

BS 6349-1-4:2021+A1:2025



BSI Standards Publication

Maritime works

Part 1-4: General – Code of practice for materials

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Foreword

Publishing information

This part of BS 6349 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 July 2021. It was prepared by Technical Committee CB/502, *Maritime works*. A list of organizations represented on this committee can be obtained on request to the committee manager.

Supersession

[BS 6349-1-4:2021](#) superseded [BS 6349-1-4:2013](#), which has been withdrawn.

BS 6349-1-4:2021+A1:2025 supersedes [BS 6349-1-4:2021](#), which is withdrawn.

Relationship with other publications

BS 6349 is published in the following parts:

- Part 1-1: *General – Code of practice for planning and design for operations*;
- Part 1-2: *General – Code of practice for assessment of actions*;
- Part 1-3: *General – Code of practice for geotechnical design*;
- Part 1-4: *General – Code of practice for materials*;
- Part 2: *Code of practice for the design of quay walls, jetties and dolphins*;
- Part 3: *Code of practice for the design of shipyards and sea locks*;
- Part 4: *Code of practice for design of fendering and mooring systems*;
- Part 5: *Code of practice for dredging and land reclamation*;
- Part 6: *Design of inshore moorings and floating structures*;
- Part 7: *Guide to the design and construction of breakwaters*;
- Part 8: *Code of practice for the design of Ro-Ro ramps, linkspans and walkways*.

Information about this document

[BS 6349-1-4:2021](#) was a full revision of the document, and introduced the following principal changes:

- a) The standard was updated to reflect current industry practice. In particular, the concrete section has been updated to be generally in line with the recommendations of [BS 8500](#).
- b) The metals section was reorganized and updated. In particular, the clauses on corrosion, protective coatings, wraps and cathodic protection have been updated and incorporated into the appropriate section.
- c) A new section on polymers was added.
- d) The sections on stone for armouring and protective works and bituminous materials was updated.
- e) The previous clauses on piles, rails, pipes and pavements were removed from this standard as they are structural elements rather than materials.

[Figure A.2](#) is a reproduction of Figure 6.2 in *Concrete in coastal structures* [1]. It is reproduced with the kind permission of ICE Publishing, 8 Storey's Gate, London SW1P 3AT.

Text introduced or altered by Amendment No. 1 is indicated in the text by tags A1 A1. Minor editorial changes are not tagged.

Amendment No.1 introduces the following changes:

- [Section 2](#) has been updated to clarify that, where appropriate, the guidance provided relates to cements and cement combinations. The standard has also been updated to align with [BS 8500-1:2023](#);
- Subclause [9.3](#), which provides guidance related to chains, has been replaced in full;
- Clause [16](#) has been updated to provide additional guidance related to extruded fender units in addition to the guidance previously provided related to moulded and wrapped fender units; and
- Clause [17](#), which provides guidance related to plastics, has been updated to include additional guidance related to regenerated UHMW-PE.

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

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Use of this document

As a code of practice, this part of BS 6349 takes the form of recommendations and guidance. It is not to be quoted as if it were a specification. Users are expected to ensure that claims of compliance are not misleading.

Users may substitute any of the recommendations in this part of BS 6349 with practices of equivalent or better outcome. Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

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

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

Where words have alternative spellings, the preferred spelling of the *Shorter Oxford English Dictionary* is used (e.g. “organization” rather than “organisation”).

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Section 1 General

Introduction

The materials covered by this part of BS 6349 include the basic materials used in civil engineering construction, and composite or manufactured materials where these are normally considered to be materials in their own right.

The materials covered in this part of BS 6349 are as follows:

- a) concrete: complementary guidance to [BS EN 206](#), [BS 8500-1:2023](#) and [BS 8500-2](#);
- b) metals;
- c) timber;
- d) polymers;
- e) stone for armouring or protection works; and
- f) bituminous materials.

Protective measures and treatments against corrosion of metals cover a wide range of methods that can be applied in the construction, operation and maintenance of maritime structures. These are also addressed in this part of BS 6349.

1 Scope

This part of BS 6349 gives recommendations for the materials used in the design and construction of maritime environment structures, and includes specific provisions for use in a seawater environment.

NOTE Materials used in these conditions are often subject to more onerous environmental conditions than onshore structures, and thus particular attention is paid to the use of durable materials to provide the required performance and design life.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions, or limits the application, of this document¹⁾. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

ANSI/AWWA C217, *Microcrystalline wax and petrolatum tape coating systems for steel water pipe and fittings*

ASTM D1765, *Standard classification system for carbon blacks used in rubber products*

[BS 4449](#), *Steel for the reinforcement of concrete – Weldable reinforcing steel – Bar, coil and decoiled product – Specification*

[BS 4482](#), *Steel wire for the reinforcement of concrete products – Specification*

[BS 4483](#), *Steel fabric for the reinforcement of concrete – Specification*

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

[BS 4486](#), *Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete*

[BS 5896](#), *High tensile steel wire and strand for the prestressing of concrete – Specification*

[BS 6349-1-1](#), *Maritime works – Part 1-1: General – Code of practice for planning and design for operations*

[BS 6349-4](#), *Maritime works – Part 4: Code of practice for design of fendering and mooring systems*

[BS 6744](#), *Stainless steel bars – Reinforcement of concrete – Requirements and test methods*

[BS 7371-6](#), *Coatings on metal fasteners – Part 6: Specification for hot dipped galvanized coatings*

[BS 7542](#), *Method of test for curing compounds for concrete*

[A1](#) [BS 8500-1:2023](#) [A1](#), *Concrete – Complementary British Standard to BS EN 206 – Part 1: Method of specifying and guidance for the specifier*

[BS 8500-2](#), *Concrete – Complementary British Standard to BS EN 206 – Part 2: Specification for constituent materials and concrete*

[BS 8666](#), *Scheduling, dimensioning, cutting and bending of steel reinforcement for concrete – Specification*

[BS EN 206](#), *Concrete – Specification, performance, production and conformity²⁾*

[BS EN 446](#), *Grout for prestressing tendons – Grouting procedures*

[BS EN 447](#), *Grout for prestressing tendons – Basic requirements*

[BS EN 523](#), *Steel strip sheaths for prestressing tendons – Terminology, requirements, quality control*

