
**Maintenance and repair of concrete
structures —**

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

iTeh STANDARD PREVIEW
Entretien et réparation des structures en béton —
(standards.iteh.ai) **Partie 2: Évaluation des structures en béton existantes**

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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 documents 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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 7, *Maintenance and repair of concrete structures*.

ISO 16311 consists of the following parts, under the general title *Maintenance and repair of concrete structures*:

- *Part 1: General Principles*
- *Part 2: Assessment of Existing Concrete Structures*
- *Part 3: Design of Repairs and Prevention*
- *Part 4: Execution of Repairs and Prevention*

Introduction

Assessment of a 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, 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 part of ISO 16311 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 part of ISO 16311 is operable with standards for test methods. Some standards for test methods are under preparation by ISO but they will not all be available as International Standards at the date of publication of this part of ISO 16311. Until and after such International Standards are available, a national annex may list standards that have established suitability in the place of use of the methods. These may be national standards or standards of other regions or nations.

This part of ISO 16311 is primarily based on the principles given in ISO 13822, *Basis of design of structures — Assessment of existing structures*. Annex B in ISO 13822 has a detailed flowchart, included as [Figure 1](#) in this part of ISO 16311.

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Maintenance and repair of concrete structures —

Part 2:

Assessment of existing concrete structures

1 Scope

This part of ISO 16311 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 part of ISO 16311 does not cover

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

2 Normative references

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

In the case of reference to International draft standards, provisions given in the National Annex or project specification should be applied until the International Standard is available.

ISO 2394, *General principles on reliability for structures*

ISO 13822:2001, *Bases for design of structures – Assessment of existing structures*

ISO 16204, *Durability — Service life design of concrete 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 and prevention*

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

ISO 19338, *Performance and assessment requirements for design standards on structural concrete*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 16311-1, ISO 2394, ISO 13822, and ISO 19338 and the following apply:

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.

[SOURCE: ISO 2394:1998]

3.2 action, direct
assembly of concentrated or distributed mechanical forces acting on a structure

3.3 assessment
set of activities performed in order to verify the reliability of an existing structure for future use

[SOURCE: ISO 13822:2010]

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

3.5 condition description
statement of the condition status and level based on condition registration of a structure or a structural member

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3.6 condition documentation
all information that explains the condition of a structure or a structural member

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

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

3.9 condition verification
comparison between condition and defined requirements

3.10 consequence level
expression of seriousness of consequences related to a defined reference level

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

[SOURCE: ISO 13822:2010]

3.12 defect

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

[SOURCE: ISO 15686-1:2000]

3.13 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

[SOURCE: ISO 13822:2010]

3.14 environmental action

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

[SOURCE: ISO 13822:2001]

3.15 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.

[SOURCE: ISO 9000:2005, 3.8.2]

3.16 risk

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

[SOURCE: ISO 13824:2009]

3.17 symptom

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

3.18 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 A National Annex can include requirements on qualification for personnel.

