International Standard

ISO 19338

Performance requirements for standards on concrete structures

Exigences de performance pour les normes relatives aux structures en béton

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete,* Subcommittee SC 4, *Performance requirements for structural concrete.*

This fourth edition cancels and replaces the third edition (ISO 19338:2014), which has been technically revised.

The main changes are as follows:

— title has been revised in order to best reflect the new Scope;

— Scope has been expanded, now including performance requirements for standards on assessment of existing concrete structures;

— Normative references has been revised;

— Terms and definitions has been expanded;

— new Clause 4 on general principles guiding the design of new concrete structures and the assessment of existing ones has been included, with an emphasis on life cycle management;

— new Clauses 7 and 11, and Annex A have been added;

— former Clause 7, Assessment, has been reorganized into two new Clauses 9 and 10.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Concrete is the most popular material used in the construction market. Presently, about four tonnes of concrete are produced each year for every human being in the world (some 32 billion tonnes per year). This also translates into an omnipresence of concrete structures in the built environment, which, in turn, are managed during their life cycle under the constraints of sustainability.

International Standards on concrete technology and concrete structures can play a significant role in improving the global trade climate. International Standards in the field of concrete and its use in civil infrastructure are increasingly needed as the economic development of the world continues and new problems are identified.

Both developed and developing countries currently face the challenge of designing and building new structures while managing an aging built environment under economic and sustainability constraints. Consequently, standardization should be pursued not only of the design of new concrete structures, but also of the assessment of existing concrete structures.

It is important for uncertainties to be dealt with in the design and assessment of concrete structures. These can be related to inherent variability such as material properties, dimensions, and loads, or epistemic uncertainties, i.e. those related to the lack of (or limited) knowledge. In this latter category, there are errors associated with predictive models, sampling errors and measurement errors.

Design standards for new concrete structures allow for uncertainties in the design and construction processes; on the other hand, much of what was initially uncertain is no longer in the finished structure[8]. However, the determination of the actual values of various parameters (e.g. in situ concrete compressive strengths and area of longitudinal reinforcement) in the existing concrete structure introduces uncertainty of its own. The structure can have undergone a deterioration process, such as corrosion of the reinforcement or been damaged by accidental actions. Additionally, economic, social and environmental considerations can result in a greater differentiation in structural reliability for the assessment of existing structures than for the design of new structures (ISO 13822). As a result, standards for the assessment of existing concrete structures should recognize the differences between the assessment of existing concrete structures and the design of new ones.

This document gives the performance requirements for design, assessment or design and assessment standards on concrete structures. This document provides general provisions and guidelines, and is intended to provide wide latitude of choice in terms of general requirements for the performance evaluation of concrete structures. It should be used, therefore, in conjunction with sound engineering judgment.

ISO/TC 71/SC 4 has defined a procedure[1)] to review codes and standards for general alignment with ISO 19338. Summaries of these reviews are shared with the Code or standard authors, and potential beneficial changes to ISO 19338 are shared with SC 4 for review and implementation. These comparable national and regional standards are generally more prescriptive in nature than International Standards and vary somewhat from region to region.

1) Document publicly accessible at: https://www.iso.org/committee/49920.html?view=documents

Performance requirements for standards on concrete structures

1 Scope

This document provides performance requirements for standards on concrete structures. It can be used for international alignment of design, assessment and construction requirements.

This document includes:

a) principles, which guide the selection of requirements that translate societal and owner's expectations for the performance of the concrete structure;

b) requirements, which define the required performance of the concrete structure;

c) criteria, which give means for expressing the requirements;

d) evaluation clauses, which give acceptable methods of verifying the specific criteria.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
accidental action
action (3.2) whose chance of occurrence is very small, but the intensity is very large compared with *variable actions* (3.37)

3.2
action
assembly of concentrated or distributed mechanical forces acting on/in a structure (direct actions), deformations imposed on the structure or contained within it (indirect actions), or *environmental actions* (3.9)

3.3
analysis
procedure or algorithm for determination of action effects

Note 1 to entry: It is an acceptable method of evaluating the performance index or verifying compliance with specific *criteria* (3.5) of a structure.

