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Eurocode — Basis of structural and geotechnical design — Part 2: Assessment of existing structures

*Eurocode — Grundlagen der Planung von Tragwerken und geotechnischen Bauwerken — Teil 2: Bewertung von bestehenden Tragwerken*

*Eurocodes — Bases de calcul des structures et géotechniques —Partie 2: Évaluation des structures existantes*

ICS:

CCMC will prepare and attach the official title page.

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European foreword

This document (prEN 1990-2:2024) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This document is currently submitted to the Enquiry.

This document will supersede CEN/TS 17440:2020.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognize the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

0 Introduction

**0.1 Introduction to the Eurocodes**

The Structural Eurocodes comprise the following standards generally consisting of a number of Parts:

— EN 1990, Eurocode — Basis of structural and geotechnical design

— EN 1991, Eurocode 1 — Actions on structures

— EN 1992, Eurocode 2 — Design of concrete structures

— EN 1993, Eurocode 3 — Design of steel structures

— EN 1994, Eurocode 4 — Design of composite steel and concrete structures

— EN 1995, Eurocode 5 — Design of timber structures

— EN 1996, Eurocode 6 — Design of masonry structures

— EN 1997, Eurocode 7 — Geotechnical design

— EN 1998, Eurocode 8 — Design of structures for earthquake resistance

— EN 1999, Eurocode 9 — Design of aluminium structures

— New parts are under development, e.g. Eurocode for design of structural glass

The Eurocodes are intended for use by designers, clients, manufacturers, constructors, relevant authorities (in exercising their duties in accordance with national or international regulations), educators, software developers, and committees drafting standards for related product, testing and execution standards.

NOTE Some aspects of design are most appropriately specified by relevant authorities or, where not specified, can be agreed on a project-specific basis between relevant parties such as designers and clients. The Eurocodes identify such aspects making explicit reference to relevant authorities and relevant parties.

**0.2 Introduction to** **EN** **1990** **(all parts)**

EN 1990 (all parts) gives the principles and requirements for safety, serviceability, robustness, and durability of new structures and existing structures that are common to all Eurocodes parts and are to be applied when using them.

EN 1990 is subdivided in various parts:

EN 1990‑1 *Eurocode — Basis of structural and geotechnical design — Part 1: New structures*

EN 1990‑2 *Eurocode — Basis of structural and geotechnical design — Part 2: Assessment of existing structures*

**0.3 Introduction to** **EN** **1990‑2**

The Eurocodes comprise rules that are primarily intended for the design of new structures, although the principles of EN 1990‑1 can also be applied for existing structures, with additional provisions. EN 1990‑2 supplies those additional provisions that enable the structural assessment of existing structures.

EN 1990‑2 includes provisions related to using updated data for basic variables and updated structural models.

EN 1990‑2 includes rules for the assessment of structures in case of interventions, as well as provisions for the assessment of retained parts from the existing structure.

**0.4 Verbal forms used in the Eurocodes**

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

**0.5 National Annex for** **EN** **1990‑2**

National choice is allowed in this document where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing EN 1990-2 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this document is to be used.

When no national choice is made and no default is given in this document, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

National choice is allowed in EN 1990-2 through notes to the following clauses:

|  |  |  |  |
| --- | --- | --- | --- |
| 4(1) | 4(2) | 5(1) | 5(4) |
| 6(1) | 10.1(2) | 10.2(1) | 11(2) |
| 11(3) |  |  |  |

National choice is allowed in EN 1990-2 on the application of the following informative annex:

|  |  |  |  |
| --- | --- | --- | --- |
| Annex A |  |  |  |

The National Annex can contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

# Scope

**1.1** **Scope of** **EN** **1990-2**

(1) This document provides additional provisions to EN 1990‑1 to cover the assessment of existing structures, including geotechnical structures, and the general principles for interventions.

NOTE This document is based on the general requirements and principles of structural reliability provided in EN 1990‑1.

(2) Unless otherwise specified, EN 1990‑1 applies.

(3) This document covers general principles regarding actions for assessment, complementing EN 1991 (all parts).

NOTE Provisions for seismic actions due to earthquake are provided in EN 1998‑3.

(4) This document does not cover the design of new structural parts that will be integrated into an existing structure.

NOTE For the design of new structural parts, see EN 1990‑1.

(5) This document does not provide:

— specific rules for initiation of assessment;

— specific rules on how to undertake interventions that may be carried out as a result of an assessment;

— material-specific technical provisions for existing structures;

— provisions for seismic assessment and retrofitting of existing structures.

NOTE For provisions for seismic assessment and retrofitting of existing structures, see EN 1998‑3.

**1.2** **Assumptions**

(1) The assumptions given in prEN 1990‑1:2024, 1.2 apply.

# 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.

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. in ‘should’ clauses), permissions (‘may’ clauses), possibilities ('can' clauses), and in notes.

prEN 1990‑1:2024, Eurocode — Basis of structural and geotechnical design — Part 1: New structures

# Terms, definitions and symbols

## Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1990‑1 and the following apply.

3.1.1

existing structure

any structure that physically (materially) exists

3.1.2

heritage structure

existing structure that has been recognized by the relevant authorities for its historical, cultural or societal value

3.1.3

assessment of an existing structure

verification of the reliability of an existing structure

3.1.4

condition survey

acquiring and verifying information on the current state of an existing structure and its boundary conditions

Note 1 to entry: A condition survey can include geometrical properties and material testing.

3.1.5

inspection

on-site non-destructive examination of an existing structure with the objective of establishing its present condition and updating information

3.1.6

investigation

collection and evaluation of information through inspection, document search, measurement, material testing, load testing or other testing

Note 1 to entry: For definition of ground investigation, see EN 1997‑2.