[A1](#) [BS EN 818-1](#), *Short link chain for lifting purposes – Safety – General conditions of acceptance*

[BS EN 818-3:1999+A1:2008](#), *Short link for chain for lifting purposes – Safety – Medium tolerance chain for chain slings – Grade 4* [A1](#)

[BS EN 912](#), *Timber fasteners – Specifications for connectors for timbers*

[BS EN 1090-1](#), *Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components*

[BS EN 1090-2](#), *Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures*

[BS EN 1090-3](#), *Execution of steel structures and aluminium structures – Part 3: Technical requirements for aluminium structures*

[BS EN 1097-1](#), *Tests for mechanical and physical properties of aggregates – Part 1: Determination of the resistance to wear (micro-Deval)*

[BS EN 1337-3:2005](#), *Structural bearings – Elastomeric bearings*

[BS EN 1369](#), *Founding – Magnetic particle testing*

[BS EN 1559-1](#), *Founding – Technical conditions of delivery – Part 1: General³⁾*

[BS EN 1559-2](#), *Founding – Technical conditions of delivery – Part 2: Additional requirements for steel castings³⁾*

[BS EN 1561](#), *Founding – Grey cast irons*

[BS EN 1563](#), *Founding – Spheroidal graphite cast irons*

[BS EN 1990](#), *Eurocode – Basis of structural design*

[BS EN 1992](#) (all parts), *Eurocode 2 – Design of concrete structures*

²⁾ This standard also gives informative references to BS EN 206:2013+A1:2016.

³⁾ This standard also gives an informative reference to all parts of the [BS EN 1559](#) series.

[BS EN 1993](#) (all parts), *Eurocode 3 – Design of steel structures*⁴⁾

[BS EN 1995](#) (all parts), *Eurocode 5 – Design of timber structures*

[BS EN 1999](#) (all parts), *Eurocode 9 – Design of aluminium structures*⁵⁾

[BS EN 10025](#) (all parts), *Hot rolled products of structural steels*

[BS EN 10080](#), *Steel for the reinforcement of concrete – Weldable reinforcing steel – General*

[BS EN 10164](#), *Steel products with improved deformation properties perpendicular to the surface of the product – Technical delivery conditions*

[BS EN 10210](#) (all parts), *Hot finished steel structural hollow sections*

[BS EN 10219](#) (all parts), *Cold formed welded steel structural hollow sections*

[BS EN 10248](#) (all parts), *Hot rolled sheet piling of non alloy steels*

[BS EN 10249](#) (all parts), *Cold formed sheet piling of non alloy steels*

[BS EN 10348-2](#), *Steel for the reinforcement of concrete – Galvanized reinforcing steel – Part 2: Galvanized reinforcing steel products*

[BS EN 12680-3](#), *Founding – Ultrasonic testing – Part 3: Spheroidal graphite cast iron castings*

[BS EN 12954](#), *General principles of cathodic protection of buried or immersed onshore metallic structures*

[BS EN 13383](#) (all parts), *Armourstone*⁶⁾

 [BS EN 13889](#), *Forged steel shackles for general lifting purposes – Dee shackles and bow shackles – Grade 6 – Safety* 

[BS EN 13670](#), *Execution of concrete structures*

[BS EN 14545](#), *Timber structures – Connectors – Requirements*

 Text deleted 

[BS EN ISO 527-2](#), *Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics*

[BS EN ISO 868](#), *Plastics and ebonite – Determination of indentation hardness by means of a durometer (Shore hardness)*

[BS EN ISO 898-1](#), *Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs with specified property classes – Coarse thread and fine pitch thread*

[BS EN ISO 898-2](#), *Mechanical properties of fasteners made of carbon steel and alloy steel – Part 2: Nuts with specified property classes – Coarse thread and fine pitch thread*

 [BS EN ISO 1133-1](#), *Plastics – Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics – Part 1: Standard method* 

[BS EN ISO 1183-1](#), *Plastics – Methods for determining the density of non-cellular plastics – Part 1: Immersion method, liquid pycnometer method and titration method*

[BS EN ISO 1461](#), *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test method*

[BS EN ISO 1628-3](#), *Plastics – Determination of the viscosity of polymers in dilute solution using capillary viscometers – Part 3: Polyethylenes and polypropylenes*

⁴⁾ This standard also gives informative references to [BS EN 1993-1-1](#) and [BS EN 1993-5:2007](#).

⁵⁾ This standard also gives a normative reference to [BS EN 1999-1-1:2007+A2:2013](#).

⁶⁾ This standard also gives an informative reference to [BS EN 13383-1:2002](#).

[BS EN ISO 2063-1](#), *Thermal spraying – Zinc, aluminium and their alloys – Part 1: Design considerations and quality requirements for corrosion protection systems*

[BS EN ISO 10684](#), *Fasteners – Hot dip galvanized coatings*

[BS EN ISO 12944](#) (all parts), *Paints and varnishes – Corrosion protection of steel structures by protective paint systems*

[BS EN ISO 13174](#), *Cathodic protection of harbour installations*

[BS EN ISO 14713](#) (all parts), *Zinc coatings – Guidelines and recommendations for the protection against corrosion of iron and steel in structures*

[BS EN ISO 15527](#), *Plastics – Compression-moulded sheets of polyethylene (PE-UHMW, PE-HD) – Requirements and test methods*

[A1](#) [BS EN ISO 21304-2](#), *Plastics – Ultra-high-molecular-weight polyethylene (PE-UHMW) moulding and extrusion materials – Preparation of test specimens and determination of properties* [A1](#)

[BS ISO 34-1](#), *Rubber, vulcanized or thermoplastic – Determination of tear strength – Part 1: Trouser, angle and crescent test pieces*

[BS ISO 37](#), *Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties*

[BS ISO 48-4](#), *Rubber, vulcanized or thermoplastic – Determination of hardness – Part 4: Indentation hardness by durometer method (Shore hardness)*

[BS ISO 132](#), *Rubber, vulcanized or thermoplastic – Determination of flex cracking and crack growth (De Mattia)*

[BS ISO 812](#), *Rubber, vulcanized or thermoplastic – Determination of low-temperature brittleness*