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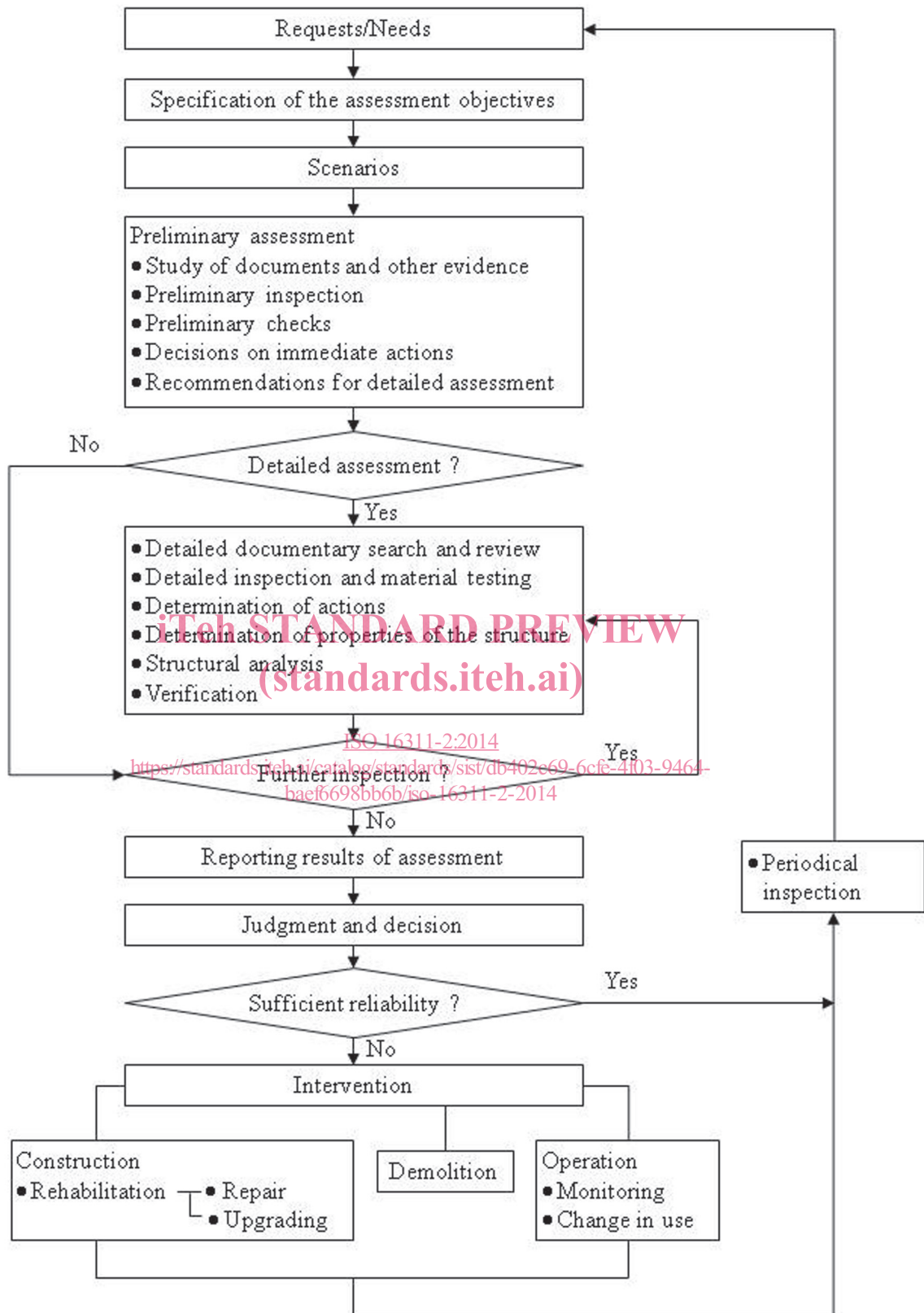


Figure 1 — General flowchart for assessment of existing structures (adapted from ISO 13822, Annex B)

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, 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 [A.1](#) gives more detailed description of 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 16311-3)

- chloride exposure, and damage related to chloride-induced corrosion,
- carbonation-induced corrosion damage,
- mechanical (impact, overload, settlement, vibration, seismic, abrasion, fatigue, explosion, etc),
- chemical (alkali-aggregate reactions, aggressive agents, biological actions, etc), and
- physical (fire, frost damage, 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, including structural safety and serviceability, and
- 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 have to 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, has to be carried out in order to make the correct judgement and decisions.

NOTE 1 A.1 provides additional information regarding levels of assessment.

NOTE 2 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 may 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.

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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 (e.g. carbonation measurements). 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 evidences, 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 in a National Annex 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 has to 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

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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) has to be tested in order to predict the load-bearing capacity. This could 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, 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 must 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, have to be employed.

When time-dependent structural analysis has to be performed, some examples of appropriate analysis methods are found in ISO 13822, [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, Clause 8.

A more detailed presentation of evaluation and analysis of results of assessment for existing concrete structures are given in [Clause 7](#).