



BSI Standards Publication

Eurocode 8 — Design of structures for earthquake resistance

Part 1-1: General rules and seismic action

National foreword

This British Standard is the UK implementation of EN 1998-1-1:2024. Together with BS EN 1998-1-2:¹⁾, it supersedes BS EN 1998-1:2004+A1:2013 which will be withdrawn on 30 March 2028.

The UK participation in its preparation was entrusted to Technical Committee B/525/8, Structures in seismic regions.

A list of organizations represented on this committee can be obtained on request to its committee manager.

National choice is allowed in this standard where explicitly stated within notes. The National Annex to this standard contains the national choices to be used for buildings and civil engineering works constructed in the UK.

The first generation of EN Eurocodes was published between 2002 and 2007, with conflicting British Standards withdrawn in 2010. This document forms part of the second generation of EN Eurocodes.

The second generation of EN Eurocodes is expected to be published between 2023 and 2026. These documents are being published as soon as they are available. This is being done to enable users to prepare for the transition from the first generation to second generation of EN Eurocodes.

UK adoptions of the first generation of EN Eurocodes will be withdrawn by BSI on 30 March 2028. Until that date, the first generation documents should be considered as the applicable standards for buildings and civil engineering works constructed in the UK unless otherwise specified by the relevant authority or in the specification for a particular project.

This standard is intended to be used with its National Annex and other referenced documents, including other second generation Eurocodes, as an interdependent suite of documents.

While the use of provisions in this standard in conjunction with first generation Eurocodes is not precluded, it should be undertaken with care and should only be done when users are satisfied that it will not result in a lower level of reliability than the minimum level set in the first generation Eurocodes and associated UK National Annexes.

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¹⁾ Not yet published.

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Amendments/corrigenda issued since publication

Date	Text affected
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English Version

Eurocode 8 - Design of structures for earthquake resistance - Part 1-1: General rules and seismic action

Eurocode 8 - Calcul des structures pour leur résistance
au séisme - Partie 1-1 : Règles générales et actions
sismiques

Eurocode 8 - Auslegung von Bauwerken gegen
Erdbeben - Teil 1-1: Grundlagen und
Erdbebeneinwirkung

This European Standard was approved by CEN on 7 July 2024.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 1998-1-1:2024) 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 European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2027, and conflicting national standards shall be withdrawn at the latest by March 2028.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

Together with EN 1998-1-2:—¹, this document will partially supersede EN 1998-1:2004. 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 main changes compared to the previous edition are listed below:

- simplification of the national-level global safety choice through seismic action classes;
- new reliability-based definition of partial factors;
- homogenisation of Limit States’ definitions across all parts and with improved consistency with EN 1990 (ULS and SLS);
- unambiguous definition of site classification introducing the depth of the bedrock formation;
- definition of one standard elastic response spectrum instead of two by introducing two parameters in place of a_g ;
- new definition of ductility classes;
- deepening of the two possible approaches for analysis: force-based or displacement-based; modelling, analysis and associated verifications;
- improved definition of the behaviour factor (decomposed in three components) for the force-based approach;
- introduction of deformation criteria and strength models for the displacement-based approach;
- new coverage for structures equipped with anti-seismic devices and dissipative components.

The Eurocodes recognise 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.

¹ Under preparation. Stage at the time of publication: prEN 1998-1-2:2023.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

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 1998 (all parts)

EN 1998 (all parts) defines the rules for the seismic design of new buildings and other structures, as well as temporary ones, including geotechnical aspects.

EN 1998 (all parts) also defines the rules for the seismic assessment and retrofit of existing buildings and other structures.

EN 1998 (all parts) additionally covers the verification of structures in the seismic design situation during construction, when required.

For the design of structures in seismic regions, the provisions of EN 1998 (all parts) are to be applied in conjunction with the relevant provisions of EN 1990 to EN 1997 and EN 1999.

EN 1998 (all parts) applies to structures of consequence classes CC1, CC2 and CC3, as defined in EN 1990. The provisions in the Eurocodes do not entirely cover design rules needed for structures classified as CC4. For these structures, additional provisions to those given in the Eurocodes can be needed.

Given that seismic hazard is characterised by a significant uncertainty, a null seismic risk is not achievable in practice. Therefore, in Eurocode 8, the seismic action is represented in a conventional form,

proportional in amplitude to earthquake ground motions likely to occur at a given location and representative of their frequency content. This representation is not the prediction of a particular seismic movement, and such a movement could give rise to more severe effects than those of the seismic action considered, inflicting damage greater than the one described by the Limit States contemplated in EN 1998 (all parts).

In addition, engineering methods are associated with assumptions that cannot be verified when considering the effects of the seismic action, under which structures are assumed to respond in the non-linear regime. Such uncertainties are taken into account according to the general framework of EN 1990, with a residual risk of underestimation of their effects.

EN 1998 is subdivided in various parts:

- EN 1998-1-1 Eurocode 8 — Design of structures for earthquake resistance — Part 1-1: General rules and seismic action
- EN 1998-1-2 Eurocode 8 — Design of structures for earthquake resistance — Part 1-2: Buildings
- EN 1998-2 Eurocode 8 — Design of structures for earthquake resistance — Part 1-2: Bridges
- EN 1998-3 Eurocode 8 — Design of structures for earthquake resistance — Part 3: Assessment and retrofitting of buildings and bridges
- EN 1998-4 Eurocode 8 — Design of structures for earthquake resistance — Part 4: Silos, tanks, pipelines, towers, masts and chimneys
- EN 1998-5 Eurocode 8 — Design of structures for earthquake resistance — Part 5: Geotechnical aspects, foundations, retaining and underground structures

0.3 Introduction to EN 1998-1-1

This document contains general requirements for the earthquake resistant design of all types of structures covered by EN 1998 (all parts), including definition of the seismic action and the description of the methods of analysis and verification.