[BS ISO 813](#), *Rubber, vulcanized or thermoplastic – Determination of adhesion to a rigid substrate – 90° peel method*

[BS ISO 815-1](#), *Rubber, vulcanized or thermoplastic – Determination of compression set – Part 1: At ambient or elevated temperatures*

[BS ISO 1407](#), *Rubber – Determination of solvent extract*

[BS ISO 1431-1](#), *Rubber, vulcanized or thermoplastic – Resistance to ozone cracking – Part 1: Static and dynamic strain testing*

[BS ISO 1817](#), *Rubber, vulcanized or thermoplastic – Determination of the effect of liquids*

[BS ISO 2000](#), *Rubber, raw natural – Guidelines for the specification of technically specified rubber (TSR)*

[BS ISO 2781](#), *Rubber, vulcanized or thermoplastic – Determination of density*

[BS ISO 4649](#), *Rubber, vulcanized or thermoplastic – Determination of abrasion resistance using a rotating cylindrical drum device*

[BS ISO 4650](#), *Rubber – Identification – Infrared spectrometric methods*

[BS ISO 9924-1](#), *Rubber and rubber products – Determination of the composition of vulcanizates and uncured compounds by thermogravimetry – Part 1: Butadiene, ethylene-propylene copolymer and terpolymer, isobutene-isoprene, isoprene and styrene-butadiene rubbers*

[BS ISO 14654](#), *Epoxy-coated steel for the reinforcement of concrete*

[A1](#) [ISO 1834](#), *Short link chain for lifting purposes – General conditions of acceptance*

[ISO 2415](#), *Forged shackles for general lifting purposes – Dee shackles and bow shackles*

[ISO 8295](#), *Plastics – Film and sheeting – Determination of the coefficients of friction* [A1](#)

ISO 12473, *General principles of cathodic protection in seawater*⁷⁾

ISO 16204, *Durability – Service life design of concrete structures*

ISO 17357 (all parts), *Ships and marine technology – Floating pneumatic rubber fenders*

NACE SP0375, *Field-applied underground wax coating systems for underground metallic pipes: application, performance, and quality control*

PD 6484, *Commentary on corrosion at bimetallic contacts and its alleviation*

Other publications

 Text deleted 

[N1] LLOYD'S REGISTER. *Rules for the manufacture, testing and certification of materials.*

London: Lloyd's Register,  2023 .

[N2] ENERGY INSTITUTE. *Guidelines for the use of anti-corrosion tape systems for process pipework.*

London: Energy Institute, 2017.

[N3] CIRIA, CUR, CETMEF. *The Rock Manual – The use of rock in hydraulic engineering.*

C683. Second edition. London: CIRIA, 2007.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this part of BS 6349, the terms and definitions given in [BS 6349-1-1](#) and the following apply.

3.1.1 elastomer

macromolecular material which returns rapidly to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of the stress

[SOURCE: [BS ISO 1382:2020](#), 3.167]

3.1.2 polyurethane

polymer prepared by the reaction of an organic di- or polyisocyanate with compounds containing two or more hydroxyl groups

NOTE Polyurethanes might be thermosetting, thermoplastic, rigid or soft and flexible, cellular or non-cellular.

[SOURCE: [BS EN ISO 14896:2009](#), 3.1]

3.1.3 rubber

(raw material) natural or synthetic elastic polymer (elastomer) which forms the basis of the compound used in many rubber products

NOTE Rubber has three different definitions, dependent on context. It can be the finished material of a product, but can also be a raw material or an intermediate material used during the manufacture of a product.

[SOURCE: [BS ISO 1382:2020](#), 3.421]

⁷⁾ This standard also gives an informative reference to ISO 12473:2017.

3.2 Abbreviated terms

For the purposes of this part of BS 6349-1-4, the following abbreviated terms apply.

ACEC	aggressive chemical environment for concrete
ALWC	accelerated low water corrosion
ASR	alkali-silica reaction
DEF	delayed ettringite formation
FRP	fibre-reinforced plastic
Ggbs	ground granulated blastfurnace slag
GRP	glass-reinforced plastic
HAT	highest astronomical tide
LAT	lowest astronomical tide
MIC	microbiologically induced corrosion
MHWS	mean high water springs
MLWS	mean low water springs
MT	magnetic testing
MWL	mean water level
PT	penetration testing
RT	radiographic testing
SMYS	specified minimum yield strength
TGA	thermogravimetric analysis
UT	ultrasonic testing

Section 2 Concrete

COMMENTARY ON SECTION 2

The maritime environment is particularly severe for reinforced concrete structures where chloride ingress from seawater accelerates corrosion of any embedded reinforcement. Consequently, the specification for concrete, in terms of both materials and workmanship, needs to focus on the concrete being constructible and durable, as well as having structural strength. The same factors apply to design and detailing.

This section applies primarily to concrete structures constructed and located in the UK, and caution is needed if the guidance on durability is used outside similar temperate climate regions. In this event, it is necessary to be aware of the different environmental conditions of exposure (such as conditions of aridity and higher or lower temperatures), make an assessment of the impact and take appropriate measures. It might be necessary to seek specialist advice for specific requirements for other climate regions. Further guidance on design and construction of concrete structures in a marine environment can also be found in [Annex A](#) and CIRIA C674 [2].

4 General recommendations for concrete

The structural design of the concrete elements of maritime structures should be carried out in accordance with the principles of relevant design standards, such as [BS EN 1992](#), as appropriate to the contract and to the application of the structure.

The environmental conditions should be identified for all stages of construction and operation to determine the appropriate exposure conditions for the design of the structure or specific elements. The design of the structure should take into account all appropriate environmental factors to ensure that the durability design is suitable for the intended working life.

Unless where specifically stated in this part of BS 6349, the specification and production of maritime concrete in the UK should conform to [BS 8500](#) as a minimum. The recommendations provided in this part of BS 6349 should be used to supplement the requirements of [BS 8500](#) where appropriate.

5 Design and construction of concrete structures

The following factors should be taken into account as a minimum in the design and construction of concrete structures.

