



**International
Standard**

ISO 16311-2

**Maintenance and repair of concrete
structures —**

**Part 2:
Assessment of existing concrete
structures**

*Entretien et réparation des structures en béton —
Partie 2: Évaluation des structures en béton existantes*

**Second edition
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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.

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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 7, *Maintenance and repair of concrete structures*.

This second edition cancels and replaces the first edition (ISO 16311-2:2014) which has been technically revised.

The main changes are as follows:

- prediction has been added as [Clause 7](#);
- some terms and definitions have been revised;
- some figures have been revised.

A list of all parts in the ISO 16311 series can be found on the ISO website.

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

Assessment of an existing concrete structure identifies and defines areas of distress, and verifies structural performance based on the evaluated condition of the structure. It includes the whole process from defining the work through the investigation, evaluation, verification, prediction, and registration to the final report. This is necessary as a basis for the design of the repair and the preparation of procedures to preserve or extend its remaining service life.

The report, concluding the assessment, includes a description of the structure, the investigation, the results of condition assessment, the verified structural performance, the expected future development and a short presentation of possible repair principles and methods, including appropriate cost calculations. A detailed planning and design of the repair work (repair or rehabilitation project specification) is not part of the assessment, see ISO 16311-3.

This document gives the requirements for assessment of concrete structures, including a framework for the assessment, a format for documentation of the condition assessment with assessed condition level and consequence level, and a format for documentation of the performance assessment with verified specific structural performance.

This document is primarily based on the principles given in ISO 13822. ISO 13822:2010, Annex B has a detailed flowchart, included as [Figure 1](#) in this document.

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Maintenance and repair of concrete structures —

Part 2: Assessment of existing concrete structures

1 Scope

This document describes general requirements and procedures for the assessment of concrete structures.

The assessment can be initiated under the following circumstances, but not limited to:

- a) an anticipated change in use or extension of design service life;
- b) structural deterioration due to time-dependent actions such as corrosion of reinforcement, fatigue, etc.;
- c) safety and/or serviceability check (e.g. for earthquake and increased traffic actions) as required by authorities, insurance companies, owners, etc.;
- d) structural damage by accidental actions (see ISO 2394).

This document does not cover

- qualification of personnel;
- contractual matters;
- health and safety requirements for the protection of workers during the investigation and testing.

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*

ISO 13822:2010, *Bases for design of structures — Assessment of existing structures*

ISO 16311-1, *Maintenance and repair of concrete structures — Part 1: General principles*

ISO 16311-3, *Maintenance and repair of concrete structures — Part 3: Design of repairs*

ISO 16311-4, *Maintenance and repair of concrete structures — Part 4: Execution of repairs*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13822, ISO 16311-1 and the following 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 that is unlikely to occur with a significant value on a given structure over a given reference period

Note 1 to entry: Accidental actions are in most cases of short duration.

3.2

condition

status of a structure or a structural member at a given time

3.3

condition level

expression of the condition of a structure or a structural member, compared to a reference level

3.4

condition registration

survey and collection of information to define the condition of a structure or structural member

3.5

consequence level

expression of seriousness of consequences related to a defined reference level

3.6

damage

unfavourable change in the condition of a structure that can affect structural performance

3.7

defect

fault or deviation from the intended level of performance of a structure or its parts

3.8

deterioration

process that adversely affects the structural performance, including reliability over time due to

- naturally occurring chemical, physical or biological actions,
- repeated actions such as those causing fatigue,
- normal or severe environmental influences,
- wear due to use, or
- improper operation and maintenance of the structure

3.9

environmental action

assembly of physical, chemical, or biological influence which can cause restraint effects or deterioration to the materials making up the structure, which in turn can adversely affect its serviceability, restorability, and safety

3.10

inspection

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

Note 1 to entry: For structures, this evaluation consists of actions collecting information on the current state of a structure through observation and simplified non-destructive or destructive testing supplemented with materials and structural testing, as required.

