INTERNATIONAL STANDARD

**ISO 22965-1**

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# Concrete —

## Part 1: Methods of specifying and guidance for the specifier

*Béton —*

*Partie 1: Méthodes de spécification et lignes directrices pour le spécificateur*

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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22965-1 was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 3, *Concrete production and execution of concrete structures*.

ISO 22965 consists of the following parts, under the general title *Concrete*:

— *Part 1: Methods of specifying and guidance for the specifier*

— *Part 2: Specification of constituent materials, production of concrete and compliance of concrete*

# Introduction

This International Standard is intended for nations that have no national concrete standard and it sets out a framework of principles for nations revising their national standards. To be operable, this International Standard needs a national annex or a reference to the national complementary provisions. This International Standard can also be applied on specific projects where a project specification supplements the standards in lieu of a national annex applicable at the place of use.

This International Standard is applied under various climatic and geographical conditions, various levels of protection and under different established regional traditions and experience. Consequently, this International Standard includes classes for concrete with different properties to cover the most frequent and normal situations. For certain uses of concrete, additional or deviating rules can be necessary. The national provisions, preferably given in a national annex to this International Standard, or the project specification can specify any additional or deviating requirements.

During the development of this International Standard, consideration was given to detailing a performance-related approach to the specification of durability. It was concluded that such an approach is not yet sufficiently developed to be detailed in an International Standard. ISO/TC 71/SC 3 recognizes that some ISO member bodies have developed local tests and criteria for performance-based specifications. This International Standard does not exclude the continuation and development of such practices valid in the place of use of the concrete as an alternative to the prescriptive approach. It is necessary that these requirements be specified in the national annex or national complementary provisions. The Model Code for Service Limit Design (MC-SLD), which was published by *fib* in 2006, is a promising basis for implementation as future International Standards from ISO/TC 71; see Annex B.

This International Standard incorporates rules for the use of constituent materials that are covered by International Standards. For materials for which International Standards have not yet been published, the standards cited in the national annex (often the regional or national standards) apply; see 5.1. In particular, documents in current use for by-products of industrial processes, recycled materials, etc. are based on local experience. Until international specifications for these materials are available, this International Standard does not provide rules for their use, but instead refers to the national annex.

This International Standard defines the two parties involved in the ordering and the supply of concrete, which are hereinafter referred to as specifier and supplier. In practice, there can be several parties specifying requirements at various stages of the design and construction process, e.g. the client, the designer, the quantity surveyor, the constructor and the concreting subconstructor. Each is expected to pass the specified requirements, together with any additional requirements, to the next party in the chain until they reach the supplier. In the terms of this International Standard, this final compilation of requirements is known as the “concrete specification”. In some cases, the specifier and the supplier is the same party (e.g. a constructor doing design, production and execution). In the case of ready-mixed concrete, the purchaser is the specifier.

This part of ISO 22965 also gives rules for the exchange of information between the parties. Contractual matters are not addressed.

This International Standard is intended for use with ISO 22965-2 and with the future ISO 22966, currently under development, which will give the requirements associated with the level of quality specified and the methods to be employed for the execution of concrete structures.

# Concrete —

# Part 1:
# Methods of specifying and guidance for the specifier

## 1 Scope

This part of ISO 22965 applies to concrete for structures cast *in situ*, pre-cast structures and structural pre-cast products for buildings and civil engineering structures. The concrete can be mixed on site, ready-mixed concrete or produced in a plant for pre-cast concrete products.

This part of ISO 22965 applies to concrete compacted to retain no appreciable amount of entrapped air other than entrained air and to normal-weight, heavy-weight and light-weight concrete.

Other International Standards for specific products, e.g. pre-cast products, or for processes within the field of the scope of this part of ISO 22965, can require or permit deviations from this part of ISO 22965.

This part of ISO 22965 contains requirements for the specification of concrete and guidance for the exchange of information between the specifier and supplier. An informative annex gives general guidance on specification. More specific guidance on specification related to the local conditions can be given in a national annex.

This part of ISO 22965 does not apply to

— concrete with a maximum aggregate size equal to or less than 4 mm or 5 mm (mortar),

— aerated concrete,

— foamed concrete,

— concrete with an open structure (“no-fine aggregate” concrete),

— concrete with a density less than 800 kg/m$^3$,

— refractory concrete.

This part of ISO 22965 does not cover health and safety requirements for the protection of workers during production and delivery of concrete.

## 2 Normative references

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

ISO 1920-1, *Testing of concrete — Part 1: Sampling of fresh concrete*

ISO 1920-3, *Testing of concrete — Part 3: Making and curing test specimens*

ISO 1920-4, *Testing of concrete — Part 4: Strength of hardened concrete*

ISO 22965-2:2007, *Concrete — Part 2: Specification of constituent materials, production of concrete and compliance of concrete*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**addition**
finely divided or ground material used in concrete in order to improve certain properties or to achieve special properties

NOTE This part of ISO 22965 deals with two types of additions:

— nearly inert additions (type I);

— pozzolanic or latent hydraulic additions (type II).