- a) The work might be substantially or permanently underwater, where access is difficult and visibility is negligible.
- b) The work might be within reach of waves at every tide and therefore subject to wave action, scour and contamination by seawater.
- c) The periods between tides in which the work is accessible might be very short, and it might be necessary to work during low tides at night as well as during the daytime.
- d) Erosion of concrete due to abrasion can be a cause of serious damage to maritime structures. It can occur at water level with floating objects or at bed level where beach materials can continually be washed against the structure.
- e) In cold climates, freezing and thawing and impact of ice can affect concrete adversely.
- f) Concrete can suffer chemical attack from foundation soils, seawater and contaminants.
- g) Steel reinforced, post-tensioned and prestressed concrete, particularly in the tidal zone, can suffer chloride ingress and serious corrosion damage to steel.

Temporary works should be simple and capable of rapid erection during tidal access, and should be strong enough to protect immature concrete and resist high temporary loadings in adverse weather.

The shape of concrete structures and members should be such that they can be formed by simple formwork, which can be easily fixed and is grout-tight, rigid and strong. Complicated shapes should not be used unless unavoidable. Thin cross-sections, in which the cover to reinforcement is sensitive to the accuracy of steel fixing, should not be used unless unavoidable.

Steel reinforcement should be carefully detailed such that it can be rapidly and accurately fixed while having adequate rigidity to resist displacement during placing and compaction of the concrete.

Detailing of the reinforcement should be in accordance with [BS EN 1992-1-1](#) and [BS 8666](#).

Due allowance should be made to include practical tolerances for the positioning of reinforcement, especially in difficult site environments.

Structural members and joint spacing should be designed to limit early thermal cracking, and/or steel reinforcement provided in order to control the size and spacing of cracks.

NOTE 1 Thick sections and massive concrete structures are at risk of early-age thermal cracking. Further guidance is given in CIRIA C766 [3].

NOTE 2 Further guidance on construction considerations is given in CIRIA C674 [2]. Additional information on execution of construction is given in [BS EN 13670](#).

6 Durability of concrete structures

The following general factors should be taken into account for the assessment of durability.

- a) Design for durability of concrete in maritime works (which can include elements of buildings, bridges or tunnels in coastal locations) is dependent upon the recognition of the specific exposure conditions that affect the various elements of a structure, both macro and microclimate and the adoption of appropriate design, detailing, materials and workmanship to suit these conditions. The specification of the concrete materials and details, such as location of construction joints and cover to reinforcement or prestressing steel (if any), is an integral part of the design process. Structural design and detailing should be undertaken in parallel to the design and selection of materials and details, such as cover, relating to durability.
- b) The maritime environment can be very aggressive to concrete in terms of physical weathering, abrasion and chemical attack. Chloride-induced corrosion can also damage embedded metal or reinforcement. The assessment of durability in conjunction with maintenance strategy should be a fundamental part of the design process.
- c) The durability of correctly placed and compacted reinforced concrete is mainly due to the cover to the reinforcement and the quality of the concrete; the quality is primarily governed by the water/cement ratio, type of cementitious materials and, to a lesser extent, the cement content. Whilst the concrete grade has traditionally been used as an indicator of quality, the strength of the concrete, and especially that measured at 28 days, is not a reliable indicator of durability performance.
- d) Durability is not in itself a limit state, but is the means by which the serviceability and structural limit states are maintained for the lifetime of the structure. Being inherently time-related, design for durability is directly related to the intended operational life and maintenance strategy for the structure.

One of the following macroclimates should be chosen to assess the durability category, together with the correct application of microclimate (as described in Clause 7):

- 1) cold with freezing;
- 2) temperate (including UK);
- 3) hot wet; and
- 4) hot dry.

NOTE 1 These are the four main divisions of macroclimate that affect many of the deterioration processes.

Whilst much of the general guidance remains universally applicable to all macroclimatic conditions, the limiting values set out in Clause 7 and in BS 8500 should be used for concrete cast and/or exposed to a temperate UK macroclimate. For other macroclimatic conditions, specialist assistance should be sought, or reference made to specialist/local guidance documents.

NOTE 2 Annex A gives further information on the effect of macroclimate for concrete in a marine environment. See also CIRIA C674 [2].

7 Deterioration processes in concrete structures

7.1 General

Concrete structures should be designed to account for the following actions where applicable:

- a) chloride-induced corrosion;
- b) corrosion induced by carbonation;
- c) freeze-thaw;
- d) sulfate attack;
- e) delayed ettringite formation;
- f) physical processes of weathering;
- g) abrasion; and
- h) alkali-silica reaction.

All concrete that is directly exposed to seawater in a UK temperate environment should, as a minimum, be in accordance with Table 1 for abrasive conditions and BS 8500-1:2023, A.4.6 for non-abrasive conditions. When CEM I cement alone is used, the C_3A content should not exceed 10%.

Table 1 — Limiting values for composition and properties for both reinforced and unreinforced concrete with normal-weight aggregates exposed to both UK seawater conditions and abrasion for a required design working life up to 100 years^{A) B)}

Max. w/c ratio ^{C)}	Min. cement content or combination content (kg/m ³) for max. aggregate size				Cement and combination types ^{D) [A₁] E) [A₁]}	Indicative compressive strength class [A ₁] F) [A ₁]
	40 mm	20 mm	14 mm	10 mm		
0.45	340	360	380	380	CEM I	C40/50
					IIA	C35/45
					IIB, IIIA	C32/40
					IVB-V	C30/37
					IIIB	C28/35

^{A)} Abrasive conditions are defined as exposure to aggressive wave action, cavitations or beach sediments; further information is given in CIRIA C674 [2]. Abrasion due to chains, ropes or other operational reasons should be assessed separately.

^{B)} Additional resistance can be achieved by incorporating steel fibres, abrasion resistance aggregate (Los Angeles Abrasion LA30) or IIA-D cement in the concrete, or, for formed surfaces, if controlled permeability formwork is used.

^{C)} Maximum free water/cement ratio, in accordance with BS EN 206.

^{D)} For thick concrete sections (typically, but not limited to, >600 mm thickness), an appropriate cement type should be chosen that enables the deleterious effects of heat of hydration to be controlled. Normally, increased proportions of ggbs or fly ash may be used to mitigate the risks for early age and DEF-induced cracking. Further guidance is given in CIRIA C766 [3].