3.11

risk

combination of the probability or frequency of occurrence of an event and the magnitude of its consequences

3.12

symptom

indicator for the condition of a structure or structural member, based on one or more characteristics

3.13

visual inspection

inspection of a structure by visual observation in the preliminary investigation for its assessment

4 Framework of assessment

4.1 General

The overall assessment procedure shall comply with ISO 13822 and include the following main parts according to [Figure 1](#), which is a general flowchart copied from ISO 13822:

- objectives of assessment;
- scenarios;
- preliminary assessment;
- detailed assessment;
- reporting results of assessment;
- judgement and decision;
- intervention.

A site visit is recommended prior to initiating the assessment.

4.2 Personnel

An assessment shall be performed by qualified personnel.

NOTE National requirements on qualification for personnel can apply.

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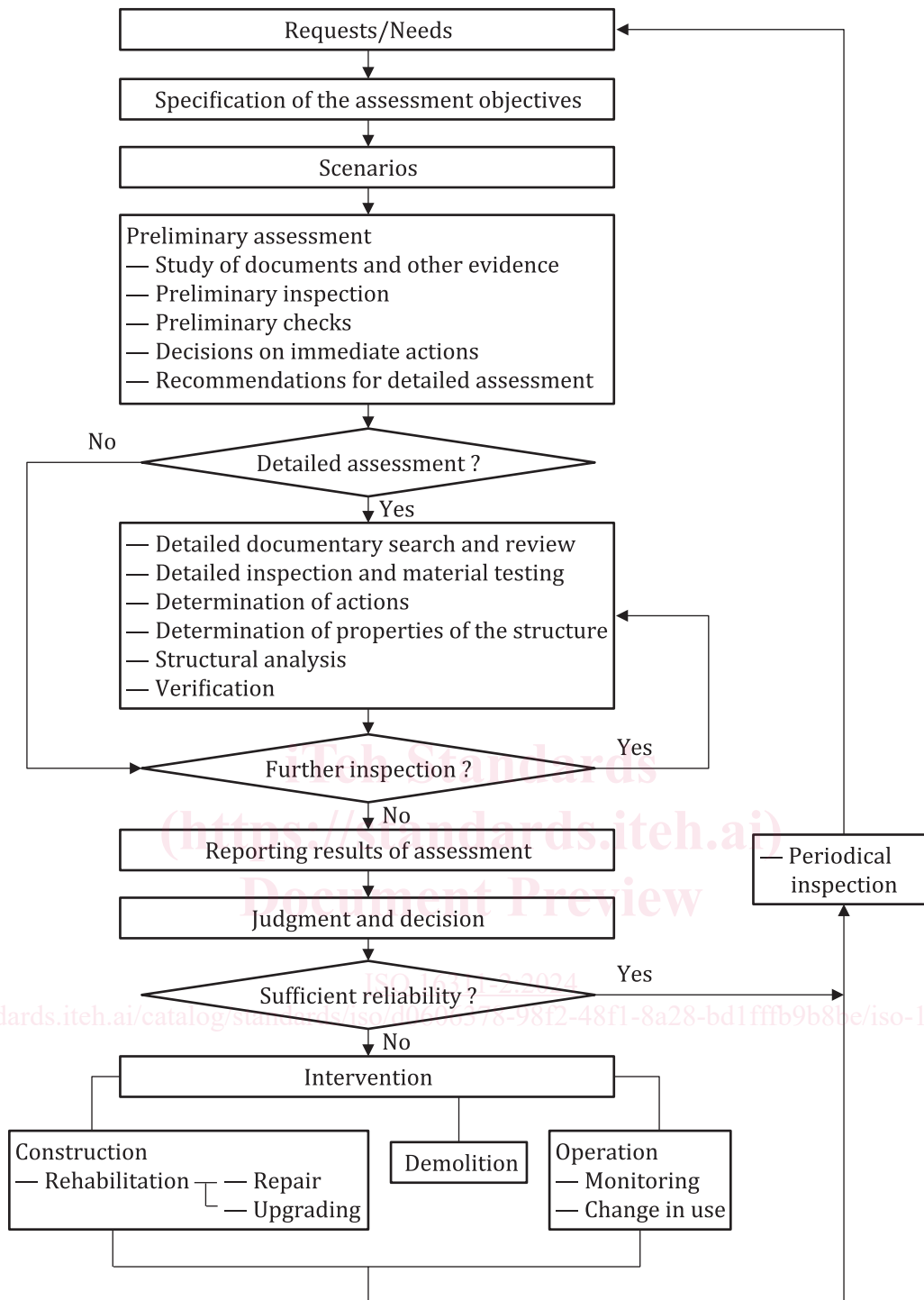