The definition of the seismic action allows adaptation to a local specific seismic context through Nationally Determined Parameters defined in the National Annex or through a site-specific assessment.

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 1998-1-1

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 1998-1-1 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 1998-1-1 through notes to the following clauses:

4.1(6)	4.2(1)	5.1.2(2)	5.2.1(1)
5.2.1(3) – 2 choices	5.2.1(4) – 2 choices	5.2.1(5)	5.2.1(6)
5.2.2.2(2)	5.2.2.2(9)	5.2.2.5(3)	F.3(1) – 2 choices
F.4(5)	G.3.2(5)	G.4(1)	

National choice is allowed in EN 1998-1-1 on the application of the following informative annexes:

Annex A	Annex D	Annex F	Annex M
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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.

1 Scope

1.1 Scope of EN 1998-1-1

(1) This document is applicable to the design and verification of buildings and other structures for earthquake resistance. It gives general rules relevant to all types of structures, except for structures belonging to consequence classes CC0 or CC4.

NOTE For further details on consequence class CC4, see 4.2.

(2) This document provides basic performance requirements and compliance criteria applicable to buildings and other structures for earthquake resistance.

(3) This document gives rules for the representation of seismic actions and the description of the design seismic situations.

NOTE Certain types of structures, dealt with in other parts of Eurocode 8, need supplementary rules which are given in those relevant Parts.

(4) This document contains general methods for structural analysis and verification under seismic actions, including base-isolated structures and structures with distributed dissipative systems.

(5) This document contains rules for modelling and verification of ultimate strengths and deformations.

1.2 Assumptions

(1) The assumptions of EN 1990 apply to this document.

(2) It is assumed that no change in the structure and in the masses carried by the structure takes place during the construction phase or during the subsequent life of the structure with respect to the design unless proper justification and verification is provided. This applies also to ancillary elements (see 3.1.2). Due to the specific nature of seismic response, this applies even in the case of changes that lead to an increase of the structural resistance.

(3) The design documents are assumed to indicate the geometry, the detailing, and the properties of the materials of all structural members. If appropriate, the design documents are also assumed to include the properties of special devices to be used and the distances between structural and ancillary elements. The necessary quality control provisions are assumed to be specified.

(4) Members of special structural importance requiring special checking during construction are assumed to be identified in the design documents and the verification methods to be used are assumed to be specified.

(5) It is assumed that in the case of high seismic action class (4.1.1(4)), formal quality system plans, covering design, construction, and use, additional to the control procedures prescribed in the other relevant Eurocodes, are specified.

2 Normative references

The following documents are referred to in the text such 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.

EN 1990:2023², *Eurocode — Basis of structural and geotechnical design*

EN 1998 (all parts), *Eurocode 8 — Design of structures for earthquake resistance*

ISO 80000, *Quantities and units*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1

ancillary element

architectural, mechanical or electrical element, system or component which, whether due to lack of strength or to the way it is connected to the structure, is not considered in seismic design as a load carrying element but may be the cause of risk to persons or to the structure in the case of an earthquake

Note 1 to entry: Ancillary elements are similar to the “elements other than structural” as defined in EN 1990, but with the difference that the consequences of their failure during an earthquake can pose severe risk to persons or to the structure and they can have a non-negligible contribution to the stiffness and strength of the structure with respect to a seismic action (e.g. masonry infills).

3.1.2

anti-seismic devices

devices which contribute to modifying the seismic response of a structure by isolating it, by dissipating energy or by creating permanent or temporary restraints via rigid connections

Note 1 to entry: The devices considered in EN 1998 (all parts) are those covered in EN 15129.

3.1.3

bearings

devices that support vertical loads and are not anti-seismic devices

3.1.4

behaviour factor

factor used for design purposes to reduce the forces obtained from a linear analysis to account for overstrength and non-linear response of a structure

Note 1 to entry: The value of the behaviour factor depends on the construction material, the structural system and the design procedure used.

² As impacted by EN 1990:2023/prA1:2024.

3.1.5**capacity design method**

design method where certain members of the structural system are chosen and suitably designed and detailed for energy dissipation under severe deformations, while all other structural members are provided with sufficient strength to ensure that the selected energy dissipation mechanisms can be developed

3.1.6**design displacement (of the isolation system in a principal direction)**

maximum horizontal displacement at the effective stiffness centre between the top of the substructure and the bottom of the superstructure, occurring in the seismic design situation

3.1.7**displacement-based approach**

design method that explicitly accounts for the strength and deformation capacity of the structure, in most cases considering its non-linear response, and uses verifications in terms of displacements or deformations

Note 1 to entry: In EN 1998, the displacement-based approach is implemented in the form of a non-linear static procedure based on a pushover analysis. A non-linear response-history analysis, complemented with displacement-based verifications, can also be adopted.

3.1.8**displacement-dependent device**

device which links two structural members without carrying vertical loads, whose behaviour is mainly dependent on displacement rather than velocity

Note 1 to entry: This category of devices includes linear and non-linear devices.

3.1.9**dissipative structure**

structure that can dissipate energy by means of ductile hysteretic behaviour and/or by other mechanisms

3.1.10**dissipative zones**

predetermined parts of a dissipative structure where the dissipative capabilities are mainly located

Note 1 to entry: These are also called critical regions.

3.1.11**dynamically independent unit**

structure or part of a structure which is directly subjected to the seismic ground motion and whose response is not affected by the response of adjacent units or structures

3.1.12**effective damping (of the isolation system in a principal direction)**

value of the viscous damping that corresponds to the energy dissipated by the isolation system during cyclic response at the design displacement

3.1.13

effective period (of the isolation system in a principal direction)

natural period, in the direction considered, of a single degree of freedom system having the mass of the superstructure and stiffness equal to the effective stiffness of the isolation system

3.1.14

effective stiffness (of the isolation system in a principal direction)

ratio of the value of the total horizontal force transferred through the isolation interface, under the design displacement in a given direction, to the value of the design displacement in that direction (see 3.1.6); this corresponds to the secant stiffness associated to the design displacement

Note 1 to entry: The effective stiffness is generally obtained iteratively through consecutive dynamic analyses.