3.4
assessment
set of activities carried out in order to verify the performance of an existing structure for future use

3.5
criteria
means of expressing the *performance requirement* (3.20) for concrete structures by specific technical values and appropriate limits

3.6
design service life
period of time specified in the design of a structure for which a structure or its members is to be used for its intended purpose without major *repair* (3.23) being necessary

[SOURCE: ISO 16311-1:2024, 3.3, modified — Note 1 to entry and Figure 2 were removed.]

3.7
deterioration
process that adversely affects the *structural performance* (3.33) including *reliability* (3.22) over time

Note 1 to entry: Deterioration may be caused by naturally occurring chemical, physical, or biological *action* (3.2), normal or severe *environmental actions* (3.9), repeated actions such as those causing fatigue, wear due to use, and improper operation and *maintenance* (3.15) of the structure.

[SOURCE: ISO 2394:2015, 2.1.31]

3.8
durability
ability of a structure or any of its components to perform its required functions in its service environment over a period of time without unforeseen cost for *maintenance* (3.15) or *repair* (3.23)

[SOURCE: ISO 17738-1:2021,3.1.7, modified — "building" has been replaced by "structure".]

3.9
environmental actions
assembly of physical, chemical or biological influences which may cause restraint effects or *deterioration* (3.7) to the materials making up the structure, which in turn may adversely affect its *serviceability* (3.30), *durability* (3.8), *safety* (3.29) and *restorability* (3.27)

3.10
experimental analysis
analysis (3.3) using physical *models* (3.17) to determine load-carrying capacity and *serviceability* (3.30) of prototype design

3.11
investigation
collection of information through inspection, document search, load testing or other methods

[SOURCE: ISO 16311-1:2024, 3.7, modified — "and other testing" has been replaced by "or other methods".]

3.12
life cycle management
set of systematic and coordinated activities and practices through which a structure is appropriately managed over its life cycle

[SOURCE: ISO 22040:2021, 3.2, modified — The acronym "LCM" was removed.]

3.13
limit state
state beyond which a structure no longer satisfies the design requirements

[SOURCE: ISO 2394:2015, 2.2.7, modified — "criteria" has been replaced by "requirements".]

3.14
load factor
multiplier applied to the *representative value of a load* (3.24), defined according to a reliability-based design procedure that takes into account the uncertainty and variability of the corresponding *action* (3.2)

3.15
maintenance
set of activities taken to check, evaluate, and preserve or restore the performance of a structure, so as to satisfy a *performance requirement* (3.20) in service

3.16
maintenance plan
plan realizing *maintenance* (3.15) strategy in order to ensure that the structure retains the performance within the specified tolerances throughout its service life

[SOURCE: ISO 16311-1:2024, 3.10, modified — Note 1 to entry was removed.]

3.17
model
physical, mathematical or numerical idealization of *actions* (3.2) and structural behaviour used for the purposes of *analysis* (3.3), design and verification

3.18
partial safety factors for materials
divisors applied to the material characteristic strength in general conformance with reliability-based design requirements

Note 1 to entry: See also *resistance factor* (3.26).

3.19
performance evaluation
procedure where *actions* (3.2) corresponding to a *limit state* (3.13) are used in the determination of the structural response, with the response checked against specified limits

3.20
performance requirement
required *structural performance* (3.33) in designed concrete structures

3.21
permanent load
action (3.2) which is likely to act continuously throughout the *design service life* (3.6) and for which variations in magnitude with time are small, compared with the mean value

3.22
reliability
ability of a structure or structural member to fulfil the specified requirements, during the service life, for which it has been designed

Note 1 to entry: Reliability is often expressed in terms of probability.