3.1.7

monitoring

frequent or continuous observation of the structural condition, structural performance or actions

3.1.8

load testing

test of a structure or part thereof by loading to evaluate its structural performance or properties

3.1.9

damage

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

3.1.10

defect

deficiency of a structure resulting from errors during design, construction, prior intervention or lack of maintenance that adversely affects the structural performance

3.1.11

deterioration

process that adversely affects the structural performance over time

EXAMPLE For example due to:

* chemical, physical or biological actions;
* repeated actions such as those causing fatigue;
* wear due to use;

— settlements of the ground.

3.1.12

remaining service life

period for which an existing structure is intended/expected to operate with planned maintenance

3.1.13

rehabilitation

structural intervention (i.e. repair, upgrade) to reach compliance with required structural performance

3.1.14

updating

process of supplementing available information with new information for assessment

3.1.15

upgrading

modifications to an existing structure to improve its structural performance

## Symbols and abbreviations

For the purposes of this document, the symbols and abbreviations given in EN 1990‑1 and the following apply.

### Latin upper-case letters

|  |  |
| --- | --- |
| *E*(.) | expectation |
| *F* | local or global structural failure represented by a limit state |
| *I* | inspection information, formulated as a notional limit state function |
| *P*(.) | probability of (.) |
| *P*ft | target probability of failure for a given reference period |
| *S* | non-failure or survival event |
| *V*(*μ*) | coefficient of variation $V$ of the mean value *μ* |
| V(*σ*) | coefficient of variation $V$ of the standard deviation *σ* |

### Latin lower-case letters

|  |  |
| --- | --- |
| g(*X*) | limit state function depending on *X* |
| *m* | sample mean value |
| *m*' | prior mean value |
| *m*" | posterior mean value |
| *n* | number of observations |
| *n*' | prior number of observations |
| *n*" | posterior number of observations |
| *s* | sample standard deviation |
| *s*' | prior standard deviation |
| *s*" | posterior standard deviation |

### Greek lower-case letters

|  |  |
| --- | --- |
| *β*t | target reliability index |
| *δ*(*n*’) | operator used in Formula (A.6) |
| *μ* | mean value |
| *ν* | number of degrees of freedom for$ s$ |
| *ν*' | prior number of degrees of freedom for *s*' |
| *ν*" | posterior number of degrees of freedom for *s*" |

# Basic requirements

(1) The assessment of an existing structure shall verify that the structure fulfils the specified requirements in the remaining service life.

NOTE 1 The basic requirements for an existing structure can be different from the basic requirements applicable for a new structure.

NOTE 2 Minimum requirements for the verification where the structure includes new and existing parts can be given in the National Annex.

(2) The reliability required for existing structures within the scope of this document shall be verified by assessment in accordance with the Eurocodes.

NOTE Reliability levels for the assessment of existing structures can be set by the National Annex. Further guidance is given in prEN 1990‑1:2024, Annex C.

# General rules

(1) Clause 4 to Clause 12 shall apply only to existing structures.

NOTE Additional conditions for existing structures to which Clause 4 to Clause 12 apply can be given in the National Annex.

(2) This document does not provide specific provisions for seismic assessment and retrofitting of existing structures.

NOTE For specific provisions for seismic assessment and retrofitting of existing structures, see EN 1998‑3.

(3) The assessment of an existing structure should be carried out using quantitative assessment methods, as specified in this document and in the other Eurocodes, where relevant.

(4) Qualitative assessment methods may be used for assessment for an existing structure together with or in place of quantitative assessment methods where conditions of use are met.

NOTE 1 Minimum conditions for or restrictions on the use of qualitative assessment methods can be given in the National Annex.

NOTE 2 Qualitative assessment methods can be used to assist the definition of the assessment scope and objectives.

(5) Additional criteria for the use of qualitative assessment methods should be as specified by the relevant authority or, where not specified, as agreed for a specific project by the relevant parties.

(6) The situations to be considered in an assessment of an existing structure shall be in accordance with prEN 1990‑1:2024, 5.2.

(7) Available information ahead of the assessment of an existing structure should be checked and taken into consideration where relevant, including from:

* the original design and construction record;
* previous condition surveys;
* inspections carried out during the past service life, monitoring;
* previous assessment reports;
* previous rehabilitation;
* information about significant environmental, seismic or other extreme events occurred after construction;
* information about changes in ground conditions occurred after construction.

NOTE For some projects no information is available ahead of the assessment.

(8) When assessing heritage structures, the historical, cultural and societal value should be taken into account in the assessment and decisions involving possible structural interventions.

NOTE Guidance on the assessment of heritage structures is provided in A.6.

(9) The assessment of a structure should be carried out following a stepwise process with increasing levels of detail and accuracy.

NOTE 1 A stepwise process can include preliminary and detailed stages in order to optimize the overall level of effort required for the assessment.

NOTE 2 Guidance on the assessment process is provided in A.3.

(10) If, during the assessment process, the structure appears to be in a situation where the level of risk requires immediate intervention, measures to mitigate the risk should be identified, agreed with the relevant parties and implemented without undue delay.

NOTE 1 In assessing risks requiring immediate interventions the following relevant factors can be taken into account:

* consequence of failure;
* nature of the hazard;
* any signs of damages or defects and the rate of deterioration or change occurring;
* possibility of hidden damages or defects;
* condition data;
* sensitivity of the structure to the applied loading;
* recent load history of the structure;
* level of assessment completed.

NOTE 2 For immediate interventions, see 12.2.

# Assessment scope and objectives

(1) The assessment scope and objectives should be defined and documented based on conditions and requirements for the existing structure including:

* intended use;
* remaining service life;
* structural performance;
* operational conditions;
* inspection and maintenance procedures.

NOTE 1 Different assessment scope and objectives can be defined at different stages of the assessment process.

NOTE 2 Minimum requirements for the assessment scope and objectives can be given in the National Annex.