Figure 1 — General flowchart for assessment of existing structures (adapted from ISO 13822:2010, Annex B)

4.3 Objectives of assessment

The objectives of the assessment of an existing concrete structure, in terms of its operable condition and its future structural performance, shall be specified in consultation with the client (the owner, the authority, insurance companies, etc.) based on the following performance levels:

- a) safety performance level;
- b) continued function performance level;

c) special performance requirements of the client.

NOTE Reference is made to ISO 13822:2010, 4.1.

The objectives of the assessment shall be determined or confirmed before starting the assessment activities. Within the determined objectives of assessment, the assessment shall be carried out with the procedure given in [Figure 1](#).

The objectives of an assessment, the extent and the application of methods and resources shall be defined in a project specification.

The extent of an assessment depends on the nature of the structure, if a rough cost estimate of recommended actions shall be included, etc.

The content of an assessment shall be re-evaluated continuously based on the observations.

NOTE [Clause A.1](#) gives more detailed description of the purpose and scope of a condition assessment.

4.4 Scenarios

One or some scenarios to represent a possible change in structural performance shall be specified prior to the preparation of assessment to identify possible critical situations for the structure. These scenarios shall be developed with an understanding of the type of construction, the timeframe of construction, and the environment to which the structure or structural member were exposed. These scenarios include, but are not limited to (see also ISO 16311-3):

- chloride exposure, and damage related to chloride-induced corrosion,
- carbonation-induced corrosion damage,
- mechanical damage due to (impact, overload, settlement, vibration, seismic, abrasion, fatigue, explosion, etc),
- chemical damage due to (alkali-aggregate reactions, aggressive agents, biological actions, etc),
- physical damage due to (fire, frost, thermal effects, shrinkage, erosion, wear, etc).

Possible scenarios shall be reviewed thoroughly before carrying out the assessment activities. Scenarios shall be continuously checked during the assessment to identify possible

- critical situations for the structure, related to structural safety and serviceability,
- amendments of the layout of the assessment.

4.5 Preliminary and detailed assessment

4.5.1 Levels of assessment

The purpose and scope of the assessment is decisive for the level of assessment and the content of each level. The assessment shall not be taken any further than what is necessary to reach a firm decision on intervention to be taken.

Normally, the assessment is classified into two levels as follows.

- a) Preliminary assessment (see [4.5.2](#)): the aim is to provide information of the condition of the structure, clarify causes for and seriousness of the deterioration, giving basis for indicating an overall condition level, and a consequence level of the structure, including future safety and serviceability of the structure. Possible immediate actions shall be decided. If necessary, a detailed assessment shall be proposed.
- b) Detailed assessment (see [4.5.3](#)): the aim is in principle the same as for preliminary assessment, but a more detailed study of previous documents, a more detailed inspection and material testing, as well as structural analysis and verification, shall be carried out in order to make the correct judgement and decisions.

NOTE 1 [Clause A.1](#) provides additional information regarding levels of assessment.