3.1.15

effective stiffness centre of the isolation system

stiffness centre calculated at the upper face of the isolation interface, i.e. including the flexibility of the isolators and of the substructure(s)

Note 1 to entry: In buildings, tanks and similar structures, the flexibility of the substructure can often be neglected in the determination of this point, which then coincides with the stiffness centre of the isolators.

3.1.16

energy dissipation device

disposable element of the energy dissipation system that dissipates energy caused by relative motion of each end of the device and does not form part of the main structural system

3.1.17

energy dissipation system

collection of structural members that includes all the energy dissipation devices and all structural members required to transfer the forces from the energy dissipation devices to the main structural system and to the base of the structure

Note 1 to entry: It also includes all pins, bolts, gusset plates, brace extensions and other components required to connect the energy dissipation devices to other elements of the structure.

3.1.18

European Technical Product Specification

ETPS

European Standard (EN), European Technical Specification (TS) or a transparent and reproducible assessment that complies with all the requirements of a European Assessment Document (EAD)

3.1.19

force-based approach

design method which employs a linear analysis that implicitly accounts for the overstrength and the non-linear response through a behaviour factor and uses verifications in terms of forces

Note 1 to entry: In EN 1998, it is implemented in the form of a static lateral force method or a dynamic response spectrum method.

3.1.20**fully isolated structure**

superstructure on an isolation system which, in the seismic design situation, remains within the elastic range

Note 1 to entry: Otherwise, the superstructure is partially isolated.

3.1.21**isolation system, isolation interface**

collection of isolators used for providing seismic isolation, which are arranged within the isolation interface

3.1.22**isolator**

device which links two structural members and possessing the characteristics needed for seismic isolation, namely, the ability to support vertical loads from the superstructure and the ability to accommodate horizontal displacements

Note 1 to entry: This category of devices includes elastomeric isolators, including those with a plug of lead or high-damping polymeric material to enhance damping, sliders, both with curved and flat surface, and other devices whose behaviour conforms to 6.8.2.4.

3.1.23**main structural system (in structures equipped with energy dissipation systems)**

collection of primary and secondary seismic members, and their connections, in structures equipped with energy dissipation systems

Note 1 to entry: The main structural system and the energy dissipation system can have common structural members.

3.1.24**non-dissipative structure**

structure designed for seismic action by solely relying on the linear elastic material behaviour

Note 1 to entry: By linear elastic material behaviour in a non-dissipative structure, it is understood that its response is limited to the elastic resistance limit of its members and can include non-linearities such as cracking.

3.1.25**performance factor**

multiplicative factor of the seismic action amplitude that accounts concurrently for the consequence class of a structure and for the limit state under consideration

3.1.26**primary structure**

set of structural members composing the seismic action resisting system

3.1.27

primary seismic member

structural member considered as part of the primary structure, modelled in the analysis for the seismic design situation and fully designed and detailed for earthquake resistance in accordance with the corresponding rules of EN 1998

Note 1 to entry: The primary seismic members form part of the seismic action resisting system. They provide strength and stiffness and can also contribute to the dissipation of energy through inelastic response.

3.1.28

reduced spectrum

spectrum that is derived from the elastic response spectrum by applying a behaviour factor, to be used within the force-based approach

3.1.29

reference seismic action

seismic action associated with the significant damage limit state for consequence class CC2

3.1.30

resistance

resistance of a structural member is the (generalised) force or (generalised) deformation it can sustain without exceeding a prescribed limit state

3.1.31

rigid connection device

device which links two structural members without transmitting bending moments and vertical loads

Note 1 to entry: This category of devices includes permanent connection devices, fuse restraints and temporary connection devices.

3.1.32

secondary seismic member

structural member which is not considered as part of the seismic action resisting system and whose resistance and stiffness against seismic actions is neglected in design

Note 1 to entry: Secondary seismic members are not required to comply with all the rules of EN 1998 but are designed and detailed to maintain support of gravity loads when subjected to the displacements caused by the seismic design situation.

Note 2 to entry: Secondary seismic members can contribute to the lateral load resistance of the structure in case of second-order effects (e.g. in the case of hinged columns).

3.1.33

seismic action class

interval of seismic action intensities used to establish the applicability of simplified methods and ductility classes

Note 1 to entry: A seismic action class accounts for both site amplification, due to topography and site category, and consequence class.

3.1.34

seismic action index

spectral acceleration, based on seismic hazard and safety choices, used to define seismic action classes

3.1.35**site-specific seismic hazard studies**

investigations and subsequent studies that are carried out for a given site in order to obtain detailed information about the seismic action at the site

3.1.36**stable site**

site that is not affected by ground rupture, slope instability, permanent settlements, caused by liquefaction or significant densification, under the considered seismic action

3.1.37**structure with energy dissipation systems**

structure composed of a main structural system and an energy dissipation system working in parallel

3.1.38**substructure(s)**

in an isolated structure, part(s) of the structure located under the isolation interface

3.1.39**superstructure**

in an isolated structure, part of the structure located above the isolation interface

3.1.40**total design displacement (of an isolator in a principal direction)**

maximum horizontal displacement at the location of the isolator, including the contribution due to the design displacement and to the global rotation due to torsion about the vertical axis

3.1.41**types of structures**

sets of structures that are addressed by a given part of Eurocode 8. The considered types of structures are:

- buildings;
- bridges;
- silos;
- tanks;
- pipelines;
- geotechnical structures and systems;
- underground structures;
- towers;
- masts;
- chimneys.

3.1.42

velocity-dependent device

device which links two structural members without carrying vertical loads, whose behaviour is mainly dependent on velocity rather than displacement

Note 1 to entry: This category of devices includes fluid viscous dampers and fluid spring dampers.