**3.2**
**admixture**
material added during the mixing process of concrete in small quantities relative to the mass of cement to modify the properties of fresh or hardened concrete

**3.3**
**aggregate**
granular mineral material suitable for use in concrete

NOTE Aggregates can be natural, artificial or recycled from material previously used in construction, e.g. recycled concrete aggregate.

**3.4**
**batch**
quantity of fresh concrete produced in one cycle of operations of a mixer or the quantity discharged during 1 min from a continuous mixer or quantity of concrete transported in a vehicle

NOTE For testing to be performed at site, the concrete transported as one load in a vehicle can be considered as one batch.

**3.5**
**cement**
〈hydraulic binder〉 finely ground inorganic material that, when mixed with water, forms a paste that sets and hardens by means of hydration reactions and processes and that, after hardening, retains its strength and stability even under water

**3.6**
**characteristic strength**
value of strength below which 5 % of the population of all possible strength determinations of the volume of concrete under consideration are expected to fall

**3.7**
**concrete**
material formed by mixing cement, coarse and fine aggregate and water, with or without the incorporation of admixtures and additions, which develops its properties by hydration of the cement

NOTE International Standards for aggregate may define aggregates larger than 4 mm or 5 mm as coarse. In concrete for general-purpose use, the coarse aggregate should normally have a maximum aggregate size of at least 16 mm.

**3.8**
**concrete specification**
all documented technical requirements necessary to produce and deliver the concrete

**3.9**
**compliance test**
test performed to verify that the concrete complies with some aspect of the specification

**3.10**
**delivery**
process of handing over the fresh concrete by the producer

**3.11**
**designed concrete**
concrete for which the minimum characteristic strength, other required properties and additional characteristics are specified to the supplier who is responsible for providing a concrete complying with the specified minimum characteristic strength, any other specified properties and any specified additional characteristics

**3.12**
**effective water content**
difference between the total water present in the fresh concrete and the water absorbed by the aggregates

**3.13**
**entrained air**
microscopic air bubbles, typically between 10 µm and 300 µm in diameter and spherical or nearly so, intentionally incorporated in concrete during mixing, usually by use of a surface-active agent

**3.14**
**entrapped air**
air voids in concrete that are not purposely entrained

**3.15**
**environmental actions**
those chemical and physical actions to which the concrete is exposed and that result in effects on the concrete or reinforcement or embedded metal that are not considered as loads in structural design

**3.16**
**evaluation of compliance**
systematic examination of the extent to which a product fulfils specified requirements

**3.17**
**fresh concrete**
fully mixed concrete that is still capable of being compacted by the intended method

**3.18**
**general suitability**
suitable for use in some concretes

**3.19**
**hardened concrete**
concrete that is in a solid state and which has developed a certain strength

**3.20**
**heavy-weight aggregate**
aggregate having an oven-dry particle density $\geqslant$ 3 000 kg/m$^3$

**3.21**
**heavy-weight concrete**
concrete having an oven-dry density greater than 2 600 kg/m$^3$

**3.22**
**identity test**
test to determine whether the concrete represented by one or more batches comes from a complying population

**3.23**
**light-weight aggregate**
aggregate of mineral origin having an oven-dry particle density $\leqslant$ 2 000 kg/m$^3$ or a loose oven-dry bulk density $\leqslant$ 1 200 kg/m$^3$

**3.24**
**light-weight concrete**
concrete having an oven-dry density of not less than 800 kg/m$^3$ and not more than 2 000 kg/m$^3$

NOTE It is produced using light-weight aggregate for all or part of the total aggregate.

**3.25**
**maximum aggregate size**
largest aggregate size used in the concrete

NOTE The requirements for aggregate size in standards often allow a small percentage to be retained on the upper sieve size.

**3.26**
**normal-weight aggregate**
aggregate with an oven-dry particle density $>$ 2 000 kg/m$^3$ and $<$ 3 000 kg/m$^3$

**3.27**
**normal-weight concrete**
concrete having an oven-dry density greater than 2 000 kg/m$^3$ but not exceeding 2 600 kg/m$^3$

**3.28**
**pre-cast concrete product**
concrete product cast and cured in a place other than the final location of use

**3.29**
**prescribed concrete**
concrete for which the composition of the concrete and the constituent materials to be used are specified to the supplier who is responsible for providing a concrete with the specified composition

**3.30**
**producer**
person or body producing fresh concrete

NOTE This part of ISO 22965 uses the terms “producer” and “supplier” in order to be able to distinguish between the technical and commercial sides. In the case of ready-mixed concrete, the practices can vary between countries, but in most cases, the producer and the supplier are the same.