(2) Additional requirements relating to the assessment scope and objectives should comply with any relevant provisions as specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

(3) The assessment scope and objectives should include the following:

— the actions to be considered in the assessment;

* the assessment situations to be considered for the structure, including those related to possible changes in structural conditions or actions;
* the limit states to be assessed and the methods of assessment for the relevant limit states (see (4));
* the format for describing the outcome of the assessment, for example in terms of a calculated operational restriction for a particular action;

— the extent of the structure to be assessed.

(4) Verification of the serviceability limit state may be omitted where appropriate.

NOTE Verification of the serviceability limit state can be relevant for example when:

* assessing for a change in use;
* investigating existing problems related to serviceability performance;
* the assessment of structural safety relies on particular serviceability criteria being satisfied.

# Assessment approach

## General

(1) The assessment approach and the assumptions for the assessment shall be defined and documented, including:

a) the method of assessment;

b) the approach for assessing the effects of structural condition, deterioration, construction process and subsequent changes to the structure, if relevant;

c) the data for the basic variables used in the assessment;

d) the structural analysis methodology;

e) the verification methods.

## Condition survey

(1) The current structural condition of the existing structure, including defects, damage and ongoing deterioration mechanisms, shall be established by condition survey and its results shall be evaluated.

NOTE 1 Prior experience from comparable structures can inform the identification and characterization of deterioration mechanisms.

NOTE 2 The deterioration mechanisms result from the combined effects of aspects related to the environment (e.g. temperature, humidity, chemical and physical actions) to which the structure is/was exposed and aspects related to the structure itself such as material characteristics, geometry, structural detailing and execution quality.

NOTE 3 The results of condition surveys can be evaluated on the basis of statistical methods, if relevant. See the relevant Eurocode.

NOTE 4 Guidance on the condition survey is provided in A.3.2.

NOTE 5 For updating procedures for basic variables, see Clause 8 and A.4.4.

(2) The results from a condition survey should be used subsequently for:

* updating information on actions and environmental influences;
* updating the information for structural modelling and analysis;
* checking the assessment situations established for the assessment;
* recommending interventions considered necessary without performing further steps in the assessment.

## Assessment of resistance

(1) The structural resistance shall be assessed using a basis that is consistent with:

* the approach taken for the corresponding assessment of action effects (see Clause 10);
* the target reliability level (see 4(2), Note).

(2) The assessment values of resistance shall be determined from resistance models that are consistent with the material properties, structural detailing, geometry, and structural conditions for the existing structure.

NOTE 1 Structures that were designed and constructed to withdrawn standards can have material properties, detailing arrangements and execution tolerances that do not comply with or are not covered by current standards. Particular attention is needed in the implementation of resistance models from current standards valid for new structures, which implicitly or explicitly rely on design requirements for material properties, detailing arrangements and execution tolerances being satisfied. Further guidance can be found in the relevant Eurocodes.

NOTE 2 Structures that do not comply with current design standards are not necessarily unsafe. The use of updated values for basic variables and refined resistance models for the assessment that explicitly account for deficiencies can be particularly beneficial in accurately assessing the resistance of existing structures.

NOTE 3 For the resistance updating based on action effect history, see also A.4.4.6.3.

NOTE 4 For assessment of resistance for geotechnical structures, see also EN 1997 (all parts).

NOTE 5 Using the Observational Method in EN 1997‑1, a prediction can be made of the performance of a geotechnical structure. Based on a comparison of the predicted ground response and ground-structure interaction with the allowable ground and ground-structure interaction response, it can be assessed, whether the structure meets the target reliability level.

(3) In absence of specific assessment resistance models in the relevant Eurocodes, resistance models in the Eurocodes, valid for design, should be used to assess structural resistance. This applies for structures in good condition that have material properties, detailing provisions and execution tolerances that satisfy the requirements of the relevant Eurocodes, the related product standards and execution standards.

(4) For deteriorated structures, the deterioration mechanism(s), the deterioration rate and the impact on structural performance should be determined using appropriate models, based on the available information.

## Assessment findings

(1) The assessment findings should be documented and reported, clearly identifying whether there is a need for interventions, for example if the assessment has not demonstrated an adequate level of reliability or performance in accordance with 12.1.

NOTE Depending on the assessment findings, the structure can, within the scope of the assessment:

* achieve the reliability required, assuming adequate inspection and maintenance during the remaining service life; or
* achieve the reliability required at the time of the assessment, but not for the complete period of time during which the existing structure is intended to remain operational, taking into account the anticipated development of its condition and the planned level of maintenance; or
* fail to achieve the reliability required; or
* fail to achieve the reliability required and require immediate correction of the existing condition by means of immediate interventions (see 12.2).

# Basic variables and updating

(1) The basic variables needed for an assessment should include:

* actions and environmental influences;
* material and product properties including ground properties;
* geometrical properties (including structural detailing).

(2) Prior information for the values for basic variables related to geometrical, material and product properties may be based on:

* original design documents, construction records, documentation on previous assessments and interventions, if applicable;
* the codes and standards and/or related background information from the time of design and construction, including those from the time of previous interventions, if applicable;
* the manufacturers’ data and product literature.

(3) If new information becomes available, relevant data should be re-evaluated and, if needed, updated, taking into account the uncertain prior information.

NOTE An updating procedure is provided in A.4.4.

(4) The values for basic variables should take account of the actual conditions of:

* the structure (including aging, damage, deterioration and defect where relevant),
* the ground and groundwater in the zone of influence of the structure,

and of other information obtained in the condition survey.

NOTE 1 The actual conditions of the structure can be taken into account in the values of basic variables such as the thickness of structural members or the material properties, in the modelling for structural analysis (see Clause 9), in the modelling of actions (see for example A.4.1.10), and in structural resistance models (see 7.3).