3.2 Symbols and abbreviations

For the purposes of this document, the symbols and abbreviations given in EN 1990:2023, 3.2, apply.

For the symbols related to materials, as well as for symbols not specifically related to the seismic design situation, the provisions of the relevant Eurocodes apply.

In addition, further symbols and abbreviations, used in connection with the seismic design situation, are defined in this document where they occur, for ease of use. However, the most frequently occurring symbols used in EN 1998-1-1 are listed and defined in 3.2.1 and abbreviations are given in 3.2.2.

3.2.1 Symbols

3.2.1.1 Symbols used in Clause 4

Upper case Latin symbols

S_δ	Seismic action index
$T_{LS,CC}$	Return period of the seismic action associated to a given limit state LS and a given consequence class CC
$T_{SD,CC2}$	Return period of the seismic action associated to the significant damage (SD) limit state and consequence class CC2

Lower case Greek symbols

δ	Coefficient that specifies S_δ depending on the consequence class
$\gamma_{LS,CC}$	Performance factor associated to a given limit state LS and a given consequence class CC
$\gamma_{SD,CC2}$	Performance factor associated to significant damage (SD) limit state and consequence class CC2, equal to 1 by definition

3.2.1.2 Symbols used in Clause 5

Upper case Latin symbols

D_R	Duration of the strong part of a ground motion
F_A	Ratio of S_α with respect to the zero-period spectral acceleration
F_L	Long-period site amplification factor
F_T	Topography amplification factor
F_α	Short-period site amplification factor
F_β	Intermediate period ($T = T_\beta$) site amplification factor

H	Reference depth for calculation of $v_{s,H}$. It coincides with H_{800} if $H_{800} < 30$ m, otherwise it is equal to 30 m
H_{800}	Depth of the bedrock formation identified by a shear wave velocity $v_s > 800$ m/s
$L_{g,l}$	Characteristic length, function of the site category of support l
L_{kl}	Distance between supports k and l
M_w	Earthquake magnitude, measured in the moment magnitude scale
N	Number of layers in the soil deposit for calculation of $v_{s,H}$
PGA_e	Design peak value of the horizontal ground acceleration
PGD_e	Design peak value of the horizontal ground displacement
PGD_{ei}	Value of PGD_e at site i for calculation of relative displacement between two sites
PGV_e	Design peak value of the horizontal ground velocity
$S_{De}(T)$	Elastic displacement response spectrum for the horizontal component of the seismic action
$S_e(T)$	Elastic response spectrum for the horizontal component of the seismic action
$S_{ve}(T)$	Elastic response spectrum for the vertical component of the seismic action
S_α	Maximum response spectral acceleration (5 % damping) corresponding to the constant acceleration range of the horizontal elastic response spectrum
$S_{\alpha,ref}$	Value of S_α on site category A and for the return period T_{ref}
$S_{\alpha,RP}$	Value of S_α on site category A and for a generic value of return period RP
$S_{\alpha,v}$	Maximum response spectral acceleration (5 % damping) corresponding to the constant acceleration range of the vertical elastic response spectrum
$S_{\alpha,475}$	Value of S_α on site category A and for a return period of 475 years
S_β	Spectral acceleration (5 % damping) at the vibration period T_β of the horizontal elastic response spectrum
$S_{\beta,ref}$	Value of S_β on site category A and for the return period T_{ref}
$S_{\beta,RP}$	Value of S_β on site category A and for a generic value of return period RP
$S_{\beta,v}$	Spectral acceleration (5 % damping) at the vibration period T_β of the vertical elastic response spectrum
$S_{\alpha,ref,X}$ $S_{\beta,ref,X}$	Values of $S_{\alpha,ref}$ and $S_{\beta,ref}$, respectively, for a site category X different from site category A
$S_{\alpha,RP,X}$ $S_{\beta,RP,X}$	Values of $S_{\alpha,RP}$ and $S_{\beta,RP}$, respectively, for a site category X different from site category A
T	Vibration period of a linear single-degree-of-freedom system
T_A	Short-period cut-off associated to the zero-period spectral acceleration

T_B	Lower corner vibration period of the constant spectral acceleration range
T_{Bv}	Lower corner vibration period of the constant spectral acceleration range for the vertical component
T_C	Upper corner period of the constant spectral acceleration range
T_{Cv}	Upper corner period of the constant spectral acceleration range for the vertical component
$T_{C,X}$	Value of T_C for a site category X different from site category A
T_D	Corner vibration period at the beginning of the first constant spectral displacement range
T_E	Corner vibration period at the end of the constant spectral displacement range
T_F	Vibration period beyond which the spectral displacement equals the peak ground displacement
T_{ref}	Value of the reference return period, corresponding to the significant damage (SD) limit state and to consequence class CC2
T_β	Vibration period anchoring the elastic horizontal spectrum for flexible structures. Unless otherwise specified, $T_\beta = 1$ s

Lower case Latin symbols

a_{kl}	Factor for the evaluation of correlation coefficient ρ_{kl} between seismic action effects on supports k and l
$d_{ij,ld,max}$	Maximum relative displacement between two sites at large distance
$d_{ij,max}$	Maximum relative displacement between two sites at distance x_{ij}
f_h	Ratio of $S_{\beta,ref}$ to $S_{\alpha,ref}$
$f_{v\alpha}$	Ratio of $S_{\alpha,v}$ to S_α
$f_{v\beta}$	Ratio of $S_{\beta,v}$ to S_β
h_i	Thickness of the i -th layer of the soil deposit
i	Average slope angle of a topographic irregularity
k	Factor for the evaluation of the relationship between $S_{\alpha,475}/S_{\alpha,ref}$ and $475/T_{ref}$
$L_{g,k}$	Characteristic length function of the site category of support k
r_α	Factor to account for non-linear site amplification effects on F_α
r_β	Factor to account for non-linear site amplification effects on F_β
v_i	Value of v_s for the i -th layer of the soil deposit
v_s	Propagation velocity of shear (S) waves, measured at low strain
$v_{s,H}$	Equivalent value of v_s down to the reference depth H
$v_{s,30}$	Equivalent value of v_s in the upper 30 m of the soil deposit

x_{ij}	Spatial distance between two sites
x_L	Normalisation distance for calculation of relative displacement between two sites