**3.31**
**ready-mixed concrete**
concrete delivered in a fresh state to the construction site by a supplier to a specifier who is the purchaser

**3.32**
**site**
**construction site**
area where the construction work is undertaken, including any land immediately adjacent to the construction specifically used for the purpose of setting up a batching plant

**3.33**
**site-mixed concrete**
concrete produced on the construction site

**3.34**
**specific suitability**
suitable for use in the specified concrete

**3.35**
**specifier**
person or body specifying fresh concrete for the execution of a construction or a component

**3.36**
**standardized prescribed concrete**
concrete for which the composition is given in a standard valid in the place of use of the concrete

**3.37**
**supplier**
person or body supplying ready-mixed concrete

**3.38**
**user**
person or body using fresh concrete

**3.39**
**total water content**
added water plus water already contained in the aggregates and on the surface of the aggregates plus water in the admixtures and in additions used in the form of a slurry and water resulting from any added ice or steam heating

**3.40**
**verification**
confirmation by examination of objective evidence that specified requirements have been fulfilled

**3.41**
**water/cement ratio**
ratio of the effective water content to cement content by mass in the fresh concrete

## 4 Symbols and abbreviated terms

| | |
|---|---|
| $D_{max}$ | maximum aggregate size |
| X0 | exposure class for no risk of corrosion or attack |
| XC | exposure classes for risk of corrosion induced by carbonation |
| XD | exposure classes for risk of corrosion induced by chlorides other than from sea water |
| XS | exposure classes for risk of corrosion induced by chlorides from sea water |
| XF | exposure classes for freeze/thaw attack |

XA exposure classes for chemical attack

S1 to S5 consistence classes expressed by slump

F1 to F6 consistence classes expressed by flow diameter

SF1 to SF5 consistence classes expressed by slump flow diameter

B compressive strength classes for normal and heavy-weight concrete

LB compressive strength class of light-weight concrete

$f_{ck}$ characteristic strength of concrete expressed in newtons per square millimetre

$f_{cm}$ mean of $n$ measurements of the compressive strength of concrete expressed in newtons per square millimetre

# 5 Specification of concrete

## 5.1 General

For the use of constituent materials that are covered by International Standards, requirements contained in the International Standards apply. For materials for which there are not yet International Standards, the standards cited in the national annex (often regional or national standards) apply.

All relevant requirements for the concrete shall be given in the concrete specification, including any properties or mix limitations that are necessary for transportation after delivery, placing, compaction, curing or further treatment.

The required properties of concrete in the structure are generally achieved only if the intended and specified execution procedures on the fresh concrete are carried out at the place of use. Therefore, the requirements for transportation, placing, compaction, curing and further treatment should also be taken into account before specifying the concrete (see relevant standard for execution of work). Many of these requirements are often interdependent. If all these requirements are satisfied, any difference in concrete properties between the concrete in the structure and standardized test specimens is adequately covered by the partial safety factor for concrete.

When preparing the concrete specification, the following aspects shall be taken into consideration:

— application of the fresh and hardened concrete;

— curing conditions;

— dimensions of the structure (the heat development);

— environmental actions to which the structure is to be exposed (see Clause A.2);

— any requirements for exposed aggregate or tooled concrete finishes;

— any requirements related to the cover to reinforcement or minimum section width, e.g. maximum aggregate size;

— any restrictions on the use of constituent materials with established suitability, e.g. inappropriate for the identified exposure classes.

The national annex or provisions valid in the place of use of the concrete should contain recommendations or guidance for these considerations. However, they only become requirements if specifically cited in the specification.

The maximum aggregate size, $D_{max}$, shall be selected taking into account the cover to reinforcement, the spacing of the reinforcement and the minimum section width.

Concrete shall be specified as either a designed concrete (see 5.2), a prescribed concrete (see 5.3) or a standardized prescribed concrete (see 5.4).

The classifications given in Clause A.3 or the national annex may be used for the concrete specification.

Requirements for durability may be specified in terms of performance-related parameters, e.g. scaling of concrete in a freezing and thawing test. Guidance on the use of a performance-related specification method with respect to durability is given in Annex B.

Any requirement for artificial cooling or heating of the concrete prior to delivery shall be specified.

## 5.2 Specification of designed concrete

### 5.2.1 General

The specification for designed concrete shall contain

a) the basic requirements given in 5.2.2,

b) the additional requirements given in 5.2.3, where required.