^{E)} [A₁] For other cement and combination notation types, no recommendation or guidance is given. [A₁]

^{F)} Water/cement ratio limit is the ruling parameter in terms of overall durability, with the cement content being secondary. The indicative compressive strength class is the anticipated 28-day strength based on the cement or combination type, and not a minimum strength class for structural requirements.

7.2 Chloride-induced corrosion

The correct classification should be assessed in accordance with Table 2 to determine the factors for the concrete specification and cover requirements.

NOTE 1 XSM exposure categories are used in this edition of BS 6349-1-4 rather than the XS categories used previously:

- to provide a more refined approach to exposure classification in a marine environment than the exposure categories given in BS EN 1992-1-1, BS EN 206 and BS 8500; and
- to differentiate more clearly between the guidance on the limiting concrete mix proportions given in BS 6439-1-4 and BS 8500 so as to prevent errors in specification and supply.

Further guidance on the classification of exposure conditions and the effect of climate is given in Annex A.

Table 2 — *Maritime exposure classes for chloride induced corrosion of steel in concrete by seawater*

Informative examples			BS 8500/BS EN 206 classification ^{A)}		
Class designation	Description of environment	Class designation	Description of the environment	BS EN 206 informative examples	BS 8500 informative examples
XSM1	Exposed to airborne salt but not in direct contact with seawater	XS1	Exposed to airborne salt but not in direct contact with seawater	Structures near to or on the coast	External reinforced and prestressed concrete surfaces in coastal areas
XSM2	Permanently submerged	XS2	Permanently submerged	Parts of marine structures	Reinforced and prestressed concrete surfaces completely submerged or remaining saturated, e.g. concrete below mid-tide level
XSM3	Mainly wetted, occasionally dry	XS3	Tidal, splash and spray zones	Parts of marine structures	Reinforced and prestressed concrete surfaces in the upper tidal zones and the splash and spray zones, including exposed soffits above sea water
XSM4	Regular wetting/drying or subject to hydraulic pressure gradient	XS3	Tidal, splash and spray zones	Parts of marine structures	Reinforced and prestressed concrete surfaces in the upper tidal zones and the splash and spray zones, including exposed soffits above sea water

^{A)} The relationship between the XSM and XS classes is provided for reference.

^{B)} Where chloride level in groundwater or via 2:1 water soil extract is greater than 1 200 mg/l, measured in accordance with BS 1377-3.

For marine structures located in the UK, the recommendations given in [Table 3](#) to [Table 5](#) should be adopted for XSM conditions where:

- a) the reinforcement conforms to [BS 4449](#), [BS 4482](#) and [BS 4483](#) (or [BS EN 10080](#));
- b) the concrete is fully compacted and properly cured;
- c) no methods of enhanced protection of the reinforcement are to be adopted (see [Annex B](#)); and
- d) a service life design has not been undertaken.

NOTE 2 The tables may be used to determine the amount of cover required for a type of concrete (e.g. for low heat concretes for thicker sections), or the types of concrete appropriate for a known cover.

NOTE 3 Concrete which is not fully compacted and properly cured prior to first exposure to saline environment, or with other construction defects, does not provide the same level of resistance to chloride ingress when subsequently exposed to that environment.

NOTE 4 In the case of reinforcement corrosion, the serviceability limit state used in the development of [Table 3](#) to [Table 5](#) for XSM exposure was to the initiation of reinforcement corrosion. Other definitions of durability failure which could be used as part of a detailed probabilistic or partial factor service life design include:

- cracking resulting from reinforcement corrosion; and
- spalling and/or loss of steel and/or concrete section.

For pre-tensioned concrete generally and post-tensioned concrete anchorages, the minimum cover given in [Table 3](#) to [Table 5](#) should be increased by 10 mm as an additive safety element ($\Delta c_{dur,y}$). The cover should also be provided to the ends of tensioning members on pre-tensioned elements and to the anchorage for post-tensioned elements.

NOTE 5 The term “additive safety element” is defined in [BS EN 1993-1-1](#).

For all other situations (e.g. different macroclimates, design working lives, durability failure criteria, different cement types, inclusion of methods of enhanced protection of reinforcement, or where the concrete is not fully compacted or contains other construction defects), a systematic probabilistic or partial factor service life design should be undertaken, as set out in ISO 16204 or a similar approach.

NOTE 6 This approach can also be adopted if a greater level of granularity to that given in the above referenced tables is required, e.g. for intermediate water cement ratios and cement/combination compositions.

NOTE 7 The term “design working life” is defined in [BS EN 1990](#).

NOTE 8 Systematic (or explicit) design methods are developing, but are at the transition stage. As a result, the specification has almost certainly to be expressed in prescriptive terms, i.e. with mix limitations for concrete properties and cover to reinforcement, all selected from tabulated values. Further guidance is given in CIRIA C674 [2] and Concrete Society Technical Report 61 [4]. Specialist advice may also be sought if this approach is considered applicable to the design of the structure, particularly outside UK temperate climatic conditions.

NOTE 9 Guidance on enhanced protection of reinforcement is given in [Annex B](#).

7.3 Carbonation-induced corrosion

For marine structures located in the UK, constructed with reinforcement conforming to [BS 4449](#), [BS 4482](#) and [BS 4483](#) (or [BS EN 10080](#)), where the concrete is fully compacted and properly cured, and in the absence of any methods of enhanced protection of the reinforcement, the requirements given in [BS 8500](#) should be adopted for XC exposure conditions.

NOTE 1 Concrete which is not fully compacted and properly cured does not provide the same level of carbonation resistance when subsequently exposed to that environment.

NOTE 2 In a marine environment, design for XSM exposure conditions (as described in [Table 2](#)) is usually more onerous.

NOTE 3 XC exposure conditions are defined in [BS 8500](#).