Note 2 to entry: Reliability covers *safety* (3.29), *serviceability* (3.30) and *durability* (3.8) of a structure.

[SOURCE: ISO 2394:2015, 2.1.8, modified — "working life" has been replaced by "service life".]

3.23
repair
restoration of a structure or its components to an acceptable condition by the renewal or replacement of worn, damaged, or deteriorated components

[SOURCE: ISO 13823:2008, 3.20]

3.24
representative value of a load
value of *action* (3.2) used for the verification of *criteria* (3.5)

3.25
resistance
ability of a member or structure to bear loads or action effects

3.26
resistance factor
multiplier applied to *resistance* (3.25) in general conformance with reliability-based design requirements

Note 1 to entry: When applied to materials, these multipliers may also be called material factors. See *partial safety factors for materials* (3.18).

3.27
restorability
ability of a structure or structural member to be repaired physically and economically when damaged under the effects of considered *actions* (3.2)

3.28
robustness
ability of a structure to withstand adverse and unforeseen events (like fire, explosion, impact) or consequences of human errors without being damaged to an extent disproportionate to the original cause

[SOURCE: ISO 2394:2015, 2.1.46, modified — The term "damage insensitivity" was removed.]

3.29
safety
ability of a structure or structural member to assure no casualty to users of, and people around, the structure, within the limits of acceptable probability

3.30
serviceability
ability of a structure or structural member to provide appropriate behaviour or functionality under the effects of considered *actions* (3.2) at a *serviceability limit state* (3.31)

3.31
serviceability limit state
limit state (3.13) concerning the *criteria* (3.5) governing the functionalities related to normal use

[SOURCE: ISO 2394:2015, 2.2.10]

3.32
structural integrity
ability of a structure to avoid widespread collapse when localized damage occurs

3.33
structural performance
qualitative or quantitative representation of the behaviour of a structure (e.g. load bearing capacity, stiffness) related to its *safety* (3.29) and *serviceability* (3.30), *durability* (3.8) and *robustness* (3.28)

[SOURCE: ISO 2394:2015, 2.1.26]

3.34
structural safety
ability of a structure or structural member to avoid exceedance of the *ultimate limit state* (3.36), including the effects of specified accidental phenomena, with a specified level of *reliability* (3.22), during a specified period of time

[SOURCE: ISO 2394:2015, 2.1.9]

3.35
sustainability
ability of a structure or structural member to contribute positively to the fulfilment of the present needs of humankind with respect to social, economic and environmental aspects, without compromising the ability of future generations to meet their needs in a similar manner

3.36
ultimate limit state
limit state (3.13) concerning the maximum load-bearing capacity or deformation

[SOURCE: ISO 2394:2015, 2.2.8, modified — "or deformation" has been added.]

3.37
variable action
action (3.2) which is likely to occur during a given *design service life* (3.6) and for which the variation in magnitude with time is neither negligible nor monotonic

4 General principles

In the design of a concrete structure, the purpose, functions and performance requirements of the structure to be ensured during the design service life shall be determined. The performance requirements shall be appropriately selected as the ability of the structure to maintain the function and sustainability of the structure. The sustainability considerations are given in Clause 7. The performance evaluation method shall always be sufficiently clear about the relationship between the performance requirements and design actions to be considered.

Structural forms and materials shall be selected, and structural dimensions shall be determined, so that execution and maintenance can be carried out appropriately during the execution and use stages. The methods of execution and planned cycles of maintenance and repair shall also be predetermined.

The designed performance of the structure shall be verified according to the corresponding requirements.

In the structural design, it is recommended to have a life cycle management perspective that always seeks the optimum solution considering the structural life cycle. The framework of the life cycle management can refer to ISO 22040 and the specification of the life cycle management can refer to ISO 22040-2.

It is important to ensure that the design outline, design calculations, design drawings, quantity calculations and maintenance plans created in the design process shall be communicated to execution and maintenance stages of the structure.