### 5.2.2 Basic requirements

The specification shall contain

a) a requirement to comply with ISO 22965-2;

b) compressive strength class, if not covered by the designation; see c);

c) concrete designation or limiting values, e.g. maximum water/cement ratio;

d) maximum aggregate size;

e) maximum chloride content;

f) where a designation has not been specified, constituent materials with specific suitability;

NOTE 1 It is desirable that the producer have the widest possible choice.

NOTE 2 Requirements for the use of additions are given in ISO 22965-2:2007, Annex G.

NOTE 3 Requirements for preventing damaging alkali-aggregate reaction are given in ISO 22965-2:2007, Annex G.

g) where the concrete producer does not hold a current accredited third-party quality certification, the method used to assess the compliance of strength (ISO 22965-2:2007, 9.4);

h) target density (only for light-weight and heavy-weight concrete);

i) consistence class or target value for consistence (only for ready-mixed concrete and site-mixed concrete.

NOTE Before specifying the target value for consistence of ready-mixed concrete, it is necessary that the specifier take into account the possible loss of fluidity during transporting and pumping, etc. subsequent to the delivery.

### 5.2.3 Additional requirements

In addition to the basic requirements (see 5.2.2), the specification for designed concrete shall contain any of the following additional requirements and provisions deemed to be necessary:

a) where a designation has been used, further restrictions on the range of permitted constituent materials;

b) characteristics required to resist freezing and thawing attack, e.g. minimum air content;

NOTE Before specifying the minimum air content at delivery, it is necessary that the specifier take into account the possible loss of air during transporting, pumping, placing, compacting etc. subsequent to the delivery.

c) requirements for the temperature of the fresh concrete where different from those in ISO 22965-2:2007, 6.2.4;

d) strength development;

e) heat development during hydration;

f) retarded stiffening;

g) resistance to water penetration;

h) resistance to abrasion;

i) tensile splitting strength;

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

k) requirement for accredited certification (recommended for designed concrete).

## 5.3 Specification for prescribed concrete

### 5.3.1 General

The specifier shall record the data linking the specified proportions to the intended performance. Where necessary, these data shall be obtained by initial testing; see ISO 22965-2. The specification shall contain proportions such that the risk of damaging alkali-aggregate reaction is minimal or a requirement for the supplier to minimize the risk of damaging alkali-aggregate reaction.

The specification for prescribed concrete shall contain

a) the basic requirements given in 5.3.2,

b) the additional requirements given in 5.3.3, where required.

### 5.3.2 Basic requirements

**5.3.2.1** The specification for prescribed concrete (see 5.3.2.2 and 5.3.2.3) shall contain the following:

a) a requirement to comply with ISO 22965-2;

b) constituent materials with specific suitability;

c) cement type and, where strength classes are used, standard cement-strength class;

d) target cement content;

e) either the target water/cement ratio or the consistence in terms of class or target value (see 5.3.2.4 and 5.3.2.5);

f) type, categories and maximum chloride content of the aggregate; in the case of light-weight or heavy-weight concrete, the maximum or minimum density of aggregate, as appropriate;

g) maximum aggregate size and any limitations for the grading of the combined aggregates;

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

i) if admixtures or additions are used to achieve particular characteristics, the sources of these constituents and the cement (see Note).

NOTE The required characteristics can normally be defined and consequently it is necessary to specify only the generic types of constituent material.

**5.3.2.2** Consideration should be given to specifying a requirement for the producer to operate a quality system meeting the requirements of ISO 9001, implementing use of an accredited certification.

**5.3.2.3** 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, by volume is deprecated. The assessment of the concrete proportions forms an essential part of the compliance requirements.

**5.3.2.4** If both the target water/cement ratio and the consistence are required to be specified, the specification should include a minimum cement content and not a target cement content.

**5.3.2.5** The specified value of the target water/cement ratio should be at least 0,02 less than any required limiting (maximum) value. Any specified consistence should be adequate for the intended method of placing and compaction.

### 5.3.3 Additional requirements

In addition to the basic requirements (see 5.3.2), the specification for prescribed concrete shall contain any of the following additional requirements and provisions deemed to be necessary:

a) the sources of some, or all, concrete constituents;

b) additional requirements for aggregates, e.g. proportion of fine aggregate;

c) requirements for the temperature of the fresh concrete where different from the limit given in ISO 22965-2:2007, 6.2.4;

d) requirements for preventing damaging alkali-aggregate reaction;

e) other technical requirements;

f) requirement for accredited certification (recommended for prescribed concrete).

## 5.4 Specification for standardized prescribed concrete

### 5.4.1 General

The specification for standardized prescribed concrete shall contain

a) the basic requirements given in 5.4.2,

b) the additional requirements given in 5.4.3, where required.

Where this method of specifying is required, the specification of standardized prescribed concrete should be provided in ISO 22965–2:—, Annex G.

NOTE The assessment of the concrete proportions forms an essential part of the compliance requirements.