NOTE 2 Changes related to the ground and groundwater conditions occurred in the past service life and predictable changes during the remaining service life can be taken into account, if relevant.

NOTE 3 For the zone of influence, see EN 1997‑1.

(5) The probability distribution functions of basic variables and the values of their parameters may be updated based on case-specific data, prior and other relevant information.

NOTE An updating procedure is provided in A.4.4.

(6) Characteristic values for basic variables for resistance may be based on:

* sample data from the existing structure; or
* sample data from the existing structure combined with statistical parameters describing the uncertainties associated with basic variables derived from a representative sample of comparable structures.

NOTE prEN 1990‑1:2024, Annex D contains methods for the derivation of characteristic values for resistance parameters from test data.

(7) If data are obtained from the existing structure by sampling, the methodology of the data acquisition should be developed considering the following aspects:

* sampling from locations that are representative for the structural parts being assessed;
* a sample size that provides a statistically significant and representative basis for updating parameters;
* sampling methods that can be carried out safely;
* repair of the structure following any removal of materials for sampling;
* testing arrangements that provide representative data for the assessment.

(8) The reference period used for the establishment of the parameters describing the time-variant basic variables should be consistent with the reference period chosen for the assessment.

# Structural modelling, updating and analysis

(1) Structural models should be based on the actual conditions of the existing structure.

(2) Prior information related to the structural system may be based on, if applicable:

* original design documents;
* construction records;
* documentation on previous assessments and interventions.

(3) Information on the structural system should be updated if prior information is:

* not sufficient for the assessment; or
* not considered to be sufficiently reliable.

EXAMPLE Information on static and kinematic boundary conditions of the structural system can include: support conditions, fixed connections, freedom of movement within joints, load transfer mechanisms, including interaction between the structure and the ground.

(4) Testing and monitoring of existing structures may be used to verify and improve assumptions for structural analysis and to calibrate structural models.

(5) Testing should have clear objectives and requires careful planning taking account of the following, if relevant:

* the structural behaviour and the boundary conditions can be different at the level of the test load and the ultimate limit state;
* permanent deformations (e.g. induced by overloads, accidental actions, settlements or changes in geotechnical conditions, occurred during the past service life);
* load duration and load history;
* amplitude of dynamic response;
* environmental or other non-structural effects;
* load sharing.

NOTE Adjacent structural and non-structural parts can be involved in resistance mechanisms if one single structural part is loaded or can influence the dynamic properties of the structure.

(6) Testing should not result in damage to the structure, if its future use is envisaged.

(7) When testing or monitoring an existing structure, the results of measurements should be compared with the response predicted by structural models.

(8) If a large deviation from the prediction is observed when testing or monitoring an existing structure, the reasons should be investigated and explained, involving additional tests if necessary.

# Verification using quantitative assessment methods

## General

(1) The verification of existing structures should be carried out using the partial factor method.

(2) The following verification methods may be used in addition to the partial factor method:

* reliability-based method;
* risk-informed method.

NOTE 1 Restrictions on the use of the reliability-based method and the risk-informed method for the assessment of an existing structure can be given in the National Annex.

NOTE 2 See C.3.1 for guidance on the applicability and criteria for use of the reliability-based method and the risk-informed method.

NOTE 3 Further guidance is given in prEN 1990‑1:2024, Annex C.

NOTE 4 For geotechnical structures, verification by testing or using the observational method can be relevant. See EN 1997 (all parts).

## Partial factor method

(1) When checking ultimate limit states prEN 1990‑1:2024, 8.3 applies, substituting where appropriate the values of design parameters with the corresponding values for assessment.

NOTE 1 Partial factors can be (i) fixed (standardized for use in a country), valid for a range of cases, or (ii) adjusted for a specific case.

NOTE 2 Fixed partial factors for actions are used, unless conditions for the use of adjusted partial factors for actions are given in the National Annex.

NOTE 3 For fixed partial factors for actions and combination factors *ψ*, see prEN 1990‑1:2024, Annex A.

NOTE 4 For partial factors for resistance and material properties, see the other Eurocodes.

NOTE 5 Conditions for the use of adjusted partial factors for resistance can be given in the other Eurocodes.

NOTE 6 For guidance on adjustment of partial factors, see prEN 1990‑1:2024, Annex C.

## Reliability-based method

(1) When using the reliability-based method, the reliability of a structure shall be verified in terms of either the failure probability *P*f or the reliability index *β* according to the condition in Formulae (10).1) or Formula (10).2).

 (10.1)

 (10.2)

where

|  |  |
| --- | --- |
| *P*ft | is the target probability of failure for a given reference period; |
| g(*X*) | is the limit state function depending on the basic variables *X*; |
| Φ() | is the cumulative distribution function of the standard normal distribution; |
| *β*t | is the target reliability index for a given reference period. |

NOTE 1 The target reliability level (see 4(2)) is defined by the target probability of failure *P*ft or the corresponding target reliability index *β*t.

NOTE 2 The reliability-based method can be applied in accordance with the principles and recommendations provided in prEN 1990‑1:2024, Annex C.

## Risk-informed method

(1) The risk should be evaluated using acceptance criteria as specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

NOTE No further guidance on the risk-informed method is given in this Clause. Relevant guidance can be found in prEN 1990:2024, Annex C and ISO 2394.

# Verification using qualitative assessment methods

(1) An investigation needed to perform the checks in (2) and (3) shall be undertaken with regard to the limit states being considered.

(2) When verifying the ultimate limit states, the following should all be satisfied:

* careful inspection does not reveal any evidence of significant damage, distress, defect, displacement, deterioration or excessive deformation;
* the structural system is understood, including the possible failure modes and the most critical parts of the structure;
* the structure has demonstrated satisfactory performance for a sufficiently long period of time during which extreme actions and unfavourable environmental conditions corresponding to the assessment situations have most likely occurred;
* any predicted deterioration (taking into account the present conditions and planned maintenance) would not be expected to affect the safety;
* there have been no changes for a period of time long enough to significantly increase the actions on the structure or affect its durability, and no such changes are anticipated;
* the risk associated with local failures is considered as acceptable;
* the risk associated with brittle failure modes is considered as acceptable.

