INTERNATIONAL STANDARD

ISO 13822

First edition
2001-12-15

Corrected version
2003-02-15

Bases for design of structures — Assessment of existing structures

Bases du calcul des constructions — Évaluation des constructions existantes

Reference number
ISO 13822:2001(E)

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Published in Switzerland

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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13822 was prepared by Technical Committee ISO/TC 98, *Bases for design of structures*, Subcommittee SC 2, *Reliability of structures*.

Annexes A to H of this International Standard are for information only.

This corrected version of ISO 13822:2001 incorporates the following corrections. The flowchart in Annex B has been corrected and the year of publication of reference [8] in the Bibliography has been changed.

Introduction

The continued use of existing structures is of great importance because the built environment is a huge economic and political asset, growing larger every year. The assessment of existing structures is now a major engineering task. The structural engineer is increasingly called upon to devise ways for extending the life of structures whilst observing tight cost constraints. The establishment of principles for the assessment of existing structures is needed because it is based on an approach that is substantially different from the design of new structures, and requires knowledge beyond the scope of design codes. This document is intended not only as a standard of principles and procedures for the assessment of existing structures but also as a guide for use by structural engineers and clients. Engineers can apply specific methods for assessment in order to save structures and to reduce a client's expenditure. The ultimate goal is to limit construction intervention to a strict minimum, a goal that is clearly in agreement with the principles of sustainable development.

The basis for the reliability assessment is contained in the performance requirements for safety and serviceability of ISO 2394. Economic, social, and sustainability considerations, however, result in a greater differentiation in structural reliability for the assessment of existing structures than for the design of new structures

Bases for design of structures — Assessment of existing structures

1 Scope

1.1 This International Standard provides general requirements and procedures for the assessment of existing structures (buildings, bridges, industrial structures, etc.) based on the principles of structural reliability and consequences of failure. It is based on ISO 2394.

1.2 It is applicable to the assessment of any type of existing structure that was originally designed, analysed and specified based on accepted engineering principles and/or design rules, as well as structures constructed on the basis of good workmanship, historic experience and accepted professional practice. The assessment can be initiated under the following circumstances:

— an anticipated change in use or extension of design working life;

— a reliability check (e.g. for earthquakes, increased traffic actions) as required by authorities, insurance companies, owners, etc.;

— structural deterioration due to time-dependent actions (e.g. corrosion, fatigue);

— structural damage by accidental actions (see ISO 2394).

NOTE 1 This International Standard is applicable to historical structures, provided additional considerations are taken into account concerning the preservation of the historical appearance of the structure and the preservation of its historical materials.

1.3 This International Standard is applicable to existing structures of any material, although specific adaptation can be required depending on the type of material, such as concrete, steel, timber, masonry, etc.

1.4 This International Standard provides principles regarding actions and environmental influences. Further detailed consideration will be necessary for accidental actions such as fire and earthquake.

NOTE 2 Fire resistance requires properties different from those for structural safety and integrity. Also fire hazards can be created by change in use. Special requirements are necessary for seismic hazards, taking the dynamic action and structural response into account.

1.5 This International Standard is intended to serve as a basis for preparing national standards or codes of practice in accordance with current engineering practice and the economic conditions.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 2394:1998, *General principles on reliability for structures*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 2394 and the following apply. (See also annex A.)

3.1
assessment
set of activities performed in order to verify the reliability of an existing structure for future use

3.2
damage
unfavourable change in the condition of a structure that can affect structural performance

3.3
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

3.4
deterioration model
mathematical model that describes structural performance as a function of time, taking deterioration into account

3.5
inspection
on-site non-destructive examination to establish the present condition of the structure

3.6
investigation
collection and evaluation of information through inspection, document search, load testing and other testing

3.7
load testing
test of the structure or part thereof by loading to evaluate its behaviour or properties, or to predict its load-bearing capacity

3.8
maintenance
routine intervention to preserve appropriate structural performance

3.9
material properties
mechanical, physical or chemical properties of structural materials

3.10
monitoring
frequent or continuous, normally long-term, observation or measurement of structural conditions or actions

3.11
reference period
chosen period of time which is used as a basis for assessing values of variable actions, time-dependent material properties, etc.

NOTE The remaining working life or the minimum standard period for safety of an existing structure can be taken as reference period (see annex F).