### 5.4.2 Basic requirements

**5.4.2.1** The specification for standardized prescribed concrete shall contain

a) a requirement to comply with ISO 22965–2; see Note;

b) designation of the standardized prescribed concrete required and whether the concrete is to be classed as unreinforced or reinforced; see 5.4.2.2;

c) maximum aggregate size;

d) slump class.

NOTE The specification of a standardized prescribed concrete by its designation is an instruction to the producer to comply with the requirements in ISO 22965–2:—, Annex G.

**5.4.2.2** If the concrete contains any embedded metal, it should be classed as reinforced.

### 5.4.3 Additional requirements

In addition to the basic requirements (see 5.4.2), the specification for standardized prescribed concrete shall contain any of the following additional requirements and provisions deemed to be necessary:

a) any restrictions on the types of cements permitted in ISO 22965–2:—, Annex G;

b) any restrictions on the types of aggregates permitted in ISO 22965–2:—, Annex G.

## 6 Exchange of information

### 6.1 Information from the specifier of the concrete to the supplier

The agreement between the specifier and the supplier shall include the delivery date, time and rate; and, where appropriate, information on the following:

a) special transport on site;

b) special methods of placing;

c) limitation of delivery vehicle, e.g. type (agitating/non-agitating equipment), size, height or gross weight;

d) sources of the constituent materials;

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

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

g) whether a non-accredited laboratory can be used for identity testing (see Annex C).

## 6.2 Information from the supplier of the concrete to the specifier

The specifier may require information on the concrete composition to permit proper placing and curing of the fresh concrete as well as for estimating the strength development. The following information should be provided on request:

a) type and strength class of cement and type of aggregates;

b) type of admixtures, type and approximate content of additions, if any;

c) target water/cement ratio for designed concrete;

d) results of relevant previous tests for the concrete, e.g. from production control or from initial tests;

e) strength development;

f) method of determination of the water absorption of fine, light-weight aggregate; see ISO 22965-2.

The supplier shall inform the user of health risks that can occur during the handling of the fresh concrete, as required by the provisions valid in the place of use of the fresh concrete.

# Annex A
(informative)

# Guidance for the specifier of exposure classes, consistence classes and strength classes

## A.1 General

Guidance on appropriate values to specify should be provided in the national annex. Where there are no such provisions, differences in the environment (temperature, wet and dry periods, severity of freezing, etc.) need to be taken into account before transposing requirements prepared for another location.

## A.2 Exposure classes

The environmental actions are classified as exposure classes in Table A.1.

**Table A.1 — Exposure classes**

| Class description and designation | | Description of the environment | Informative examples of where exposure classes may occur |
|---|---|---|---|
| 1. No risk of corrosion or attack | X0 | For concrete without reinforcement or embedded metal: All exposures except where there is freezing and thawing, abrasion or chemical attack | |
| | | For concrete with reinforcement or embedded metal: Very dry | Concrete inside buildings with very low air humidity |
| 2. Corrosion induced by carbonation<br>(concrete containing reinforcement or other embedded metal is exposed to air and moisture)[a] | XC1 | Dry or permanently wet | Concrete inside buildings with low air humidity<br>Concrete permanently submerged in water |
| | XC2 | Wet, rarely dry | Concrete surfaces subject to long-term water contact<br>Many foundations |
| | XC3 | Moderate humidity<br>Cyclic wet and dry | Concrete inside buildings with moderate or high air humidity<br>Concrete surfaces subject to water contact not within exposure class XC2<br>External concrete sheltered from rain |

**Table A.1** *(continued)*

| Class description and designation | | Description of the environment | Informative examples of where exposure classes may occur |
|---|---|---|---|
| 3. Corrosion induced by chlorides other than from sea water<br>(concrete containing reinforcement or other embedded metal is subjected to contact with water containing chlorides, including de-icing salts, from sources other than from sea water) | XD1 | Moderate humidity | Concrete surfaces exposed to airborne chlorides |
| | XD2 | Wet, rarely dry | Swimming pools<br>Concrete exposed to industrial waters containing chlorides |
| | XD3 | Cyclic wet and dry | Parts of bridges exposed to spray containing chlorides<br>Pavement<br>Car park slabs |
| 4. Corrosion induced by chlorides from sea water<br>(concrete containing reinforcement or other embedded metal is subject to contact with chlorides from sea water or air carrying salt originating from sea water) | XS1 | Exposed to airborne salt but not in direct contact with sea water | Structures near to, or on, the coast |
| | XS2 | Permanently submerged | Parts of marine structures |
| | XS3 | Tidal, splash and spray zones | Parts of marine structures |
| 5. Freezing and thawing attack<br>(concrete is exposed to significant attack by freeze/thaw cycles whilst wet) | XF1 | Moderate water saturation, without de-icing agent | Vertical concrete surfaces exposed to rain and freezing |
| | XF2 | Moderate water saturation, with de-icing agent | Vertical concrete surfaces of road structures exposed to freezing and airborne de-icing agents |
| | XF3 | High water saturation, without de-icing agent | Horizontal concrete surfaces exposed to rain and freezing |
| | XF4 | High water saturation, with de-icing agent or sea water | Road and bridge decks exposed to de-icing agents<br>Concrete surfaces exposed to direct spray containing de-icing agents and to freezing<br>Splash zone of marine structures exposed to freezing |
| 6. Chemical attack<br>(concrete is exposed to chemical attack from natural soils and ground water as given in Table A.2 [b, c]) | XA1 | Slightly aggressive chemical environment according to Table A.2 | |
| | XA2 | Moderately aggressive chemical environment according to Table A.2 | |
| | XA3 | Highly aggressive chemical environment according to Table A.2 | |

