INTERNATIONAL STANDARD

**ISO 16204**

First edition
2012-09-01

# Durability — Service life design of concrete structures

*Durabilité — Conception de la durée de vie des structures en béton*



Reference number
ISO 16204:2012(E)



ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

# Contents

Page

## 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 16204 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*.

# Introduction

This International Standard is based on the principles given in ISO 2394, *General principles on reliability for structures*, ISO 13823, *General principles on the design of structures for durability*, and fib[1)] "Model Code for Service Life Design" [1] (MC SLD, today implemented in fib Model Code 2010 [2]). The two International Standards were prepared by ISO/TC 98, *Bases for design of structures*.

The limit-states method, as developed in ISO 2394, has been adopted and used for preparing and harmonizing national and regional standards for structural design around the world. The objective of ISO 13823 is to provide a framework for the development of standards to predict the service life of components of a structure and to ensure that these principles are incorporated in the material-specific standards developed by other ISO Technical Committees.

The objective of fib MC SLD is to implement the principles of ISO 2394 in service life design of concrete structures.

This International Standard treats design for environmental actions leading to deterioration of concrete and embedded steel.

The flowchart in Figure 1 illustrates the flow of decisions and the design activities needed in a rational service life design process with a chosen level of reliability. Two strategies have been adopted; in the first, three levels of sophistication are distinguished. In total, four options are available.

Strategy 1: Design to resist deterioration

Level 1 Full probabilistic method (option 1)

Level 2 Partial factor method (option 2)

Level 3 Deemed-to-satisfy method (option 3)

Strategy 2: Avoidance-of-deterioration method, (option 4)



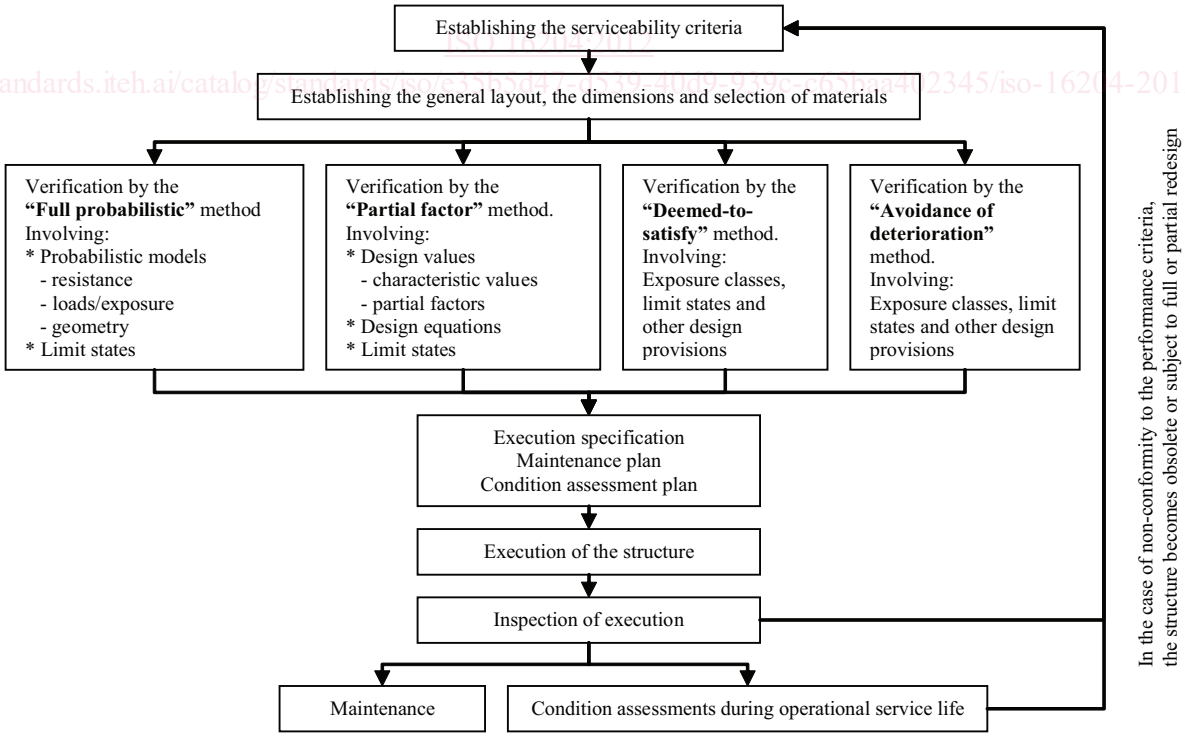


**Figure 1 — Flowchart for service life design**

1) The International Federation for Structural Concrete.