NOTE Additional checks can be given in the National Annex.

(3) When verifying the serviceability limit states, the following should all be satisfied:

* careful inspection does not reveal any evidence of significant damage, distress, deterioration, displacement, deformation or other serviceability concerns;
* the structure has demonstrated satisfactory performance for a sufficiently long period of time for damage, distress, deterioration, displacement or vibration to occur;
* there will be no changes to the structure or its use that would significantly affect the serviceability (for example, a significant increase in the actions, including environmental influences);
* any predicted deterioration (taking into account the present conditions and planned maintenance) would not be expected to significantly affect the durability or serviceability performance.

NOTE Additional checks can be given in the National Annex.

# Interventions

## General

(1) Proposals for intervention should be developed if the degree of reliability or performance required for an existing structure or a part of an existing structure is not achieved.

NOTE For assessment findings, see 7.4(1), Note.

(2) Interventions to achieve an adequate level of reliability during the remaining service life, may be categorized as shown in Figure 12.1.

Figure 12.1 — Intervention types

(3) The documents relating to the intervention should include the justification of the type of intervention selected and the description of its expected effect on the structural response.

## Immediate interventions

(1) Where immediate interventions are needed the following measures may be considered:

* alarm activation and evacuation of endangered areas, giving preference to people over material goods;
* decommissioning and cordoning-off of the structure;
* urgent structural safety measures (e.g. shoring and underpinning of the structure);
* restrictions of use and access.

(2) If immediate interventions are carried out, these should not rule out further interventions if needed.

## Maintenance

(1) The maintenance activities should be recommended on the basis of the conditions and requirements for the use of an existing structure and its expected behaviour during the remaining service life.

## Rehabilitation

(1) Repair can be realized either by restoring or replacing existing structural parts that have been damaged, or by adding new structural parts in order to restore its function.

(2) Interventions for upgrading may be implemented on the basis of one or a combination of the following approaches:

* modification of the structural resistance or some other performance parameter of a structure or a structural part;
* introduction of additional structural parts;
* modification of boundary conditions or methods of support.

(3) When using different types of rehabilitation on the same structure or structural part, mutual compatibility should be verified.

(4) A rehabilitated structure shall, as a minimum, meet the specified requirements for an existing structure.

(5) Replaced, new or additional structural members should be designed to meet the specified requirements for a new structural member, unless otherwise specified by the relevant authority or, where not specified, agreed by the relevant parties.

## Monitoring after the assessment

(1) Structural monitoring after the assessment can be used to derive information about the following aspects including their variations with time, in order to assist interventions:

* structural performance;
* deterioration processes;
* actions;
* environmental influences on the structure;

(2) The measured (monitored) values should be compared to threshold values.

(3) Threshold values should be established taking into account all relevant uncertainties, including those associated with the measured values.

(4) If threshold values are exceeded, the interventions to be taken should be agreed for a specific project by the relevant parties.

NOTE The utilization plan can be used to record actions to be taken if thresholds are exceeded.

1. (informative)

Additional guidance on assessment of existing structures
	1. Use of this annex

(1) This informative annex provides supplementary guidance for assessment of existing structures.

NOTE National choice on the application of this informative annex is given in the National Annex. If the National Annex contains no information on the application of this informative annex, it can be used.

* 1. Scope and field of application

(1) This informative annex covers guidance on:

* assessment approach including condition survey, preliminary stage of assessment, detailed stage of assessment, plausibility check and assessment findings (see A.3):
* basic variables and updating (see A.4);
* interventions (see A.5);
* heritage structures (see A.6).

NOTE Detailed guidance on the assessment of heritage structures are provided in ISO 13822:2010, Annex I.

* 1. Assessment approach
		1. General

(1) The assessment may be performed according to the process illustrated in Figure A.1.

Figure A.1 — Indicative assessment process

* + 1. Condition survey

(1) The data acquisition techniques should have a sufficient resolution and accuracy to provide useful data for assessment.

(2) The methodology for condition survey should be in accordance with prior plans and relevant standards.

(3) Procedures and methods that jeopardize structural reliability should be avoided.

(4) The method of evaluating the results of condition survey should be as specified by the relevant authorities or agreed for a specific project by the relevant parties.

* + 1. Preliminary stage of assessment

(1) A preliminary stage of assessment should be undertaken, except in specific cases if it is agreed with the relevant parties for a specific structure to proceed directly to a detailed stage of assessment.

NOTE 1 The purpose of a preliminary stage of assessment can be to:

* use conservative and/or simplified methods to demonstrate that the structure fulfils the specified requirements;
* identify the scope, objectives and approach of a subsequent detailed stage of assessment.

NOTE 2 A preliminary stage of assessment can include:

* preliminary documentation search and review;
* evaluation of the findings of the condition survey;
* preliminary structural analysis and verifications;

— recommendations such as on potential future interventions.

(3) The preliminary stage of assessment should include a recommendation for whether a detailed stage of assessment should be carried out and what additional considerations should be included in the detailed stage of assessment.

* + 1. Detailed stage of assessment

(1) A detailed assessment should be carried out, if needed.

NOTE A detailed stage of assessment can include:

* detailed documentation search and review;
* further condition survey, if needed;
* detailed structural analysis and verifications, including comparison with data from monitoring if available;
* recommendations such as need for additional assessment stages.
	+ 1. Plausibility check

(1) The conclusions from the assessment stages should be verified by a plausibility check if there are significant inconsistencies between the assessment results and the actual performance of the structure.