Lower case Greek symbols

η	Damping correction factor for the elastic response spectrum, with a reference value $\eta = 1$ for 5 % damping ratio ξ
ξ	Equivalent viscous damping ratio of the structure
ρ_{kl}	Correlation coefficient between action effects, when the seismic action is represented by a set of response spectra, for every couple of supports with indices k and l
χ	Factor for the evaluation of corner period T_B based on T_C

3.2.1.3 Symbols used in Clause 6

Upper case Latin symbols

E_d	Design value of the action effect in the seismic design situation, including possible influence of second-order effects
E_D	Energy dissipated by the anti-seismic devices
E_{Di}	Energy dissipated by anti-seismic device i
E_E, E_{Ei}	Maximum value of a seismic action effect (force, displacement, etc.) and value of this seismic action effect due to vibration mode i , respectively
E_{Edx}, E_{Edy}	Action effect due to the application of the seismic action along orthogonal horizontal axis x and y , respectively
E_{Edz}	Action effect due to the application of the vertical component of the design seismic action
E_s	Energy reversibly stored (elastic strain energy and potential energy) within the structure including the isolation system
E^*	Area under the transformed capacity curve $F^*(d^*)$ up to the point (d_m^*, F_m^*) of the equivalent SDOF system in pushover analysis
F^*	Equivalent force in the equivalent SDOF system in pushover analysis
F_b	Total shear force in pushover analysis
F_i	Pushover lateral force in the direction under consideration at the i -th node
$\bar{F}_i$	Pattern of the pushover forces
F_m^*	Force at the last point on the curve $F^*(d^*)$ or the point of maximum force of the equivalent SDOF system in pushover analysis
F_y^*	Yield force obtained by bilinearisation of the force-deformation relationship of the equivalent SDOF system in pushover analysis
F_0	Force at zero displacement of the isolation system under cyclic loading not including the contribution of velocity-dependent devices

$G_{k,j}$	Permanent gravity loads as appearing in the seismic design situation
K_{eff}	Effective stiffness of a base-isolated structure
K_p	Post-elastic (tangent) stiffness of the isolation system
M_d	Mass of the rigid superstructure of an isolation system
$Q_{k,i}$	Variable gravity loads as appearing in the seismic design situation
R_d	Design value of resistance corresponding to the design action effect E_d
$R_q(T)$	Reduction factor used in the definition of the reduced design spectrum
R_{q0}	Value of $R_q(T)$ associated with the zero-period spectral acceleration
$S_r(T)$	Reduced design spectrum in the horizontal direction
$S_{vr}(T)$	Reduced design spectrum in the vertical direction
S_y	Yield acceleration of the equivalent SDOF model
T^*	Equivalent period of the equivalent SDOF system in pushover analysis
T_{eff}	Effective period of a base-isolated structure
T_i	Period of vibration of mode i
T_{SSI}	Predominant period of the structure in the considered direction resulting from an analysis accounting for soil-structure interaction (SSI) effects
T_1	Predominant period of the structure in the considered direction
V_R	Design resistance of brittle mechanisms
$V_{R,SD}$	Resistance of brittle mechanisms at SD limit state

Lower case Latin symbols

c_{dt}	Correction factor to be applied to the target displacement to account for a transverse participation of the mode considered
d^*	Equivalent displacement of the equivalent SDOF system in pushover analysis
d_{db}	Design displacement of the equivalent linear model of an isolation system in the seismic situation, including γ_x
d_{Ed}	Seismic displacement of the isolation system in the considered direction
d_{et}^*	Target displacement of the equivalent SDOF model with unlimited elastic behaviour
d_m^*	Displacement corresponding to F_m^* of the equivalent SDOF system in pushover analysis
d_n	Control displacement in pushover analysis
d_s, d_r	Displacement of a point of the structural system induced by the design seismic action and calculated displacement of the same point of the structural system under the reduced spectrum associated to the design seismic action, respectively

d_{SD}^*	Displacement of the equivalent SDOF oscillator that corresponds to the attainment of SD limit state
d_t^*	Target displacement in pushover analysis
d_u	Control displacement at which the ultimate local deformation, brittle failure or instability is attained in any member
d_u^*	Ultimate displacement considered in the force-displacement relationship of the equivalent SDOF system in pushover analysis
d_y^*	Yield displacement obtained by bilinearisation of the force-deformation relationship of the equivalent SDOF system in pushover analysis
k^*	Stiffness of the equivalent SDOF system in pushover analysis
m^*	Mass of the equivalent SDOF system in pushover analysis
m_i	Effective mass of the i -th node
q	Behaviour factor in the horizontal direction
q_{disp}	Displacement behaviour factor
q_D	Behaviour factor component accounting for the deformation capacity and energy dissipation capacity of a fixed-base structure
$q_{D,SSI}$	Value of q_D to be used in an analysis accounting for SSI effects
q_R	Behaviour factor component accounting for overstrength due to the redistribution of seismic action effects in redundant structures
q_S	Behaviour factor component accounting for overstrength due to all other sources
q_v	Behaviour factor in the vertical direction
r_{ij}	Correlation factor in modal combination
u	Force reduction factor in pushover analysis

Upper case Greek symbols

Γ	Transformation factor between a MDOF system and the equivalent SDOF system
Γ'	Value of Γ denoting the modal participation factor of the mode in the direction orthogonal to the one under consideration