[a] The moisture condition relates to that in the concrete cover for reinforcement or other embedded metal. In many cases, the classification is applied to the surrounding environment, which may be adequate. This may not be the case, however, if there is a barrier between the concrete and its environment.

[b] The national annex or a special study can be needed to establish the relevant exposure condition where there are

— limits outside of Table A.2,

— other aggressive chemicals,

— chemically polluted ground or water, or

— high water velocity in combination with the chemicals in Table A.2.

[c] The classification of sea water depends on the geographical location; therefore the classification valid in the place of use of the concrete applies.

**Table A.2 — Limiting values for exposure classes for chemical attack from natural soil and ground water**

| Environment | Parameter | | Reference test method | Class of chemical attack | | |
|---|---|---|---|---|---|---|
| | Chemical characteristic | Units | | XA1 | XA2 | XA3 |
| Ground water | $SO_4^{2-}$ | mg/l | See national annex | $\geqslant$ 200 and $\leqslant$ 600 | $\geqslant$ 600 and $\leqslant$ 3 000 | $>$ 3 000 and $\leqslant$ 6 000 |
| | pH | — | ISO 4316 | $\leqslant$ 6,5 and $\geqslant$ 5,5 | $<$ 5,5 and $\geqslant$ 4,5 | $<$ 4,5 and $\geqslant$ 4,0 |
| | $CO_2$ (aggressive) | mg/l | See national annex | $\geqslant$ 15 and $\leqslant$ 40 | $>$ 40 and $\leqslant$ 100 | $>$ 100 up to saturation |
| | $NH_4^+$ | mg/l | ISO 7150-1 or ISO 7150-2 | $\geqslant$ 15 and $\leqslant$ 30 | $>$ 30 and $\leqslant$ 60 | $>$ 60 and $\leqslant$ 100 |
| | $Mg^{2+}$ | mg/l | ISO 7980 | $\geqslant$ 300 and $\leqslant$ 1 000 | $>$ 1 000 and $\leqslant$ 3 000 | $>$ 3 000 up to saturation |
| Soil | $SO_4^{2-}$ (total) [a] | mg/kg | See national annex [b] | $\geqslant$ 2 000 and $\leqslant$ 3 000 [c] | $>$ 3 000 [c] and $\leqslant$ 12 000 | $>$ 12 000 and $\leqslant$ 24 000 |
| | Acidity | ml/kg | See national annex | $>$ 200 Beaumann Gully | Not encountered in practice | |

The aggressive chemical environments are classified based on the nature of the soil and ground water at water/soil temperatures between 5 °C and 25 °C and a water velocity sufficiently slow as to approximate to static conditions.

The most onerous value for any single chemical characteristic determines the class.

Where two or more aggressive characteristics lead to the same class, the environment shall be classified into the next higher class, unless a special study for this specific case proves that it is not necessary.

[a] Clay soils with a coefficient of permeability below 10 m/s to 5 m/s may be moved into a lower class.

[b] The test method should prescribe the extraction of $SO_4^{-2}$ by hydrochloric acid; alternatively, water extraction may be used, if experience is available in the place of use of the concrete.

[c] The 3 000 mg/kg limit shall be reduced to 2 000 mg/kg where there is a risk of accumulation of sulfate ions in the concrete due to drying and wetting cycles or capillary suction.

## A.3 Recommended classes for use in specification

### A.3.1 Consistence classes

Consistence should be specified using one of the classes given below or by a target value.

Consistence classes for slump, flow and slump flow are given in Tables A.3 to A.5 together with the likely target value. ISO 22965-2 gives the compliance limits for these classes.

Other methods of specifying consistence, e.g. degree of compactability, Vebe time, etc., may be used, in which case the method of test, target value and tolerances should be specified.