Similar principles should apply to the assessment of existing concrete structures. Performance requirements for the existing structure shall be ensured during the revised design service life. While in the case of design of concrete structures, requirements are established for a structure with expected properties, in the assessment of existing structures, requirements shall be established for the performance of a structure in its "as is" condition. The condition of the existing structure shall be evaluated through a comprehensive investigation. Furthermore, economic, social and environmental considerations shall result in a greater differentiation in structural reliability for the assessment of existing structures than for the design of new structures (see ISO 13822).

The performance evaluation method defined in a design or assessment standard for concrete structures shall account for the uncertainties related to inherent variability and epistemic uncertainties. This shall be accomplished via reliability-based design methods or semi-probabilistic methods. Moreover, considering that the structure shall satisfy different performance requirements during its design service life (safety, serviceability, durability, etc.), these standards shall follow the limit states design format.

5 General requirements

5.1 Overall structural concept

The overall quality of a structure shall be implemented through strict quality control and care by a knowledgeable qualified design professional complying with ISO 2394. In conceiving a structural system, materials and their combinations, safety, serviceability, durability, constructability, restorability, life-cycle management and sustainability shall be evaluated.

5.2 Structural integrity

Design of concrete structures shall provide general structural integrity, directly or implicitly. Localized damage or deterioration in a structure shall not impair general structural integrity.

5.3 Design and assessment approach

Design and assessment standards for concrete structures shall be based on quantitative performance evaluation at the limit states. Design and assessment shall consider safety, serviceability, restorability, structural integrity, robustness, sustainability, environmental adequacy and durability. Where applicable, limit states caused by fatigue, fire, explosion, impact and rare accidental actions or other extreme loadings or actions shall be considered.

5.4 Service life

Service life shall be determined in consideration of the structural role, the social importance of the structures concerned, performance and the economic constraints. Structural requirements shall be satisfied throughout the defined service life.

5.5 Workmanship, materials and quality assurance

In order for the properties of the completed structure to be consistent with the requirements and the assumptions made during the planning and design stage, the quality and execution expectations for construction shall be ensured and the quality control measures shall be taken.

6 Performance requirements

6.1 General

For limit states, the design and assessment standard shall specify sets of action combinations and a reliability-based design concept that can be analytically demonstrated to give an adequate performance level during the service life of the structure.

6.2 Structural safety and ultimate limit states

The safety level shall be selected considering the consequences of failure, the inability of the facility to fulfil its function, the relative importance of the expected modes of failure, the redundancy of the structure, the ability to inspect and maintain the finished structure during the service life, and the additional costs associated to increased safety. Compressive stresses in concrete under any loads, including sustained loads, shall not cause crushing of the concrete.

6.3 Serviceability limit states

6.3.1 General

Service load deflections, vibrations and cracking shall be limited so that they do not impair the use of the structure. Serviceability limit states shall be evaluated using factored loads and load combinations in which the load factors correspond to an acceptable probability of occurrence of the serviceability limit state being checked.

6.3.2 Vibration

Either dynamic response or periods of vibration of a structure, or both, shall be evaluated and limited to either avoid discomfort to occupants, impair use of the structure, or avoid the risk of resonance, or all three. Dynamic analyses shall be used where required.

6.4 Restorability

Damages in structures caused by loadings and actions, such as earthquake and environmental actions, shall be limited so that the restoration works can be conducted in an economically, technically and environmentally feasible way.

6.5 Durability

The structure shall be designed and assessed in a way that deterioration does not cause it to reach an ultimate or a serviceability limit state during its service life. Regular maintenance shall be prescribed in the standard, or through reference to an applicable standard.

6.6 Fire resistance

When exposure to fire during the life of a structure is possible, the concrete structure shall provide adequate fire resistance regarding life safety and residual structural capacity during and after a fire.