Lower case Greek symbols

α	Pushover loading factor used to modulate the amplitude of the pushover forces
α_{ij}	Factor for the evaluation of r_{ij} : $\alpha_{ij} = (T_i - T_j)/(T_i + T_j)$
$\alpha_{SD,d}$	Portion of the plastic part of the displacement of the equivalent SDOF oscillator that corresponds to the attainment of SD limit state
$\alpha_{SD,\theta}$	Portion of the plastic part of the ultimate chord rotation that corresponds to the attainment of SD limit state

β	Lower bound factor for the horizontal reduced design spectrum
γ_{Rd}	Partial factor on resistance for displacement-based approach
γ_x	Amplification factor for anti-seismic devices
δ_{NC}	Value of δ_s that corresponds to the attainment of NC limit state
δ_s	Deformation parameter associated to a plastic mechanism in state s
δ_{SD}	Value of δ_s that corresponds to the attainment of SD limit state
δ_u	Ultimate capacity value of δ_s
δ_u^{pl}	Plastic part of ultimate capacity value of δ_s
δ_y	Value of δ_s at yielding
θ	Chord rotation of frames
ξ_{eff}	Effective damping of a base-isolated structure
ξ_i, ξ_j	Damping ratios corresponding to vibration modes i and j
ρ_d	Additional amplification factor for anti-seismic devices introduced to cope with cumulative displacements
ρ_{ij}	Factor for the evaluation of r_{ij} ; $\rho_{ij} = T_i/T_j$
ϕ_i	Displacement value of mode ϕ at the i -th node in the considered direction of seismic action
ϕ_n	Displacement value of mode ϕ at the control node in the considered direction of seismic action in pushover analysis
$\psi_{E,i}$	Combination coefficients taking into account the likelihood of the loads $Q_{k,i}$ not acting on the entire structure during the earthquake

3.2.1.4 Symbols used in Clause 7

Upper case Latin symbols

A	Cross-sectional area of a steel brace
A_c	Cross-sectional area of a steel column
A_{net}^{core}	Yielding zone of the BRB core
A_{eff}	Effective shear area of a steel cross section
A_{sw}	Area of one layer of transverse reinforcement in the direction of shear
A_w	Web area of the steel cross section
D	Diameter of a circular section
D_o	Centreline diameter of circular hoop
EI	Cross-sectional stiffness (effective flexural stiffness) of beams and columns

G	Shear modulus of steel
I_p	Moment of inertia of the web panel cross section, including the column web doubler plates
K_e	Elastic stiffness ($= Q_y^*/\delta_y$); axial stiffness of a BRB
L	Assumed clear member length
L_0	Shear span of the steel beam
L_b	Unbraced length of the steel beam
L_V	Shear span of a frame (= moment/shear at the end section, i.e. length to the point of contraflexure)
L_{Vl}	Value of L_V on the left side of the point of contraflexure of a frame
L_{Vr}	Value of L_V on the right side of the point of contraflexure of a frame
M_{pl}	Full plastic flexural resistance of the web panel
M_{Rk}	Characteristic flexural resistance of the steel beam for strong axis bending
M_u^*	Effective flexural resistance at ultimate limit state of the steel beam
$M_{u^+}^*$	Effective flexural resistance at ultimate limit state of the composite steel-concrete beam under sagging
$M_{u^-}^*$	Effective flexural resistance at ultimate limit state of the composite steel-concrete beam under hogging
M_y^*	Effective flexural resistance at yield of a steel beam
$M_{y^+}^*$	Effective flexural resistance at yield of the composite steel-concrete beam under sagging
$M_{y^-}^*$	Effective flexural resistance at yield of the composite steel-concrete beam under hogging
$N_{b,compr}$	Number of bars near the extreme compression fibres
$N_{b,Rd}$	Buckling resistance of steel brace
N_{Ed}	Compressive or tensile axial force of the steel member in the seismic design situation
$N_{Ed,G}$	Axial load demand of the column due to non-seismic actions in the seismic design situation
$N_{pl,e}$	Axial yield resistance of a steel column or bracings
N_{u^t}, N_{u^c}	Effective axial resistance at ultimate limit state of the steel brace in tension and compression, respectively
N_y^*	Effective axial resistance at yield of the yielding zone of the BRB core
Q_u^*	Effective ultimate limit state resistance
Q_v^*	Yield resistance of steel and composite steel-concrete structure members
Q_y^*	Effective yield resistance
V	Effective shear resistance at yield of an EBF link

V_y Shear resistance at yield of a web panel

Lower case Latin symbols

a^*	Effective hardening ratio of a structural steel column under flexure
$a_v z$	Tension shift of the bending moment diagram ($a_v = 1$ if shear cracking is expected to precede flexural yielding at the end section, = 0 otherwise)
b	Width of the compression zone
b_f	Flange width of I-shaped steel cross section
b_w	Width of the steel cross section of one web (even in box-sections with more than one parallel web) which is perpendicular to the direction of shear
c	Web depth of I-shaped steel cross section
d, d'	Depths to the tension and compression reinforcement, respectively, for concrete sections; depth of the edge of the respective HSS cross section parallel to the direction of the seismic action
d_{bL}	(mean) Diameter of the tension reinforcement
e	Length of link beam
f_c	Concrete mean compressive strength (in MPa)
f_y	Longitudinal bar mean yield strength; nominal yield stress of the steel material of the structural steel beam or column (in MPa)
f_{ym}	Structural steel members mean strength (in MPa)
f_{yw}	Stirrup mean yield strength (in MPa)
h	Depth of the (unspalled) concrete section or full depth of the steel cross section
h_b	Steel beam cross-sectional depth
h_c	Steel column cross-sectional depth
h_{rib}	Overall depth of the profiled steel sheeting excluding the longitudinal stiffener
i_z	Radius of gyration of a steel cross section with respect to its weak axis
l_0	Straight lap-splice length of longitudinal bars
l_{pl}	Plastic hinge length
n	Number of longitudinal bars laterally restrained by a stirrup corner or hook along the perimeter of the cross section or shear deformation contribution factor for steel members
s_w	Transverse reinforcement centreline spacing
t	Thickness of the square or rectangular HSS cross section
t_f	Flange thickness of I-shaped steel cross section
t_{sl}	Slab thickness above the steel deck

t_p	Thickness of web panel
t_w	Web thickness of I-shaped steel cross section
z	Internal lever arm of a reinforced concrete section