* + 1. Assessment findings

(1) The documentation of assessment findings can include the following information:

* scope of the assessment;
* description of the structure;
* basis of the assessment;
* investigations undertaken and relevant findings;
* any relevant assumptions;
* analysis, verifications and interpretation of the findings, including any sensitivity analyses regarding the assumptions;
* conclusions and recommendations;
* review of intervention options.
	1. Basic variables and updating
		1. Actions and environmental influences
			1. General

(1) Actions and environmental influences that are not specifically treated in this Annex may be updated applying the approaches given in A.4, if appropriate.

* + - 1. Permanent actions

(1) The self-weight of the structure or structural members and other permanent actions should be based on the relevant geometrical properties and the specific weight of materials.

NOTE See prEN 1990‑1:2024, 6.1.2.2 for further instructions.

(2) The specific weight of materials may be based on the review of prior information.

NOTE Typical specific weights are provided in EN 1991‑1‑1.

(3) The self-weight of the structure or structural members and other permanent actions may be updated based on data collected through testing and survey.

(4) If it is anticipated that permanent actions are likely to change during the remaining service life (for example, the permanent action due to the weight of surfacing on bridges due to the replacement of the surface course with a thicker or thinner surface course system), the predicted change should be taken into account in the relevant assessment values of actions.

* + - 1. Imposed deformations

(1) If the results of the assessment are sensitive to imposed deformations, the magnitudes of the deformations that actually occurred should be established by survey and the expected additional deformations during the remaining service life should be estimated.

* + - 1. Prestressing

(1) The assessment prestressing action should be derived by one of the following:

a) prior information (such as manufacturers’ data, design documentation and construction records) taking into account the initial prestress and calculating all losses according to the models in the relevant Eurocodes;

b) tests made on the existing structure taking into account uncertainties in the test methods;

c) a combination of a) and b).

(2) When assessing the prestressing action, deterioration effects should be taken into account where relevant.

EXAMPLE Deterioration effects can include:

* sectional loss of the structure;
* sectional loss of the prestressing system;
* reduction of the prestressing action due to possible reduction in bond strength of the prestressing system;
* reduction of ductility due to corrosion of the prestressing system.
	+ - 1. Imposed loads on buildings

(1) Imposed loads on buildings may be assessed using EN 1991‑1‑1.

(2) Updated values for imposed loads on buildings may be assessed based on the actual use and planned use over the remaining service life if allowed by the relevant authority and agreed for a specific project by the relevant parties.

(3) If operational restrictions are in place that limit the imposed loading over the remaining service life, the values for the loads may be assessed based on the operational restrictions as specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

NOTE The utilization plan can establish limitations on loading and use.

* + - 1. Snow loads

(1) Snow loads should be assessed using EN 1991‑1‑3.

(2) If fail-safe measures are in place that limit the snow loading over the remaining service life, the values for the loads may be assessed based on such limits if allowed by the relevant authority and agreed for a specific project by the relevant parties.

NOTE Appropriate fail-safe measure can be defined by means of risk analysis, identifying any possible cause of failure and providing appropriate solutions.

(3) If fail-safe measures to limit the snow loading are adopted to ensure that the assumptions concerning the reduction of the snow loads are fulfilled, they should be defined in the utilization plan together with the required maintenance.

* + - 1. Wind actions

(1) Wind actions should be assessed using EN 1991‑1‑4.

* + - 1. Thermal actions

(1) Thermal actions should be assessed using EN 1991‑1‑5.

(2) Temperature-induced effects (such as deformations or stresses) may be updated by measurements on the existing structure.

* + - 1. Accidental actions

(1) Accidental actions should be assessed using EN 1991‑1‑7.

* + - 1. Traffic loads

(1) Traffic loads should be assessed using EN 1991‑2.

(2) If operational restrictions are in place that limit the traffic loading over the remaining service life, the values for the loads may be assessed based on the operational restrictions, if allowed by the relevant authority and agreed for a specific project by the relevant parties.

NOTE The utilization plan can establish limitations on loading and use.

* + - 1. Actions originating from the ground

(1) Actions originating from the ground should be assessed using EN 1997 (all parts).

(2) Actions originating from the ground should be assessed, including the effects of changes in the ground and groundwater conditions since construction, if relevant.

* + - 1. Environmental influences

(1) Environmental influences of a physical, chemical or biological nature that induce deterioration mechanisms affecting the material properties or the performance of an existing structure should be taken into account, if relevant.

* + 1. Material and product properties

(1) If samples are tested, the material properties of the structure may be determined by combining the obtained results with the corresponding prior information, if available.

NOTE 1 An updating procedure is provided in A.4.4.

NOTE 2 Requirements for sampling and testing methods and standards to be used can be given in the relevant Eurocodes.

NOTE 3 For use of conversion factors, see prEN 1990‑1:2024, 6.2(5).

* + 1. Geometrical properties

(1) The geometry of the structure and its parts may be based on the available information included in e.g. original design documents, construction records, documentation on previous assessments and interventions, if applicable, with key dimensions verified by taking on-site measurements.

NOTE See also Annex A.3.2 covering condition survey.

* + 1. Updating process
			1. General

(1) If a basic variable is related to measured parameters through an analytical model (indirect type of information), the associated model uncertainties should be considered.

(2) Prior distribution functions in a Bayesian statistical inference for parameters of the investigated basic variable should reflect the available prior information.

NOTE 1 Given such prior distributions and statistical data from observations, posterior distributions can be derived.

NOTE 2 In general, the following assumptions are appropriate for most applications:

* a Gaussian distribution for permanent action effects;
* an distribution to represent a maximum value within a chosen reference time (e.g. wind velocity, snow load on the ground);
* for dimensions and material properties, a Gaussian distribution or a log-normal distribution.
	+ - 1. Prior information for the normal distribution

(1) When updating the probability distribution function of a basic variable, which follows a normal distribution, its distribution parameters (the mean and the standard deviation) may be considered as random variables.