6.7 Fatigue

For structures or parts of structures, fatigue performance may be a design consideration. In such cases, fatigue loading shall be specified.

7 Sustainability

Sustainability is a global goal focusing on assurance of quality of life on Earth for the current and future generations. Concrete products and structures shall, through their performance within the entire life cycle, contribute to sustainable growth of society and sustainable development of life by reducing negative impacts and increasing positive effects on the society, environment and the economy.

Sustainability is a key conceptual principle to be considered through the life cycle of concrete structures, including design, production, construction, operation, maintenance, repair and dismantlement or circular use of any building or civil engineering work forming the built environment.

According to ISO 13315-1 and ISO 22040, sustainability should be described by means of interdependent, interconnected and mutually reinforcing aspects of sustainability on which sustainable development depends on social, environmental and economic aspects.

The awareness of the impact of structural design on all aspects of social performances shall be fostered by modern structural codes. While structural performance is highlighted by structural engineers as the basic aspect of social performance that structures are required to exhibit, all other aspects of social performances are to be treated as additional requirements that structural design shall pursue. These aspects include, but are not limited to:

— buildability;

— maintainability;

— ability of the structure in being dismantled and recyclability of its members;

— aesthetics;

— safety of workers and external persons;

— minimization of hindrance to neighbouring stakeholders;

— minimization of disturbances to traffic, communication and other operations;

— acoustic comfort;

— thermal comfort;

— security.

A structure shall be designed, constructed, managed and taken care of during its life cycle in order to minimize harmful impacts to the environment and providing environmental benefits. Key aspects within environmental performance shall include: use of resources; use of energy; use of land; emissions to air, water and soil; noise and vibration; waste production; species and ecosystem. Details can be found in the ISO 13315 series.

8 Loadings and actions

8.1 General

Loads due to use and occupancy, seismic actions in earthquake prone areas, and environmental actions shall be defined considering the exceedance probability or recurrence interval based on statistically surveyed data.

8.2 Load factors

Either load factors or action factors, or both in general conformance with a reliability-based design concept shall differentiate between the different variabilities of permanent loads, frequent variable loads due to use and occupancy, seismic actions, frequent environmental actions, and rare loads. Load factors shall also differentiate between stabilizing and destabilizing loads and actions.

8.3 Action combinations

Action combinations used shall recognize the reduced probability of the simultaneous occurrence of variable loads or actions.

8.4 Permanent loads

Permanent loads, including self-weight and the weight of permanently attached items, shall be included.

8.5 Variable loads

Variable loads that result from use of the structure shall be included.

8.6 Accidental loads

Where accidental loads due to collision, explosion, or other unusual actions are possible, such actions shall be evaluated.

8.7 Construction loads

Loads during any stage of construction that may lead to the ultimate limit state shall be evaluated.

8.8 Impact load

The impact load shall include dynamic effects of actions on the structure.

8.9 Seismic actions

In earthquake prone areas, seismic action is subject to applicable national regulations or codes. Seismic action effects shall include the dynamic response.

8.10 Wind forces

Wind effects shall be evaluated.

8.11 Environmental actions

Environmental actions shall be evaluated when physical, chemical, or biological influences can adversely affect serviceability, durability, restorability and safety.

8.12 Investigation actions

Loads during investigation of an existing structure shall be evaluated. Methods used for load testing an existing structure shall consider load levels, load patterns and load duration.

9 Resistance

9.1 Materials

Materials used in concrete structures shall satisfy codes of practice for water, aggregates, admixtures, cementitious materials, concrete and reinforcement.

In the assessment of existing structures, the material properties of interest shall be obtained in a comprehensive investigation.

9.2 Resistance calculation

9.2.1 General

Resistance calculation shall be based on ultimate limit state conditions. The calculation procedures shall be based on engineering principles and shall show agreement with a wide range of relevant test results.