Within Clause 6 the following deterioration mechanisms are addressed:

— carbonation-induced corrosion;

— chloride-induced corrosion;

— freeze/thaw attack without de-icing agents or sea-water;

— freeze/thaw attack with de-icing agents or sea-water.

For these mechanisms widely accepted mathematical models exist.

The other deterioration mechanisms:

— chemical attack, and

— alkali-aggregate reactions,

are not treated in detail primarily because widely accepted mathematical models do not exist at present.

To make this International Standard complete, the missing models have to be developed and comply with the general principles of Clause 5.

This International Standard includes four informative annexes giving background information for the application in service life design and one informative annex giving guidance for the preparation of a possible national annex.

# Durability — Service life design of concrete structures

## 1 Scope

This International Standard specifies principles and recommends procedures for the verification of the durability of concrete structures subject to:

— known or foreseeable environmental actions causing material deterioration ultimately leading to failure of performance;

— material deterioration without aggressiveness from the external environment of the structure, termed self-ageing.

NOTE The inclusion of, for example, chlorides in the concrete mix might cause deterioration over time without the ingress of additional chlorides from the environment.

This International Standard is intended for use by national standardization bodies when establishing or validating their requirements for durability of concrete structures. It may also be applied:

— for the assessment of remaining service life of existing structures; and

— for the design of service life of new structures provided quantified parameters on levels of reliability and design parameters are given in a national annex to this International Standard.

Fatigue failure due to cyclic stress is not within the scope of this International Standard.



## 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 2394, *General principles on reliability for structures*

ISO 13823, *General principles on the design of structures for durability*

ISO 22965-1, *Concrete — Part 1: Methods of specifying and guidance for the specifier*

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

ISO 22966, *Execution of concrete structures*

ISO 6935 (all parts), *Steel for the reinforcement of concrete*

ISO 16311 (all parts), *Maintenance and repair of concrete structures*[2)]

2) To be published. ISO 16311-1, -2, -3 and -4 are under preparation.

## 3 Terms and definitions

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

**3.1**
**basic variable**
part of a specified set of variables representing physical quantities, which characterize actions and environmental influences, material properties including soil properties, and geometrical quantities

[ISO 2394:1998, 2.2.18]

**3.2**
**characteristic value**
$X_k$ **or** $R_k$
value of a material or product property having a prescribed probability of not being attained in a hypothetical unlimited test series

NOTE 1 This value generally corresponds to a specified fractile of the assumed statistical distribution of the particular property of the material or product.

NOTE 2 A nominal value is used as the characteristic value in some circumstances.

**3.3**
**characteristic value of a geometrical property**
$a_k$
value usually corresponding to the dimensions specified in the design

NOTE Where relevant, values of geometrical quantities may correspond to some prescribed fractiles of the statistical distribution.



**3.4**
**characteristic value of an action**
$F_k$
principal representative value



NOTE It is chosen:

— on a statistical basis, so that it can be considered to have a specified probability for not being exceeded towards unfavourable values during a reference period;

— on acquired experience; or

— on physical restraints.

[ISO 2394:1998, 2.3.12]

**3.5**
**design criteria**
quantitative formulations that describe for each limit state the conditions to be fulfilled

**3.6**
**design service life**
assumed period for which a structure or a part of it is to be used for its intended purpose with anticipated maintenance, but without major repair being necessary

**3.7**
**design situation**
set of physical conditions representing a certain time interval for which the design demonstrates that the relevant limit states are not exceeded

[ISO 2394:1998, 2.2.1]

**3.8**
**design value of a geometrical property**
$a_d$
generally a nominal value

NOTE 1 Where relevant, values of geometrical quantities may correspond to some prescribed fractile of the statistical distribution.

NOTE 2 The design value of a geometrical property is generally equal to the characteristic value. However, it may be treated differently in cases where the limit state under consideration is very sensitive to the value of the geometrical property. Alternatively, it can be established from a statistical basis, with a value corresponding to a more appropriate fractile (e.g. rarer value) than applies to the characteristic value.