3.12
rehabilitation
work required to repair, and possibly upgrade, an existing structure

3.13
remaining working life
period for which an existing structure is intended/expected to operate with planned maintenance

3.14
repair, verb
⟨of a structure⟩ improve the condition of a structure by restoring or replacing existing components that have been damaged

3.15
safety plan
plan specifying the performance objectives, the scenarios to be considered for the structure, and all present and future measures (design, construction, or operation, such as monitoring) to ensure the safety of the structure

3.16
structural performance
qualitative or quantitative representation of the behaviour of a structure (e.g. load-bearing capacity, stiffness) in terms of its safety and serviceability

3.17
target reliability level
level of reliability required to ensure acceptable safety and serviceability

3.18
upgrading
modifications to an existing structure to improve its structural performance

3.19
utilization plan
plan containing the intended use (or uses) of the structure, and listing the operational conditions of the structure including maintenance requirements, and the corresponding performance requirements

4 General framework of assessment

4.1 Objectives

The objective of the assessment of an existing structure in terms of its required 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, which provides appropriate safety for the users of the structure.

b) Continued function performance level, which provides continued function for special structures such as hospitals, communication buildings or key bridges, in the event of an earthquake, impact, or other foreseen hazard.

c) Special performance requirements of the client related to property protection (economic loss) or serviceability. The level of this performance is generally based on life cycle cost and special functional requirements.

4.2 Procedure

The assessment procedure is composed in general of the following steps so that the assessment is carried out taking into account the actual conditions of the structures (see the flowchart in annex B). The procedure depends on the assessment objectives (see 4.1), and on specific circumstances (e.g. the availability of the design documents, the observation of damage, the use of the structure). A site visit is recommended prior to initiating the procedure.

a) Specification of the assessment objectives.

b) Scenarios.

c) Preliminary assessment:

1) study of documents and other evidence;

2) preliminary inspection;

3) preliminary checks;

4) decisions on immediate actions;

5) recommendation for detailed assessment.

d) Detailed assessment:

1) detailed documentary search and review;

2) detailed inspection and material testing;

3) determination of actions;

4) determination of properties of the structure;

5) structural analysis;

6) verification.

e) Results of assessment:

1) report;

2) conceptual design of construction interventions;

3) control of risk.

f) Repeat the sequence if necessary.

The procedure outlined above may be applied to both the assessment of one specific structure and the assessment of a group of structures.

4.3 Specification of the assessment objectives

At the outset, the objective of the assessment of the structure shall be clearly specified in terms of its future performance in an agreement between the client, the authorities when relevant and the assessing engineer (see 4.1). The required future performance shall be specified in the utilization plan and safety plan.

4.4 Scenario

Scenarios related to a change in structural conditions or actions should be specified in the safety plan in order to identify possible critical situations for the structure. Each scenario is characterized by a predominant process or action and, where appropriate, by one or more accompanying processes or actions. The identification of scenarios represents the basis for the assessment and design of interventions to be taken to ensure structural safety and serviceability.

4.5 Preliminary assessment

4.5.1 Study of documents and other evidence

Design and inspection documents contain important information that is necessary for a thorough assessment of an existing structure. It shall be verified that the documents are correct, and that they are updated to include information of any previous intervention to the structure. Other evidence, such as the occurrence of significant environmental or seismic actions, large actions, changes in soil conditions, corrosion, and misuse of the structure, shall be recorded and documented.

4.5.2 Preliminary inspection

The aim of a preliminary inspection is to identify the structural system and possible damage to the structure by visual observation with simple tools. The information collected is related to aspects such as surface characteristics, visible deformations, cracks, spalling, corrosion. The results of the preliminary inspection are expressed in terms of a qualitative grading of structural conditions (e.g. none, minor, moderate, severe, destructive, unknown) for possible damage.

4.5.3 Preliminary checks

The purpose of the preliminary checks is to identify the critical deficiencies related to the future safety and serviceability of the structure with a view to focussing resources on these aspects in subsequent assessment. Based on these results, it is then judged whether a further investigation is necessary or not.

4.5.4 Decisions on immediate actions

When the preliminary inspections and/or checks clearly indicate that the structure is in a dangerous condition, it is necessary to report to the client that interventions should be taken immediately to reduce the danger with respect to public safety. If there is uncertainty, the critical deficiencies should be assessed immediately and actions taken, if necessary.

4.5.5 Recommendations for detailed assessment

The preliminary checks may clearly show the specific deficiencies of the structure, or that the structure is reliable for its intended use over the remaining working life, in which case a detailed assessment is not required. Where there is uncertainty in the actions, action effects or properties of the structure, a detailed assessment should be recommended in accordance with 4.6.