Table 3 — Maximum water/cement ratio^(A), minimum cement/combination content^(B) and indicative compressive strength class^(C) for normal-weight concrete^(D) of 20 mm maximum aggregate size for reinforced and prestressed^(E) concrete exposed to XSM exposure conditions in a temperate climate for an intended working life of up to 30 years

Nominal cover ^(F) (mm)	30+Δc	35+Δc	40+Δc	45+Δc	50+Δc	55+Δc	60+Δc	65+Δc	70+Δc	75+Δc	80+Δc	Cement/combination types ^(G)
XSM1 Exposed to airborne salt but not in direct contact with seawater	–	0.35 ^(G) 380 C45/55	0.40 380 C40/50	0.45 360 C35/45	0.50 340 C32/40	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 C28/35	CEM I, IIA, IIB-M, IIB-S
	0.50 340 C28/35	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 C25/30	0.55 320 C25/30	IIB-P, IIB-Q, IIB-V, IIA
	0.52 320 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 C25/30	0.55 320 C25/30	0.55 320 C25/30	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	0.52 320 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 C20/25	0.55 320 C20/25	0.55 320 C20/25	0.55 320 C20/25	0.55 320 C20/25	IVB-V, IIB
XSM2 – Permanently submerged	–	–	–	0.35 ^(G) 380 C45/55	0.40 380 C40/50	0.42 360 C35/45	0.45 360 C35/45	0.50 340 C32/40	0.55 320 C28/35	0.55 320 C28/35	0.55 320 C28/35	CEM I, IIA, IIB-M, IIB-S
	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	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	IIB-P, IIB-Q, IIB-V, IIA
	0.45 360 C32/40	0.50 340 C28/35	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 C25/30	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	0.45 360 C28/35	0.50 340 C25/30	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 C20/25	0.55 320 C20/25	0.55 320 C20/25	IVB-V, IIB
XSM3 Mainly wetted, occasionally dry	–	–	–	–	–	0.35 ^(G) 380 C45/55	0.40 380 C40/50	0.42 360 C35/45	0.45 360 C35/45	0.47 340 C32/40	0.50 340 C32/40	CEM I, IIA, IIB-M, IIB-S
	–	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	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	IIB-P, IIB-Q, IIB-V, IIA
	0.35 ^(G) 380 C35/45	0.45 360 C32/40	0.5 340 C28/35	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	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	0.35 ^(G) 380 C35/45	0.45 360 C28/35	0.5 340 C25/30	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 C20/25	0.55 320 C20/25	IVB-V, IIB

Table 3 — Maximum water/cement ratio^{A)}, minimum cement/combination content^{B)} and indicative compressive strength class^{C)} for normal-weight concrete^{D)} of 20 mm maximum aggregate size for reinforced and prestressed^{E)} concrete exposed to XSM exposure conditions in a temperate climate for an intended working life of up to 30 years (continued)

Nominal cover ^{E)} (mm)	30+Δc	35+Δc	40+Δc	45+Δc	50+Δc	55+Δc	60+Δc	65+Δc	70+Δc	75+Δc	80+Δc	Cement/combination types ^{F)}
XSM4 Regular - wetting/ drying or subject to hydraulic pressure gradient	-	-	-	-	-	-	0.35 ^{G)} 380 C45/55	0.37 380 C40/50	0.40 380 C40/50	0.45 360 C35/45	0.47 340 C32/40	CEM I, IIA, IIB-M, IIB-S
	-	-	0.35 ^{G)} 380 C40/50	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	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	IIB-P, IIB-Q, IIB-V, IIA
	-	0.35 ^{G)} 380 C35/45	0.40 360 C32/40	0.45 340 C28/35	0.50 320 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	IIB-V ≥25% fly ash, IIA ≥46% ggbs
	-	0.35 ^{G)} 380 C35/45	0.40 380 C32/40	0.45 360 C28/35	0.50 340 C25/30	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	IVB-V, IIB

A dash (-) indicates that a greater cover should be used.

A) Maximum free water/cement ratio in accordance with BS EN 206.

B) Minimum cement/combination content depends on maximum aggregate size and should be adjusted for concretes with a maximum aggregate size other than 20 mm in accordance with BS 8500-1:2023 [4]. Depending on aggregate type and the specified consistency class, higher cement contents might be required and this should be taken into account, such as when assessing early age cracking.

C) Resistance to chloride ingress is primarily dictated by cement type/combination and the w/c ratio, with cement content and aggregate type being secondary factors. Compressive strength class measured at early ages, e.g. 28 days, is a poor indicator of chloride resistance and has only historically been used as a convenient proxy measurement due to the difficulty in measuring the water/cement ratio directly. The compressive strength class is provided in this table as an indicative value and is not a requirement; failure to achieve the given values should not be used as a reason for rejection. The values of compressive strength class given are provided to indicate what 28-day strength class is likely to be achieved for a particular concrete as an aid to the structural designer. Concretes with significant levels of additions tend to have reduced 28-day compressive strengths when compared to CEM I or similar concretes with the same water/cement ratio, but continue to increase in strength over longer periods of time. Air entrained concrete has a lower compressive strength class than that indicated in this table, typically in the region of 10 MPa lower, but provides an equivalent resistance to chloride ingress.

D) Also applies to heavyweight concrete. For lightweight concrete, the maximum w/c ratio and minimum cement or combination content applies, but the indicative compressive strength class should be changed to a lightweight compressive strength class.

E) Expressed as minimum cover to reinforcement (C_{min}) plus an allowance in design for deviation (Δc), e.g. to allow for workmanship. An additional 10 mm should be added to C_{min} for prestressed steel not in ducts and to post tensioning anchorages. The minimum cover should also be increased where surface erosion of the concrete is anticipated, such as a result of abrasion, freeze-thaw damage or the action of aggressive chemicals.