**3.9**
**design value of an action**
$F_d$
value obtained by multiplying the representative value by the partial factor $\gamma_f$ or $\gamma_F$.

[Modified from ISO 2394:1998, 2.3.16]

**3.10**
**design value of material or product property**
$X_d$ **or** $R_d$
value obtained by dividing the characteristic value by a partial factor $\gamma_m$ or $\gamma_M$, or, in special circumstances, by direct determination

NOTE See 5.4.2 (3).

[Modified from ISO 2394:1998, 2.4.3]



**3.11**
**execution specification**
documents covering all drawings, technical data and requirements necessary for the execution of a particular project

NOTE The execution specification is not one single document but signifies the total sum of documents required for the execution of the work as provided by the designer to the constructor and includes the project specification prepared to supplement and qualify the requirements of this International Standard, as well as referring to the national provisions relevant in the place of use.

[ISO 22966:2009, 3.8]

**3.12**
**inspection**
conformity evaluation by observation and judgement accompanied as appropriate by measurement, testing or gauging

[ISO 9000:2005, 3.8.2]

**3.13**
**limit state**
state beyond which the structure no longer satisfies the relevant design criteria

NOTE Limit states separate desired states (no failure) from undesired states (failure).

[Modified from ISO 2394:1998, 2.2.9]

**3.14**
**maintenance**
set of activities that are planned to take place during the service life of a structure in order to fulfil the requirements for reliability

**3.15**
**project specification**
project-specific document describing the requirements applicable for the particular project

[ISO 22966:2009, 3.15]

**3.16**
**reference period**
chosen period of time which is used as a basis for assessing values of variable actions, time-dependent material properties, etc.

[ISO 2394:1998, 2.2.8]

**3.17**
**reliability**
ability of a structure or a structural member to fulfil the specified requirements, including the design service life, for which it has been designed

NOTE 1 Reliability is usually expressed in probabilistic terms.

NOTE 2 Reliability covers safety, serviceability and durability of a structure.

[Modified from ISO 2394:1998, 2.2.7]

**3.18**
**reliability differentiation**
measures intended for socio-economic optimization of the resources to be used to build construction works, taking into account all expected consequences of failures and the cost of the construction works



**3.19**
**repair**
activities performed to preserve or to restore the function of a structure that fall outside the definition of maintenance

**3.20**
**representative value of an action**
$F_{rep}$

value used for the verification of a limit state

NOTE Representative values consist of characteristic values, combination values, frequent values and quasi-permanent values, but may also consist of other values.

[ISO 2394:1998, 2.3.11]

**3.21**
**resistance**
capacity of a member or component, or a cross-section of a member or component of a structure, to withstand actions that lead to deterioration

**3.22**
**serviceability limit state**
state that corresponds to conditions beyond which specified service requirements for a structure or structural element are no longer met

[ISO 2394:1998, 2.2.11]

**3.23**
**serviceability criterion**
design criterion for a serviceability limit state

**3.24**
**ultimate limit state**
state associated with collapse or with other similar forms of structural failure

NOTE They generally correspond to the maximum load-carrying resistance of a structure or structural element, but in some cases to the maximum applicable strain or deformation.

[ISO 2394:1998, 2.2.10]

# 4 Symbols and abbreviated terms

## 4.1 Abbreviated terms

| | |
|---|---|
| SLD | service life design |
| SLS | serviceability limit state |
| ULS | ultimate limit state |

## 4.2 Main letters

| | |
|---|---|
| $F$ | action in general |
| $R$ | resistance |
| $S$ | action effect |
| $T$ | temperature |
| $X$ | basic variable |
| $a$ | geometric quantity |
| $p$ | probability |
| $t$ | time |
| $x$ | distance |
| $\alpha$ | ageing factor |
| $\Delta$ | margin |
| $\gamma$ | partial factor |
| $\gamma_c$ | partial factor for concrete |
| $\gamma_f$ | partial factor for actions without taking account of model uncertainties |
| $\gamma_F$ | partial factor for actions, also accounting for model uncertainties and dimensional variations |
| $\gamma_m$ | partial factors for a material property, taking account only of uncertainties in the material property |
| $\gamma_M$ | partial factors for a material property, taking account of uncertainties in the material property itself and in the design model used |
| $\gamma_{Rd}$ | partial factor associated with the uncertainty of the resistance model, plus geometric deviations if these are not modelled explicitly |