9.2.2 Flexure and combined flexure and axial load

Flexural strength estimation shall account for:

a) nonlinear concrete stress distribution at failure;

b) nonlinear stress-strain curves for steel;

c) strain compatibility; and

d) sustained load effect.

9.2.3 Shear and torsion

Strength calculations for shear and torsion shall be based on engineering principles and shall be shown to agree with experimental results.

9.2.4 Bond, anchorage and splices

Forces in reinforcement shall be designed to develop on each side of every critical section by one or more of the following mechanisms:

— bond and anchorage of reinforcement;

— hooks, mechanical anchorages;

— lap splices.

9.2.5 Bearing

Bearing stresses and forces on concrete shall prevent failure. Confinement may be used to enhance the bearing strength.

9.3 Partial safety factors for materials

These safety factors, which are divisors applied to the concrete and steel characteristic strengths, shall be in general conformance with reliability-based design requirements. They shall take into account the differences between the strength of test specimens of the structural materials and their in-situ strength, the different variabilities of concrete and steel, and other sources of uncertainties in the prediction of the structural resistance.

9.4 Resistance factors

Resistance factors used shall recognize, directly or indirectly, the different variabilities of concrete and steel, the different calculation models, and the different levels of ductility in the failure mode of interest. These safety factors, which are multipliers applied to estimated values of the nominal resistance, shall be in general conformance with reliability-based design requirements.

10 Performance evaluation

10.1 Analysis of concrete structures

10.1.1 Analysis for ultimate limit states

An acceptable standard for the design and assessment of structures shall allow the use of the following types of analysis for the ultimate limit states:

a) linear analysis;

b) nonlinear analysis;

c) linear analysis with redistribution;

d) plastic analysis (with specified minimum levels of ductility);

e) experimental analysis.

For the analysis, the structural members are classified as one-dimensional, two-dimensional or three-dimensional models. Accuracy of analytical methods allowed in this document shall be verified against experimental observation.

10.1.2 Analysis for serviceability limit states

For serviceability limit states, linear, nonlinear, or experimental analysis shall be allowed.

10.1.3 Theoretical and numerical analyses

Theoretical and numerical results shall be verified using established equilibrium checks.

10.1.4 Experimental analysis

Experimental analyses may be used provided they are carried out by personnel experienced in experimental analysis and providing that the variabilities of the material strengths and the resistances of the actual structure are considered.

10.2 Safety criteria

Criteria shall be established so that design resistance exceeds design actions (or their effects). The resistance shall be established to agree with mechanical principles and material behaviour or shall be based on tests.

In the assessment of existing structures, the resistance shall be determined based on the "as is" condition of the structure with due consideration of potential deleterious effects. Actual conditions of the materials involved, dimensions and geometric data, gathered during the investigation process, shall be considered in the evaluation of the structural resistance. Design actions (or their effects) shall take in account the foreseeable actions during the revised design service life. A clear rationale for acceptable safety levels for the existing structure shall be provided.

10.3 Stability

10.3.1 General

Design requirements shall consider the stability of members and structures. Design requirements for columns shall distinguish between braced frames and frames which are free to sway.

10.3.2 Design for stability

Design for stability shall allow for the effects of cracking and creep where these are significant. Design for stability should also account for progressive development (increasing the number) of plastic hinges in the structural system.

10.4 Precast concrete

When precast concrete structures are being considered, the design and assessment standard shall provide for the overall structural integrity. It shall also give requirements for composite action between previously cast and newly cast elements of structural members.

10.5 Prestressed concrete

10.5.1 Design and assessment of prestressed concrete structures

If prestressed concrete is to be included in the structures, the applied design and assessment standard for concrete structures shall include design and assessment requirements for prestressed concrete.

10.5.2 Prestress losses

Design and assessment of concrete structures containing prestressing steel shall account for prestress losses.

10.5.3 Grouting of tendons

Bonded tendons shall be grouted. Corrosion protection shall be provided for all corrosion-prone tendons.