segregation and bleeding

Where there is a requirement to minimize segregation or bleeding of the fresh concrete the method of sampling, test method, target value and conformity criteria should be specified.

Annex B (normative) Identity testing for slump, flow, 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; or

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, flow and slump flow testing

B.2.1 Sampling

The sampling shall be either:

a) in accordance with BS EN 12350-1; or

b) 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 m^3 by taking six increments from the moving stream of the concrete in accordance with BS EN 12350-1.

The sample shall be remixed on a non-absorbent surface and tested for slump, flow or slump 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. Slump-flow shall be measured in accordance with BS EN 12350-8.

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 with respect to consistence.

Table B.1 **Identity criteria for slump specified as a slump class**

Dimensions in millimetres

Specified slump class	Requirement			
	For composite samples taken in accordance with BS EN 12350-1		For spot samples taken from initial discharge	
	Not less than	Not more than	Not less than	Not more than
S1	0	50	0	60
S2	40	100	30	110
S3	90	160	80	170
S4	150	220	140	230
S5 [A)]	210	—	200	—

[A)] Due to a lack of sensitivity of the slump test at slump values less than 10 mm or greater than 210 mm, it is recommended to only use the test for slump ≥10 mm and ≤210 mm.

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 with respect to consistence.

Table B.2 **Identity criteria for slump specified as a target value**

Specified slump class	Tolerance			Dimensions in millimetres
	For composite samples taken in accordance with BS EN 12350-1		For spot samples taken from initial discharge	
	Not less than	Not more than	Not less than	Not more than
≤40	–10	+10	–20	+20
50 to 90	–20	+20	–30	+30
≥100 A)	–30	+30	–40	+40

A) Due to a lack of sensitivity of the slump test at slump values less than 10 mm or greater than 210 mm, it is recommended to only use the test for slump ≥10 mm and ≤210 mm.

Table B.3 **Identity criteria for flow specified as a flow class**

Specified flow class	Requirement			Dimensions in millimetres
	For composite samples taken in accordance with BS EN 12350-1		For spot samples taken from initial discharge	
	Not less than	Not more than	Not less than	Not more than
F1 A)	—	350	—	360
F2	340	420	330	430
F3	410	490	400	500
F4	480	560	470	570
F5	550	630	540	640
F6 A)	620	—	610	—

A) Due to a lack of sensitivity of the flow test at flow diameters of 340 mm and less, or greater than 620 mm, it is recommended to only use the test for flow diameter >340 mm and ≤620 mm.

Table B.4 **Identity criteria for flow specified as a flow value**

Specified flow class	Requirement			Dimensions in millimetres
	For composite samples taken in accordance with BS EN 12350-1		For spot samples taken from initial discharge	
	Not less than A)	Not more than A)	Not less than A)	Not more than A)
All values	–50	+50	–60	+60

A) As permitted these conformity criteria for target values of consistence take precedence over the values given in BS EN 206:2013, Table 23. The measured flow shall not differ from the specified target value by more than the amount shown.

B.2.5 Identity criteria for the slump-flow of an individual batch

If the measured slump-flow meets the requirements specified in Table B.5 or is within the tolerances specified in Table B.6, the identity test confirms that the batch conforms to BS EN 206 with respect to consistence.

Table B.5 **Identity criteria for slump-flow specified as a slump-flow class**

Dimensions in millimetres

Specified slump-flow class	Requirements			
	For composite samples taken in accordance with BS EN 12350-1		For spot samples taken from initial discharge[A)]	
	Not less than	Not more than	Not less than	Not more than
SF1	550	650	540	660
SF2	660	750	650	760
SF3	760	850	750	860

[A)] BS EN 206:2013, Table 23 does not indicate identity criteria for spot samples taken from initial discharge and so these are set at UK level.

Table B.6 **Identity criteria for slump-flow specified as a target value**

Dimensions in millimetres

Specified slump-flow class	Requirements[A)]			
	For composite samples taken in accordance with BS EN 12350-1		For spot samples taken from initial discharge	
	Not less than	Not more than	Not less than	Not more than
All values	–50	+50	–60	+70

[A)] As permitted these conformity criteria for target values of consistence take precedence over the values given in BS EN 206:2013, Table 23.

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-weight and non air-entrained lightweight hardened concrete shall be not more than ±130 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 206:2013, 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 206:2013, 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 206:2013, 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.

B.6 Consistence retention testing

B.6.1 General

Requirements for consistence retention times in excess of that required to place concrete shall be specified. Where there is a requirement to measure consistence beyond the time of placing this shall also be specified as well as the procedures and apparatus required for transporting, handling, care and remixing of samples. The containers shall be stored near the point of discharge but protected from direct sunlight.

Where there is a specified requirement for consistence retention, e.g. a flow of 450 mm at 5 h, this requirement shall be tested on a sample not used previously, stored in a single container and re-mixed prior to testing at the specified time.

NOTE 1 The difference between standard consistence test results and those obtained from stored and re-mixed samples is unknown. Due to the potential for moisture and grout loss from stored samples, consideration should be given to increasing the acceptable range of consistence test results.

NOTE 2 For information, the loss of consistence with time may be assessed by re-testing a single large samples. Such testing might provide an indication of the concrete's performance but the results should not be used for conformity assessment.

B.6.2 Containers for storing samples

The containers for storing concrete for delayed testing shall be sealable cylindrical container made from non-absorbent material not readily attacked by cement paste. To minimize the potential loss of mortar, the ratio of height to diameter shall be not less than 0.7 or greater than 1.3.

The size of the container shall be such that, when filled, the top surface of the concrete shall be within 25 mm to 50 mm of the container lid.

NOTE Plastic cement tubs have been found to be suitable.

B.6.3 Sample size

For consistence retention testing of single samples the sample shall be at least 1.5 times the quantity estimated as being required for the test.

B.6.4 Temperature

The temperature of the concrete sample and ambient temperature shall be recorded at the time of consistence testing.

B.6.5 Report

The test report shall include a summary of the delayed testing procedures as well as a record of the consistence test results, temperatures and time of testing.

Annex C (informative) Expected cement or combination 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 or combination 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 or combination contents for nominal proportions**

Nominal proportions	Target cement or combination content [A)] kg/m³
1:1:2	480
1:1:3	350
1:2:4	275
1:2:5	225
1:3:6	190
1:4:8	150
4:1 all in	330
5:1 all in	290
6:1 all in	250
7:1 all in	220
8:1 all in	195
9:1 all in	175
10:1 all in	160
12:1 all in	135
14:1 all in	120
15:1 all in	115
18:1 all in	95
20:1 all in	85

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

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