4.6 Detailed assessment

4.6.1 Detailed documentary search and review

The following documents, if available, should be reviewed:

— drawings, specifications, structural calculations, construction records, inspection and maintenance records, details of modifications;

— regulations and by-laws, codes of practice which were used for constructing the structure;

— topography, subsoil conditions, groundwater level at the site.

4.6.2 Detailed inspection and material testing

The details and dimensions of the structure as well as characteristic values of material properties can be obtained from design documents, provided that the documents exist and that there is no reason for doubt. In case of any doubts, the details and dimensions of components and properties of materials assumed for the analysis shall be determined from a detailed inspection and material testing. The planning of such an inspection is based on information that is already available. The detailed quantitative inspection will result in a set of updated values or distributions for certain relevant parameters that affect the properties of the structure (see annex C).

4.6.3 Determination of actions

Actions and, in particular, environmental actions on structures shall be determined by analysis in accordance with ISO 2394, taking into account provisions laid down in the safety and utilization plan.

4.6.4 Determination of properties of the structures

Testing of the structure is used to measure its properties and/or to predict the load-bearing capacity when other approaches such as detailed structural analysis or inspection alone do not provide clear indication or have failed to demonstrate adequate structural reliability (see annex D).

4.6.5 Structural analysis

Structural analysis in accordance with ISO 2394 shall be carried out to determine the effects of the actions on the structure. The capacity of structural components to resist action effects shall also be determined. The deterioration of an existing structure shall be taken into consideration. When deterioration of an existing structure is observed, the reliability assessment of the structure becomes a time-dependent deterioration problem as described in ISO 2394, and an appropriate analysis method shall be used. In the case of deteriorated structures, it is essential to understand the causes for the observed damage or misbehaviour.

Some examples of appropriate analysis methods to assess time-dependent reliability can be found in annex E.

NOTE For deterioration, it is often more practical to use service-life predictors (such as S-N curves for fatigue or time-to spalling models for corrosion of reinforcement) based on test data.

4.6.6 Verification

The verification of an existing structure should normally be carried out to ensure a target reliability level that represents the required level of structural performance (see 4.1 and annex F). Current codes or codes equivalent to ISO 2394 which have produced sufficient reliability over a long period of application may be used. Former codes that were valid at the time of construction of an existing structure should be used as informative documents. Alternatively, verification may be based on satisfactory past performance (see clause 8).

4.7 Results of assessment

4.7.1 Report

The results of assessment shall be documented in a report (see annex G for an example).

4.7.2 Conceptual design of construction interventions

If the structural safety or serviceability is shown to be inadequate, the results of the assessment should be used to recommend construction interventions for repair, rehabilitation, or upgrading of the structure to perform in accordance with the objective of the assessment for its remaining working life (see annex H).

4.7.3 Control of risk

An alternative approach to construction interventions, which may be appropriate in some circumstances, is to control or modify the risk. Various measures to control the risk environment include imposing load restrictions, altering aspects of the use of the structure, and implementing some form of in-service monitoring and control regime.

5 Data for assessment

5.1 General

Data for assessment should be related to the material properties, structural properties, dimensions, and other conditions as actually established for the existing structure and for previous and/or future actions on the structure.

NOTE Current codes are normally design codes and therefore cannot be used directly for assessment. First, the actual condition is considered, which is not normally foreseen in a design code. Secondly, if current codes have more severe requirements than the codes that were applied at the time of design, the existing structure may be judged to be unsafe. However, as discussed in clause 7 and annex F, reduced service life and target reliability level may be considered for an existing structure. Furthermore, refined analyses, testing and a consideration of the actual behaviour of a structure can help in this respect.

5.2 Actions and environmental influences

5.2.1 Actions

Actions shall be determined in accordance with current codes. Changes of actions caused by the change in use or modification of an existing structure shall be taken into consideration.

5.2.2 Environmental infuences

Environmental influences of a physical, chemical or biological nature that can have an effect on the material properties of an existing structure shall be taken into account. Changes in environmental influences as a result of change in use or modification of an existing structure shall be taken into consideration.

5.2.3 Original drawings and design specifications

The actions and environmental influences for which the structure was originally designed, may be determined from drawings and design specifications when there is no uncertainty about their validity.

5.2.4 Inspection

Environmental influences should be determined by inspection in cases of uncertainty. In such cases, some types of actions may also be determined by inspection, for example by measurement of dimensions of components.