NOTE 2 [Clause A.2](#) provides details on condition registration, including current information from construction and operation, observation on site, possible tests on site and in laboratory as well as a listing of symptoms and possible causes for defects.

4.5.2 Preliminary assessment

4.5.2.1 Study of documents and other data

Design and inspection documents, such as original design, drawings, project specification, structural calculations, as built documentation, previous assessments, and intervention, etc. provide important information. For many existing structures, it can be difficult to find such information and to be sure that the information is correct. Both structural requirements (e.g. service load, dead load, overload, wind, snow, etc.), and environmental conditions (e.g. chlorides, gasses, temperature, etc.) shall be documented, and if any changes have occurred. The use and possible misuse of the structure, compared to the original design assumptions, shall be documented, if possible.

4.5.2.2 Preliminary inspection

The preliminary inspection is primarily a visual observation, in some cases supported with simple types of testing at the structure. This inspection shall give information on the structural system and if any surface characteristics are visible (e.g. reinforcement corrosion, cracks, spalling, deformation etc.).

4.5.2.3 Preliminary checks

Based on the study of documents and other evidence, and the results of the preliminary inspection, preliminary checks shall be performed. This is to identify the critical deficiencies related to the future safety and serviceability of the structure or structural members. Such checks can be based on general knowledge and experience, or by simple calculations.

The results of the preliminary inspection and checks shall be described by condition levels and consequence levels.

The choice of an appropriate condition level shall be based on judgement of the observed symptoms and the preliminary checks and related to a reference level for the structure or a structural member. Normally five condition levels are defined from “Good” to “Unsafe”.

NOTE 1 [Annex B](#) gives a more detailed description of the condition levels.

NOTE 2 Reference levels for different cause(s) for deterioration can be provided with a picture catalogue based on symptoms.

The consequences of the observed condition and the preliminary checks for a structure or a structural member, if nothing is done within a certain time, shall be described by consequence levels. The consequence levels refer to the consequence for the structure itself and are independent of the reliability class of the structure, which shall also be recorded. Normally, five consequence levels are defined from “No consequences” to “Potentially hazardous or (structurally) unsafe consequences”.

NOTE 3 [Annex B](#) gives more detailed description of consequence levels.

4.5.2.4 Decisions on immediate actions

When the results of the preliminary inspection and/or the checks shows that the structure is in a dangerous condition, it shall be reported to the client that immediate interventions shall be taken in order to reduce the dangerous situation with respect to safety of the general public, workers or occupants, and adjacent structures. If the safety of a structure or structural member is not clearly understood after the preliminary assessment, a detailed assessment shall be performed immediately to assess the critical deficiencies, and if necessary, recommendations made to the client for intervention.

4.5.2.5 Recommendation for detailed assessment

When the preliminary inspection and checks clearly show that the consequences of any deficiencies are very low and that the structure or structural members are reliable for its intended use over the remaining design service life, a detailed assessment is not required.

In the case where a structure or structural members are reliable for a defined period of time, a plan for future assessment shall be described.

When the preliminary inspection and checks are not able to give answer to the question of reliability and serviceability of a structure or a structural member, or the information is insufficient for planning necessary intervention, a detailed assessment shall be recommended.

4.5.3 Detailed assessment

4.5.3.1 Detailed documentary search and review

The detailed assessment shall be done based on values of basic variables corresponding to the actual situation. For that purpose, investigation shall be intended to update the knowledge about the present state of the structure.

This includes a more comprehensive search and review of documents than described in [4.5.2.1](#) and is based on the preliminary assessment. Especially documents covering the following, if available, shall be reviewed:

- a) drawings, specifications, structural calculations, construction records, inspection and maintenance records, details of modifications;
- b) regulations, by-laws, codes and standards which were originally used for design, calculations and execution of the structure;
- c) topography, subsoil and environmental conditions, groundwater level at the site.