Table 3 — Maximum water/cement ratio^{a)}, minimum cement/combination content^{b)} and indicative compressive strength class^{c)} for normal-weight concrete^{d)} of 20 mm maximum aggregate size for reinforced and prestressed^{e)} concrete exposed to XSM exposure conditions in a temperate climate for an intended working life of up to 30 years (continued)

Nominal cover ^{e)} (mm)	30+Δc	35+Δc	40+Δc	45+Δc	50+Δc	55+Δc	60+Δc	65+Δc	70+Δc	75+Δc	80+Δc	Cement/combination types ^{f)}
<p>^{f)} This column covers the following cement combination types.</p> <p>a) CEM I-SR0 and CEM I-SR3 should not be used. CEM I-SR5 can be used and should be taken as being equivalent to CEM I.</p> <p>b) IIA-D $\overline{A_1}$ and CEM I containing up to 5% microsilica $\overline{A_1}$ can be used and should be evaluated as CEM I, with the effective water/cement ratio being calculated using the k concept in accordance with BS EN 206.</p> <p>c) IIA-L, IIA-LL, IIB-L and IIB-LL cements $\overline{A_1}$ /cement combinations $\overline{A_1}$ should be evaluated as CEM I on the basis of an effective water/cement ratio. The effective water/cement ratio should be calculated using the actual cement content minus the difference between the total amount of limestone and the maximum amount permitted $\overline{A_1}$ for $\overline{A_1}$ CEM I. Where the amount of limestone is not declared, it should be assumed to be the maximum permitted for the declared cement type.</p> <p>d) $\overline{A_2}$ cements/cement combinations with notation $\overline{A_2}$ IIA-M and IIB-M $\overline{A_2}$ and conforming to BS EN 197-5 $\overline{A_2}$ should be evaluated on the basis of the most appropriate CEM II cement type, after disregarding the amount of limestone present over and above that permitted in a CEM I cement and an effective water/cement ratio. The effective water/cement ratio should be calculated from the effective cement content which is the actual cement content minus the difference between the total amount of limestone and the maximum amount permitted $\overline{A_2}$ for $\overline{A_2}$ CEM I. Where the amount of limestone is not declared, it should be assumed to be the maximum permitted for the declared cement type.</p> <p>e) For cement types not specifically listed, no advice is given and specialist advice should be sought.</p> <p>g) In some parts of the UK, it is not possible to produce a practical concrete with a maximum water/cement ratio as low as 0.35 with the locally available aggregate.</p>												

Table 4 — Maximum water/cement ratio^(A), minimum cement/combination content^(B) and indicative compressive strength class^(C) for normal-weight concrete^(D) of 20 mm maximum aggregate size for reinforced and prestressed^(E) concrete exposed to XSM exposure conditions in a temperate climate for an intended working life of up to 50 years

Nominal cover ^(E) (mm)	30+Δc	35+Δc	40+Δc	45+Δc	50+Δc	55+Δc	60+Δc	65+Δc	70+Δc	75+Δc	80+Δc	Cement/Combination types ^(F)
XSM1 Exposed t-o airborne salt but not in direct contact with seawater	-	-	-	0.35 ^(G)	0.40	0.45	0.50	0.55	0.55	0.55	0.55	CEM I, IIA, IIB-M, IIB-S
	0.35 ^(G)	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	IIB-P, IIB-Q, IIB-V, IIA
	380 C40/50	360 C32/40	340 C28/35	320 C25/30	320 C25/30	320 C25/30	320 C25/30	320 C25/30	320 C25/30	320 C25/30	320 C25/30	IIB-V ≥25% fly ash, IIA ≥46% ggbs
	0.40	0.50	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	IVB-V, IIB
XSM2 – Permanently submerged	0.40	0.50	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	CEM I, IIA, IIB-M, IIB-S
	-	-	0.40	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.55	IIB-P, IIB-Q, IIB-V, IIA
	-	0.35 ^(G)	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.55	0.55	IIB-V ≥25% fly ash, IIA ≥46% ggbs
	-	0.35 ^(G)	0.45	0.50	0.55	0.55	0.55	0.55	0.55	0.55	0.55	IVB-V, IIB
XSM3 Mainly - wetter, occasionally dry	-	-	-	-	-	-	-	-	0.35 ^(G)	0.40	0.42	CEM I, IIA, IIB-M, IIB-S
	-	-	-	0.35 ^(G)	0.40	0.45	0.50	0.55	0.55	0.55	0.55	IIB-P, IIB-Q, IIB-V, IIA
	-	-	0.35 ^(G)	0.4	0.45	0.5	0.55	0.55	0.55	0.55	0.55	IIB-V ≥25% fly ash, IIA ≥46% ggbs
	-	-	0.35 ^(G)	0.4	0.45	0.5	0.55	0.55	0.55	0.55	0.55	IVB-V, IIB

Table 4 — Maximum water/cement ratio^{A)}, minimum cement/combination content^{B)} and indicative compressive strength class^{C)} for normal-weight concrete^{D)} of 20 mm maximum aggregate size for reinforced and prestressed^{E)} concrete exposed to XSM exposure conditions in a temperate climate for an intended working life of up to 50 years (continued)

Nominal cover ^{E)} (mm)	30+Δc	35+Δc	40+Δc	45+Δc	50+Δc	55+Δc	60+Δc	65+Δc	70+Δc	75+Δc	80+Δc	Cement/Combination types ^{F)}
XSM4 Regular - wetting/ drying or subject to hydraulic pressure gradient	-	-	-	-	-	-	-	-	-	-	0.35 ^{G)} 380 C45/55	CEM I, IIA, IIB-M, IIB-S
	-	-	-	-	0.35 ^{G)} 380 C40/50	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	0.55 320 C25/30	0.55 320 C25/30	0.55 320 C25/30	IIB-P, IIB-Q, IIB-V, IIA
	-	-	-	0.35 ^{G)} 380 C40/50	0.45 360 C32/40	0.50 340 C28/35	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	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	-	-	-	0.35 ^{G)} 380 C35/45	0.45 360 C28/35	0.50 340 C25/30	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	IVB-V, IIB

A dash (–) indicates that a greater cover should be used.

A) Maximum free water/cement ratio in accordance with BS EN 206.

B) Minimum cement/combination content depends on maximum aggregate size and should be adjusted for concretes with a maximum aggregate size other than 20 mm in accordance with BS 8500-1:2023 ⁴¹. Depending on aggregate type and the specified consistency class, higher cement contents might be required and this should be taken into account, such as when assessing early age cracking.