**Table A.3 — Slump classes**

| Slump class | Likely target slump [a] mm |
|---|---|
| S1[b] | 25 |
| S2 | 70 |
| S3 | 125 |
| S4 | 185 |
| S5 [b] | 250 |

[a] Where there are lower and upper limits, this is the mid-range value.

[b] The test method may lack sensitivity with these classes.

**Table A.4 — Flow classes**

| Flow class | Likely target flow [a] mm |
|---|---|
| F1[b] | 310 |
| F2 | 380 |
| F3 | 450 |
| F4 | 520 |
| F5 | 590 |
| F6 [b] | 660 |

[a] Where there are lower and upper limits, this is the mid-range value.

[b] The test method may lack sensitivity with these classes.

**Table A.5 — Slump flow classes**

| Slump flow class | Likely target slump flow [a] mm |
|---|---|
| SF1 | 450 |
| SF2 | 550 |
| SF3 | 650 |
| SF4 | 750 |

[a] Where there are lower and upper limits, this is the mid-range value.

### A.3.2 Strength classes

Recommended compressive strength classes are given in Table A.6. In special cases, intermediate strength levels may be used if this is permitted by the relevant design standard.

For normal-weight and heavy-weight concrete, compressive strength classes use the letter “B” followed by a number that is the required characteristic strength of 150 mm diameter by 300 mm length cylinders, or 100 mm diameter by 200 mm length cylinders. However, ISO 22965-2 permits compliance with these strength classes to be based on test data from either cylinders or cubes; see ISO 22965-2:2007, 6.3.1.

The producer is required to use only one shape and size of specimen for compliance testing. The shape and size of the specimen tested is selected by the concrete producer and declared.

Where light-weight concrete is required, the strength classes used in Table A.6 should be specified, but the designation should be preceded by the letter “L”, e.g. LB25.

**Table A.6 — Recommended compressive strength classes for concrete**

| Strength class | Required characteristic cylinder strength $N/mm^2$ |
|---|---|
| B8 | 8 |
| B12 | 12 |
| B16 | 16 |
| B20 | 20 |
| B25 | 25 |
| B30 | 30 |
| B35 | 35 |
| B40 | 40 |
| B45 | 45 |
| B50 | 50 |
| B55 | 55 |
| B60 | 60 |
| B70 | 70 |
| B80 | 80 |
| B90 | 90 |
| B100 | 100 |
| B110 | 110 |
| B120 | 120 |

# Annex B
(informative)

# Performance-related design methods with respect to durability

## B.1 Introduction

**B.1.1** This annex gives brief details of the approach and principles for a performance-related design method with respect to durability as referred to in 5.1.

**B.1.2** Further guidance can be found in the Model Code for Service Life Design published by *fib*. The *fib* MC-SLD presents four different approaches for SLD:

— full-probabilistic design approach;

— partial-factor design approach;

— deemed-to-satisfy design approach;

— avoidance-of-deterioration design approach.

**B.1.3** Deterioration mechanisms considered are the following:

— carbonation-induced corrosion;

— chloride-induced corrosion;

— freezing and thawing attack without de-icing agents;

— freezing and thawing attack with de-icing agents.

## B.2 Definition

The performance-related method considers, in a quantitative way, each relevant deterioration mechanism, the working life of the element of structure and the criteria that define the end of this working life.

Such a method may be based on satisfactory experience with local practices in local environments, on data from an established performance test method for the relevant mechanism or on the use of proven predictive models.

## B.3 Application and general guidance

a) Some aggressive actions are best dealt with by a prescriptive approach, e.g. alkali-silica reaction, sulfate attack, or abrasion.

b) Performance-related design methods are more relevant to corrosion-resistance and, possibly, freeze-thaw resistance of concrete. This approach may be appropriate where:

   — a working life significantly differing from 50 years is required;

   — the structure is “special,” requiring a lower probability of failure;

   — the environmental actions are particularly aggressive or are well defined;

— standards of workmanship are expected to be high;

— a management and maintenance strategy is expected to be introduced, perhaps with planned upgrading;

— significant populations of similar structures, or elements, are expected to be built;

— new or different materials are expected to be used;

— limiting values are used in the design, but there was a failure to comply with these limits.

c) In practice, the level of durability achieved depends on a combination of design, materials and execution.

d) The sensitivity of the design concept, the structural system, the shape of members and structural/ architectural detailing are all significant design parameters for all methods of durability design.

e) Compatibility of materials, the construction method, quality of workmanship, levels of control and quality assurance are significant parameters for all methods of durability design.

f) The required durability performance depends on the required life, on the possible future use of the structure, on the particular protective measures, on the planned maintenance in service and on the consequences of failure in the particular local environment.

g) For any required level of performance, it is possible to derive alternative equivalent solutions from different combinations of design, material and construction factors.

h) The level of knowledge of the ambient and local microclimate is important in establishing the reliability of performance-related design methods.