(2) The prior information about the standard deviation σ should be characterized by the parameters *s*' (prior standard deviation) and *ν*' (prior number of degrees of freedom for *s*').

(3) If *ν*' is larger than 3, the expectation *E*(.) and the coefficient of variation *V* of the standard deviation *σ* may be expressed by Formula (A.1) and Formula (A.2):

*E*(*σ*) = *s*' (A.1)

*V*(*σ*)=1/√(2 *ν*') (A.2)

NOTE 1 The prior information can be interpreted as the result of hypothetical prior test series for the mean and standard deviation. In that case, the information about the standard deviation is given by:

* *s*' is the standard deviation of the hypothetical sample;
* (*ν*'+1) is the number of observations in the hypothetical sample.

NOTE 2 The prior parameter *s*' represents the best estimate for the standard deviation. Through the choice of *ν*’, the uncertainty with respect to these estimates can be expressed.

(4) The prior information about the mean value *μ* should be characterized by the parameters *m*’ (prior mean value), *n*’ (prior number of observations) and *s*’.

(5) If *n*’ is larger than 3, the expectation *E*(.) and the coefficient of variation *V* of the mean value *μ* may be expressed by Formula (A.3) and Formula (A.4):

*E*(*μ*) = *m'* (A.3)

*V*(*μ*) = *s'*/(*m'∙*√(*n'*)) (A.4)

NOTE 1 Compared to the standard deviation, the information about the mean value requires two additional parameters:

* *m*’ hypothetical sample average;
* *n*’ hypothetical number of observations for m’.

NOTE 2 The prior parameter m’ represents the best estimates for the mean value. Through the choice of *n*’, the uncertainty with respect to these estimates can be expressed. The hypothetical prior parameter *n*’ can be chosen independently from *ν*' (in general *ν*' ≠*n*' - 1).

(6) Estimates for the prior parameters should be chosen if technically justified.

* + - 1. Posterior parameters of the normal distribution

(1) Combining the prior information characterized by Formulae (A.1) to (A.4) and new data constituted by *n* observations with sample mean *m* and sample standard deviation *s*, the posterior normal distribution for the unknown mean value and standard deviation of a variable may be obtained by Formula (A.5) to Formula (A.8):

*n” = n'* + *n* (A.5)

*ν” = ν'* + *ν* + *δ*(*n'*) (A.6)

*n”∙ m”* = *n' ∙ m'* + *n ∙ m* (A.7)

*ν” ∙* (*s”*)2 + *n” ∙* (*m”*)2 = *ν' ∙* (*s'*)2 + *n' ∙* (*m'*)2 + *ν ∙ s*2 + *n ∙ m*2 (A.8)

where

|  |  |
| --- | --- |
| *m*’, *m*, *m*” | denote respectively the prior, sample and posterior mean values;  |
| *s*’, *s, s*” | denote respectively the prior, sample and posterior standard deviations;  |
| *n*’, *n*, *n*” | denote respectively the prior, sample and posterior numbers of observations;  |
| *ν* ', *ν*, *ν*” | denote respectively the prior, sample and posterior numbers of degrees of freedom;  |
| *δ* (*n*') |  = 0 for *n*' = 0; |
| *δ* (*n*') |  = 1 for *n*' > 0; |
| *ν*  |  = *n* – 1. |

NOTE In order to update statistical parameters of a non-normally distributed random variable statistical methods can be applied. As a prior for the updating, the underlying distributions used to derive the design values can be used.

* + - 1. Assessment value of a basic variable

(1) Predictive distributions for variables based on posterior (i.e. updated) distribution parameters for basic variables may be used to determine the corresponding updated assessment values.

NOTE 1 Updated assessment values can be determined based on the principles of statistical methods that are consistent with structural reliability methods and distribution functions provided in prEN 1990‑1:2024, Annex C.

NOTE 2 prEN 1990‑1:2024, Annex D provides a procedure to establish assessment values of material properties if only test results are available with no prior information.

(2) The choice of probability distribution functions should be made with caution, considering possible bias and skewness.

NOTE Quantile-Quantile plots can provide valuable information for determining the appropriate theoretical model (probability distribution function). If the actual distribution shows a multimodal character, the choice of one single distribution can lead to considerable error.

(3) The assessment values should be determined taking into appropriate sensitivity factors *α* and target reliability indices *β*t.

NOTE 1 The target reliability index *β*t specifies the reliability requirements. Information about the establishment of numerical values for the target reliability index is included in prEN 1990‑1:2024, Annex C.

NOTE 2 For sensitivity factors *α*, see prEN 1990‑1:2024, Annex C.

* + - 1. Characteristic value of a basic variable

(1) In accordance with A.4.4.4, predictive distributions for variables may be used to determine the corresponding updated characteristic values at appropriate fractile levels.

(2) Assessment values may be obtained from characteristic values by applying the appropriate partial factors.

NOTE For the derivation of partial factors, see prEN 1990‑1:2024, C.4.

* + - 1. Updating the failure probability
				1. Direct updating

(1) Direct update of the structural failure probability may be carried out by using the basic relationship from probability theory in Formula (A.9):

*P*(*F*│*I*) = *P*(*F*∩*I*)/*P*(*I*) (A.9)

where

|  |  |
| --- | --- |
| *P*(.) | denotes probability of (.); |
| *P*(*F*│*I*) | is the failure probability updated by using new data; |
| *F* | denotes a local or global structural failure event represented by a limit state; |
| *I* | denotes new data, formulated as a notional limit state function h(*X*); h(*X*) = 0 for example in case of measurement or h(*X*) > 0 for example in case of load survival; |
| ∩ | indicates the intersection of two events; |
| | | indicates “conditional upon”. |

NOTE 1 The denominator *P*(*I*) in Formula (A.9) is a normalizing constant, which follows from the fact that the conditional probabilities of failure *P*(*F*|*I*) and non-failure *P*(*S*|*I*), given the inspection information *I*, are complementary, see Formula (A.10):

*P*(*F*│*I*) + *P*(*S*│*I*) = 1 (A.10)

where

|  |  |
| --- | --- |
| *S* | indicates non-failure or survival event. |

NOTE 2 Formula (A.9) can be solved by applying suitable reliability methods.