C) Resistance to chloride ingress is primarily dictated by cement type/combination and the w/c ratio, with cement content and aggregate type being secondary factors. Compressive strength class measured at early ages, e.g. 28 days, is a poor indicator of chloride resistance and has only historically been used as a convenient proxy measurement due to the difficulty in measuring the water/cement ratio directly. The compressive strength class is provided in this table as an indicative value and is not a requirement; failure to achieve the given values should not be used as a reason for rejection. The values of compressive strength class given are provided to indicate what 28-day strength class is likely to be achieved for a particular concrete as an aid to the structural designer. Concretes with significant levels of additions tend to have reduced 28-day compressive strengths when compared to CEM I or similar concretes with the same water/cement ratio, but continue to increase in strength over longer periods of time. Air entrained concrete has a lower compressive strength class than that indicated in this table, typically in the region of 10 MPa lower, but provides an equivalent resistance to chloride ingress.

D) Also applies to heavyweight concrete. For lightweight concrete, the maximum w/c ratio and minimum cement or combination content applies, but the indicative compressive strength class should be changed to a lightweight compressive strength class.

E) Expressed as minimum cover to reinforcement (C_{min}) plus an allowance in design for deviation (Δc), e.g. to allow for workmanship. An additional 10 mm should be added to C_{min} for prestressed steel not in ducts and to post tensioning anchorages. The minimum cover should also be increased where surface erosion of the concrete is anticipated, such as a result of abrasion, freeze-thaw damage or the action of aggressive chemicals.

Table 4 — Maximum water/cement ratio^{a)}, minimum cement/combination content^{b)} and indicative compressive strength class^{c)} for normal-weight concrete^{d)} of 20 mm maximum aggregate size for reinforced and prestressed^{e)} concrete exposed to XSM exposure conditions in a temperate climate for an intended working life of up to 50 years (continued)

Nominal cover ^{f)} (mm)	30+Δc	35+Δc	40+Δc	45+Δc	50+Δc	55+Δc	60+Δc	65+Δc	70+Δc	75+Δc	80+Δc	Cement/Combination types ^{f)}
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^{f)} This column covers the following cement combination types.

- a) CEM I-SR0 and CEM I-SR3 should not be used. CEM I-SR5 can be used and should be taken as being equivalent to CEM I.
- b) IIA-D $\overline{A_1}$ and CEM I containing up to 5% microsilica $\overline{A_1}$ can be used and should be evaluated as CEM I, with the effective water/cement ratio being calculated using the k concept in accordance with BS EN 206.
- c) IIA-L, IIA-LL, IIB-L and IIB-LL cements $\overline{A_1}$ /cement combinations $\overline{A_1}$ should be evaluated as CEM I on the basis of an effective water/cement ratio. The effective water/cement ratio should be calculated using the actual cement content minus the difference between the total amount of limestone and the maximum amount permitted $\overline{A_1}$ for $\overline{A_1}$ CEM I. Where the amount of limestone is not declared, it should be assumed to be the maximum permitted for the declared cement type.
- d) $\overline{A_1}$ cements/cement combinations with notation $\overline{A_1}$ IIA-M and IIB-M $\overline{A_1}$ and conforming to BS EN 197-5 $\overline{A_1}$ should be evaluated on the basis of the most appropriate CEM II cement type, after disregarding the amount of limestone present over and above that permitted in a CEM I cement and an effective water/cement ratio. The effective water/cement ratio should be calculated from the effective cement content which is the actual cement content minus the difference between the total amount of limestone and the maximum amount permitted $\overline{A_1}$ for $\overline{A_1}$ CEM I. Where the amount of limestone is not declared, it should be assumed to be the maximum permitted for the declared cement type.
- e) For cement types not specifically listed, no advice is given and specialist advice should be sought.
- g) In some parts of the UK, it is not possible to produce a practical concrete with a maximum water/cement ratio as low as 0.35 with the locally available aggregate.

Table 5 — Maximum water/cement ratio^(A), minimum cement/combination content^(B) and indicative compressive strength class^(C) for normal-weight concrete^(D) of 20 mm maximum aggregate size for reinforced and prestressed^(E) concrete exposed to XSM exposure conditions in a temperate climate for an intended working life of up to 100 years

Nominal cover ^(E) (mm)	30+Δc	35+Δc	40+Δc	45+Δc	50+Δc	55+Δc	60+Δc	65+Δc	70+Δc	75+Δc	80+Δc	Cement/Combination types ^(F)
XSM1 Exposed t-o airborne salt but not in direct contact with seawater	-	-	-	-	-	-	-	0.35 ^(G) 380 C45/55	0.40 380 C40/50	0.45 360 C35/45	0.50 340 C32/40	CEM I, IIA, IIB-M, IIB-S
	-	-	0.35 ^(G) 380 C40/50	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	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	IIB-P, IIB-Q, IIB-V, IIA
	-	-	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	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	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	-	-	0.40 380 C32/40	0.45 360 C28/35	0.50 340 C25/30	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	IVB-V, IIIB
XSM2 – Permanently submerged	-	-	-	-	-	-	-	-	-	-	-	CEM I, IIA, IIB-M, IIB-S
	-	-	-	-	0.35 ^(G) 380 C40/50	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	0.52 320 C25/30	0.55 320 C25/30	0.55 320 C25/30	IIB-P, IIB-Q, IIB-V, IIA
	-	-	-	0.35 ^(G) 380 C40/50	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	0.55 320 C25/30	0.55 320 C25/30	0.55 320 C25/30	0.55 320 C25/30	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	-	-	-	0.35 ^(G) 380 C35/45	0.40 380 C32/40	0.45 360 C28/35	0.50 340 C25/30	0.55 320 C20/25	0.55 320 C20/25	0.55 320 C20/25	0.55 320 C20/25	IVB-V, IIIB
XSM3 Mainly - wetted, occasionally dry	-	-	-	-	-	-	-	-	-	-	-	CEM I, IIA, IIB-M, IIB-S
	-	-	-	-	-	-	0.35 ^(G) 380 C40/50	0.40 380 C35/45	0.45 360 C32/40	0.50 340 C28/35	0.52 320 C25/30	IIB-P, IIB-Q, IIB-V, IIA
	-	-	-	-	-	-	-	0.45 360 C32/40	0.5 340 C28/35	0.55 320 C25/30	0.55 320 C25/30	IIB-V ≥25% fly ash, IIIA ≥46% ggbs
	-	-	-	-	-	-	0.4 380 C35/45	0.45 360 C32/40	0.5 340 C28/35	0.55 320 C25/30	0.55 320 C25/30	IVB-V, IIIB