4.5.3.2 Detailed inspection and material testing

The aim of the detailed inspection and material testing is to determine the cause(s) for the deterioration and the extent, as well as providing necessary information on dimensions of components and properties of materials assumed for structural analysis and necessary for planning possible interventions. Detailed inspection and material testing shall be carried out to collect more specific and useful data for evaluating the detailed information. Some necessary non-destructive and/or minor-destructive test methods shall be applied.

Detailed inspection and material testing shall result in supplementary information to the information found in the detailed documentary search and review.

4.5.3.3 Determination of actions

All kind of actions, both mechanical and environmental actions on the structure or structural members, shall be determined by analysis in accordance with ISO 2394, and evaluated on the basis of the current design codes, and taking into account provisions laid down in the safety and utilization plan. Changes of actions caused by the change in use or modification of the structure, shall be taken into consideration per [6.3.2](#).

4.5.3.4 Determination of properties of the structures

In some situations, the response of the structure or a structural member from action(s) shall be tested in order to predict the load-bearing capacity. This can be both static and dynamic testing. Load testing of a structure or structural member is very costly and time-consuming. However, this type of testing is normally not necessary, and used only when other approaches, such as detailed structural analysis or inspection alone do not provide clear indication or have failed to demonstrate adequate structural reliability. When this type of testing has to be performed, reference is made to ISO 13822:2010, Annex D.

4.5.3.5 Structural analysis

Based on detailed documentary review, inspection and material testing, a structural analysis shall be carried out to determine the effects of the actions on the structure or structural members. When deterioration of an existing structure is observed, which is the normal situation for existing structures, the reliability assessment of the structure becomes a time-dependent deterioration challenge and this time-dependent development shall be taken into account.

A structural analysis can be based on the principles given in ISO 2394. However, the limit state method developed in ISO 2394, has been adopted and used for preparing and harmonizing national and regional standards for structural design around the world, and in most situations, national codes and standards for safety philosophy and structural calculations, shall be employed.

When time-dependent structural analysis has to be performed, some examples of appropriate analysis methods are found in ISO 13822:2010, Annex E. However, in most situations, national codes, standards, and guidelines for safety philosophy and time-dependent models, can be employed.

NOTE 1 For time-dependent deterioration, it is often more practical to use limit states like time to initiation of corrosion for reinforcement corrosion, based on data from the structure.

NOTE 2 ISO 16204 gives methods for evaluating time-dependent deterioration.

4.5.3.6 Verification

Based on the results from the evaluation and from the detailed assessment, the structural performance shall be verified with reference to defined requirements, i.e. requirements from government (e.g. standards, codes), owner, designer, user, etc. If necessary, structural analysis can be carried out to investigate structural behaviours with the consideration of the investigated properties. The results from the assessment shall be documented to clearly indicate and explain the investigated results.

Current codes and standards shall be used in the verification. Former codes and standards that were valid at the time of construction of an existing structure shall be used as informative documents. Alternatively, verification can be based on satisfactory past performance, taking into account time-dependant development of deterioration processes. If this approach is to be employed, reference is made to ISO 13822:2010, Clause 8.

A more detailed presentation of evaluation and analysis of results of assessment for existing concrete structures are given in [Clause 6](#).

4.6 Reporting results of assessment

As the final step, all the investigated and assessed results shall be documented in a report as presented in [Clause 9](#).

4.7 Judgement and decision

Based on all information available from documentary review, inspection, and material testing, judgement and decisions shall be made.

The condition of a structure is classified in a condition level and a consequence level (see [Annex B](#)).

The probability that a given consequence can occur for a structure, or a structural member, at the present time or in the future, shall be evaluated. The conclusions drawn from this evaluation will provide an estimate of the risk represented by the defect.

The risk shall be evaluated and reported and be the basis for recommending whether any immediate action(s) are necessary or not. The consequence(s) leading to the risk shall be reported.

NOTE [Annex C](#) gives more detailed description of evaluation and verification.