## B.4 Performance-related design methods with respect to durability

In applying the methods listed below, it is important to define, in advance, at least the following:

— type of structure and its form;

— local environmental conditions;

— expected quality of construction;

— required working life.

Some assumptions and judgements on these issues will usually be necessary to reduce the chosen method to a pragmatic and practical level.

The methods that may then be used include:

a) the refinement of the method using limiting values based on long-term experience of local materials and practices, and on detailed knowledge of the local environment;

b) methods based on approved and proven tests that are relatable to actual conditions and have approved performance criteria;

c) methods based on analytical models that are calibrated against test data representative of actual conditions in practice.

The concrete composition and the constituent materials should be closely defined to enable the level of performance to be maintained.

# Annex C
(normative)

# Identity testing for compressive strength

## C.1 General

The procedure in this annex is provided for the situation where the producer, using option B to assess the production (see ISO 22965-2:2007, 9.4.3), establishes the compliance of concrete and the specifier wishes to confirm that the batches they have received come from a complying population; see 6.1 g).

Identity testing indicates where the defined volume of concrete in question belongs to a population with the specified strength class; see ISO 22965-2:2007, 9.4.3, Note 2.

The procedure is not applicable to concrete subject to production assessment using option A; see ISO 22965-2:2007, 9.4.2.

## C.2 Sampling and testing plan

Where identity testing is to be performed, the particular volume of concrete shall be defined, such as concrete supplied for each storey of a building or group of beams/slabs or columns/walls of a storey of a building or comparable parts of other structures.

NOTE A test on an individual batch falls under compliance testing; see ISO 22965-2:2007, Table E.4.

The number of samples taken from a particular volume of concrete shall be defined.

Samples shall be taken from different batches or loads in accordance with ISO 1920-1.

Test specimens shall be prepared and cured in accordance with ISO 1920-3. The compressive strength of the specimens shall be determined in accordance with ISO 1920-4.

The test result shall be that obtained from the average of the results of two or more specimens made from one sample for testing at the same age. Where the range of the test values is more than 15 % of the mean, the results shall be disregarded unless an investigation reveals an acceptable reason to justify disregarding an individual test value.

## C.3 Identity criteria for compressive strength

Each individual strength test result is assessed for compliance with ISO 22965-2:2007, Table E.4, and the average of "$n$" non-overlapping, discrete results is assessed against the criterion in Table C.1 to determine whether the concrete represented by the batches comes from a population with the specified strength class.

The concrete represented by the batches is deemed to come from a complying population if the criterion in Table C.1 is satisfied for "$n$" results derived from strength tests on samples taken from the defined volume of concrete.

**Table C.1 — Identity criteria for compressive strength**

| Number of test results for compressive strength from the defined volume of concrete<br>$n$ | Mean of $n$ results<br>$f_{cm}$<br>N/mm$^2$ |
|---|---|
| 2 to 4 | $\geqslant f_{ck} + \alpha$ [a] |
| 5 to 6 | $\geqslant f_{ck} + \beta$ [a] |

[a] Values of $\alpha$ and $\beta$ shall be the values specified in provisions valid in the place of use of the concrete or, where no values are specified in the provisions valid in the place of use of the concrete, they shall be taken as 1 for $\alpha$ and 2 for $\beta$.

# Annex D
(informative)

# Guidance on the national annex

The national annex should include the following:

a) classification for aggressive conditions that are outside the scope of Table A.2, e.g. mobile water conditions and brown-field sites;

b) method for determination of the sulfate in a sample of ground water; see Table A.2;

c) method for determination of aggressive carbon dioxide in a sample of ground water; see Table A.2;

d) method for determination of the sulphate in a sample of soil; see Table A.2;

e) method for determination of the acidity in a sample of soil; see Table A.2;

f) where other methods of specifying consistence are required, the method and recommended target values, e.g. Vebe time, degree of compactability; see A.3.1;

g) where needed, additional compressive strength classes; see Table A.6 in A.3.2;

h) recommended designations, performance requirements, classes, limiting values and constituent materials that are appropriate for the place of use of the concrete, for the exposure classes given in Clause A.2, defined intended working lives (“at least 50 years” and “at least 100 years”) and defined minimum covers to reinforcement, i.e. the nominal cover minus the tolerance for fixing;

i) recommended maximum chloride content of fresh concrete;

j) where testing the chloride content of the fresh concrete is specified, the test method for determination of the chloride content of fresh concrete;

k) recommendations for temperature limits different to those given in 6.2.4 of ISO 22965-2:2007;

l) if used, recommendations where standardized prescribed concrete is an appropriate method of specifying.

# Bibliography

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[6] ISO 22966[1)], *Execution of concrete structures — Common rules*

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