* + - * 1. Updating by load testing

(1) To update the failure probability of a structure or a structural member on the basis of a known load, a load test may be performed.

NOTE The observation that a structure or a structural part has survived a load test indicates that its minimum resistance at the time of the test is greater than the action effect caused by the applied test load.

(2) The target test load, defined as the load the structure has to carry in addition to the self-weight and permanent load and other acting loads if relevant, should be determined such that:

* the probability that the action effect is not lower than the action effect caused by the applied test load corresponds to the target reliability if no prior knowledge on the resistance is available; or
* the updated probability of failure, given non-failure under the applied test load, corresponds to the target reliability if prior knowledge on the resistance is available.

(3) Before testing, criteria should be specified to control the structure during the test and avoid permanent damage to the structure.

* + - * 1. Updating of resistance based on action effect history

(1) If a structure has experienced, without significant damage, an action effect of known magnitude during the past years of service, the distribution function for resistance may be updated taking into account the known maximum action effect.

NOTE The failure probability can be updated by implementing the truncated probability distribution of resistance and action effects.

* 1. Interventions

(1) Appropriate interventions may be defined taking account of the following:

* the type and importance of the structure;
* the specific requirement (i.e. safety, serviceability, durability, robustness) that is not met;
* possible cause and mode of attaining a limit state;
* expected consequences of failure;
* options for interventions that are available.

(2) The intervention options, characterized by their type, technique and extent, may be selected and developed taking into account the following aspects, if relevant:

* remaining service life of the structure;
* presence and extent of damage, defect or deterioration;
* results of monitoring and inspection activities performed after the assessment;
* previously applied interventions;
* type of actions and influences;
* requirements to be improved;
* structural behaviour;
* architectural, functional and aesthetic considerations and restrictions;
* sustainability;
* materials and technologies to be used for the intervention;
* compatibility of retained structural parts of the existing structure and the new structural parts, including their materials;
* intervention principles in heritage structures such as minimum level and removability of the measures adopted;
* cost considerations;
* disruption of use and duration of the works.
	1. Heritage structures
		1. General

(1) The reliability level for the verification of heritage structures may be set equal to that for existing structures, unless different values are specified by the relevant authority or where not specified, agreed for a specific project by the relevant parties.

(2) The choice of an appropriate level of reliability for heritage structures should take account of the potential losses of historical, cultural or societal value in addition to the aspects in prEN 1990‑1:2024, 4.2(4).

NOTE Measures such as a restricted use or the provision of an alternate escape route can be adopted to limit the consequences of a failure.

(3) Heritage structures should be preserved, as far as possible, with its original materials and structural concept to retain authenticity and integrity.

NOTE The historical, cultural and societal value of a historic structure resides in the authenticity and integrity of its character-defining parts including architectural and engineering components.

(4) If the historical, cultural or societal value is in immediate danger, this shall be reported to the relevant authority or relevant parties so that relevant mitigation measures can be implemented immediately.

(5) Any interim interventions necessary to ensure the stability of the structure should not cause damage to its historical, cultural or societal value.

(6) Specific serviceability criteria for protecting the historical, cultural or societal value of the structure should be considered.

EXAMPLE Protection of artistic paintings through crack width, deformation or vibration limitations.

* + 1. Testing

(1) Samples for material testing taken from those parts of the structure that have high historical, cultural or societal value should be avoided.

(2) Destructive tests causing reduction in the historical, cultural or societal value should be kept to a minimum and justified.

EXAMPLE The justification can be the need for calibration of non-destructive tests.

* + 1. Interventions

(1) Interventions on heritage structures resulting in the loss or major alteration of historical, cultural or societal value should be avoided.

(2) Materials used for interventions should be compatible with the original materials in terms of mechanical, chemical and other characteristics.

Bibliography

References contained in recommendations (i.e. “should” clauses)

The following documents are referred to in the text in such a way that some or all of their content constitutes highly recommended choices or course of action of this document. Subject to national regulation and/or any relevant contractual provisions, alternative documents could be used/adopted where technically justified. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1991‑1‑3, Eurocode 1 — Actions on structures — Part 1-3: Snow loads

EN 1991‑1‑4, Eurocode 1 — Actions on structures — Part 1-4: Wind actions

EN 1991‑1‑5, Eurocode 1 — Actions on structures — Part 1-5: Thermal actions

EN 1991‑1‑7, Eurocode 1 — Actions on structures — Part 1-7: Accidental actions

EN 1991‑2, Eurocode 1 — Actions on structures — Part 2: Traffic loads on bridges and other civil engineering works

EN 1997 (all parts), Eurocode 7 — Geotechnical design

References contained in permissions (i.e. “may” clauses)

The following documents are referred to in the text in such a way that some or all of their content expresses a course of action permissible within the limits of the Eurocodes. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1991‑1‑1, Eurocode 1 — Actions on structures — Part 1-1: Specific weight of materials, self-weight of construction works and imposed loads on buildings

References contained in possibilities (i.e. “can” clauses) and notes

The following documents are cited informatively in the document, for example in “can” clauses and in notes.

EN 1998‑3, Eurocode 8 — Design of structures for earthquake resistance — Part 3: Assessment and retrofitting of buildings

ISO 2394, General principles on reliability for structures

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