Upper case Greek symbols

Δ	Deflection at the end of the shear span of a structural member
Δ_l	Value of Δ on the left side of the point of contraflexure of a frame
Δ_r	Value of Δ on the right side of the point of contraflexure of a frame
Δ_u	Axial displacement at ultimate limit state for a BRB
Δ_u^{pl}	Plastic part of the deformation up to the peak axial resistance in tension and compression of a BRB
Δ_y	Value of Δ at yield; axial displacement at yield of a BRB
$\Delta\theta_{u,slip}$	Post-yield fixed-end rotation due to yield penetration in the anchorage zone beyond the yielding end of the member

Lower case Greek symbols

α	Confinement effectiveness factor
β	Factor for the evaluation of the effective flexural resistance at yield of a steel beam
γ_{CT}	Compression strength adjustment factor
γ_p	Shear distortion at ultimate of an EBF link or column web panel
γ_y	Yield shear distortion of the web panel
$\delta_t, \delta_c, \delta_u$	Steel brace axial displacement at yield in tension, at buckling in compression, and at ultimate limit state, respectively
δ_u^{pl}	Plastic part of ultimate deformation capacity of a member
δ_u^*	Deformation at ultimate capacity of a member corresponding to the attainment of the effective ultimate limit state resistance Q_u^*
δ_y	Deformation at yield, corresponding to the attainment of the effective yield resistance Q_y^*
ε_{c2}	Ultimate compression strain of (unconfined) concrete
$\varepsilon_{c2,c}$	Ultimate compression strain of confined concrete core
ε_{su}	Ultimate tensile strain of longitudinal bars
$\varepsilon_{su,nom}$	Uniform elongation at tensile strength in a standard steel coupon test
θ_l	Chord rotation on the left side of the point of contraflexure of a frame
θ_r	Chord rotation on the right side of the point of contraflexure of a frame

θ_{u0}^{pl}	Basic value of the plastic part of chord rotation capacity of a member
$\theta_u^{pl,+}$	Plastic part of rotation capacity of composite steel-concrete beams under sagging
$\theta_u^{pl,-}$	Plastic part of rotation capacity of composite steel-concrete beams under hogging
κ_{axial}	Correction factor of plastic chord rotation capacity for an axial force different than zero
$\kappa_{concrete}$	Correction factor of plastic chord rotation capacity for concrete strength different than 25 MPa
$\kappa_{confinement}$	Correction factor of plastic chord rotation capacity considering the confinement of concrete due to transverse bars
$\kappa_{conform}$	Correction factor of plastic chord rotation capacity, accounting for structures conforming to a given ductility class (DC)
κ_{reinf}	Correction factor of plastic chord rotation capacity for asymmetrical reinforcement
$\kappa_{shearspan}$	Correction factor of plastic chord rotation capacity for a shear span ratio different from 2,5
$\lambda, \lambda_{Cl,1}$	Critical local slenderness ratio for the steel brace cross section and corresponding local slenderness for Class 1 HSS sections, respectively
$\lambda_{Cl,1}$	Limit of width-to-thickness ratio of class 1 cross section
λ_{axial}	Correction factor of plastic hinge length accounting for axial force
λ_f	Width-to-thickness ratio of a cross section
$\lambda_{section}$	Correction factor of plastic hinge length accounting for section dimensions
$\lambda_{shearspan}$	Correction factor of plastic hinge length accounting for shear span
ν	Normalised axial force
ν_G	Axial load ratio of the steel column due to the non-seismic actions in the seismic design situation
ρ'	Geometrical ratio of the bars under compression
ρ_{sw}	Volumetric ratio of transverse reinforcement in the direction of shear
ρ_{tot}	Geometrical ratio of all longitudinal bars
χ_{LT}	Reduction factor for lateral torsional buckling
ϕ_u	Ultimate curvature at the end-section calculated from a section analysis
ϕ_y	Yield curvature at the end-section calculated from a section analysis
ω_{rm}	Material randomness factor, i.e. the ratio between the expected average yield strength of steel products of a certain steel grade and the nominal yield strength of that steel grade; for aluminium, it corresponds to the ratio of the expected (i.e. average) value of the conventional elastic limit f_o to its design value from EN 1999-1-1
ω'	Mechanical ratio of the bars under compression

ω_{tot}	Mechanical ratio of all longitudinal bars
ω_{sh}	Hardening factor of the BRB core

3.2.1.5 Further symbols used in Annex B

Lower case Latin symbols

f_0	Fundamental frequency of the soil deposit
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3.2.1.6 Further symbols used in Annex E

Upper case Latin symbols

F_3, F_4	Forces corresponding to the characteristic points from the idealised force-displacement relationship
N_a	Number of accelerograms
$S_{e,LS}$	Limit-state spectral acceleration, i.e. the median value of spectral acceleration at the predominant vibration period of the structure which causes a designated limit state
$S_{e,LS,i}$	Limit-state spectral acceleration corresponding to the i -th accelerogram, i.e. the value of spectral acceleration at the predominant vibration period of the structure which causes a designated limit state in the case of the i -th accelerogram

Lower case Latin symbols

c	Coefficient of damping of an equivalent SDOF model
d_3, d_4	Displacements corresponding to the characteristic points from the idealised force-displacement relationship
$d_{t,i}^*$	Peak displacement of the equivalent SDOF model for the i -th accelerogram
k^*	Initial stiffness of the equivalent SDOF model

3.2.1.7 Further symbols used in Annex F

Upper case Latin symbols

$H(S_e)$	Seismic hazard function, i.e. the median of annual frequency of exceedance of S_e
$H(S_{e,LS})$	Median of annual frequency of exceedance of $S_{e,LS}$
$S_e(T_1) = S_e$	Spectral acceleration at the predominant period of the structure
$S_{e,LS}$	Limit-state spectral acceleration, i.e. the median value of spectral acceleration (at the predominant vibration period of the structure) which causes the designated LS
$S_{e,ref}$	Value of spectral acceleration at the predominant period of structure T_1 , corresponding to the reference return period T_{ref} of the seismic action for SD limit state
P_{LS}	Annual probability of exceedance of a specific limit state

$P(LS S_e)$	Probability that the ground motion with intensity equal to S_e will cause the exceedance of limit state LS
$P_{t,LS,CC}$	Target annual probability of exceedance of a specific limit state for a given consequence class of the structure

Lower case Latin symbols

k	Negative slope of the seismic hazard curve for S_e in logarithmic domain
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Upper case Greek symbols

Φ	Cumulative distribution function of the standardised Normal distribution
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Lower case Greek symbols

$\beta_{Se,LS}$	Logarithmic standard deviation of $S_{e,LS}$
$\beta_{Se,LS,min}$	Minimum value of the $\beta_{Se,LS}$
$\beta_{Se,LS,max}$	Maximum value of the $\beta_{Se,LS}$

3.2.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

BRB	Buckling restrained braces
CCi	Consequence classes, $i = 1, 2$ or 3 (possibly subdivided in 3-a and 3-b, depending on the relevant part of Eurocode 8)
CPT	Cone penetration test
CQC	Complete quadratic combination
DC1	Ductility class 1
DC2	Ductility class 2
DC3	Ductility class 3
DL	Damage limitation
EBF	Eccentrically braced frame
ER	Energy ratio for the standard penetration test
ETA	European Technical Assessment
ETPS	European Technical Product Specification
FVT	Field vane test
HSS	Hollow structural steel
LS	Limit state
MDOF	Multi-degree-of-freedom

NC	Near collapse
OP	Fully operational
PGA	Peak ground acceleration
PGD	Peak ground displacement
PGV	Peak ground velocity
PMT	Pressuremeter test
RBS	Reduced beam section
SD	Significant damage
SDOF	Single-degree-of-freedom
SLS	Serviceability limit state
SPT	Standard penetration test
SRSS	Square root of the sum of the squares
SSI	Soil-structure interaction
ULS	Ultimate limit state

3.3 S.I. Units

For the purposes of this document, the S.I. Units given in ISO 80000 apply.

For calculations, the following units are used when applicable:

- mass: kg
- mass density: kg/m³
- forces and loads: N, kN, N/m, kN/m, N/m², kN/m²
- unit weight: N/m³, kN/m³
- stresses and strengths: Pa (= N/m²), kPa (= kN/m²), MPa (= MN/m²)
- moments (bending, etc.): Nm, kNm
- time: s
- displacement and length: m
- velocity: m/s
- acceleration: m/s²

4 Basis of design

4.1 Performance objectives

(1) Structures shall be designed so that, in the event of earthquakes, the following performance requirements are met with an appropriate degree of reliability:

- human lives are protected;
- damage is limited;
- facilities important for civil protection remain operational.

NOTE 1 The random nature of the seismic events and the necessary optimal allocation of limited economic resources are such as to make the attainment of these goals only measurable in probabilistic terms. Annex F provides a basis for measuring performance of structures in probabilistic terms.

NOTE 2 Strong ground motions generated by individual earthquakes are not predictable in a deterministic way. Therefore, the purpose of EN 1998 (all parts) is not to determine the seismic response of structures in the event of a specific earthquake, but rather to limit the overall consequences of earthquakes.

(2) In order to meet the performance requirements in (1), it shall be verified that structures are designed in such a way that specified limit states are not exceeded under prescribed seismic actions.

NOTE Seismic actions are introduced in this standard to meet the performance requirements despite the unpredictable variability of the seismic input motion. Such actions are to be regarded as conventional and cannot be related to any specific earthquake event.

(3) It shall be verified that ancillary elements are designed in such a way that the performance requirements in (1) are met under the design seismic action.

(4) The seismic design cases should be categorised in seismic action classes according to Table 4.1, depending on the value of the seismic action index, S_δ , defined by Formula (4.1).

$$S_\delta = \delta F_\alpha F_T S_{\alpha,475} \quad (4.1)$$

where

- δ is a coefficient that depends on the consequence class of the considered structure;
- F_α is the site amplification factor given in 5.2.2.2(5);
- F_T is the topography amplification factor given in 5.2.2.2(10);
- $S_{\alpha,475}$ is the reference maximum spectral acceleration for the return period of 475 years (see 5.2.1(2)).

Table 4.1 — Range of S_δ values to define seismic action classes

Seismic action class	Range of seismic action index
Very low	$S_\delta < 1,30 \text{ m/s}^2$
Low	$1,30 \text{ m/s}^2 \leq S_\delta < 3,25 \text{ m/s}^2$
Moderate	$3,25 \text{ m/s}^2 \leq S_\delta < 6,50 \text{ m/s}^2$
High	$S_\delta \geq 6,50 \text{ m/s}^2$

NOTE 1 The values of δ are given in the relevant parts of Eurocode 8 according to the type of structure considered.

NOTE 2 Values in Table 4.1 are calibrated based on seismicity levels presented in Table 5.2 for buildings of consequence class CC2, with an assumed 1,3 value for lumped effects of site and topography amplification factors.

(5) The provisions of EN 1998 (all parts) may be neglected in cases of very low seismic action class.

(6) In cases of low seismic action class and for well-defined categories of structures, the performance requirements may be satisfied through the application of rules simpler than those given in the relevant parts of Eurocode 8.

NOTE If any, the categories of structures, with their associated design and verification rules, for which (6) applies in a country can be provided by the relevant authorities or can be found in the National Annex.

(7) For specific structures as specified in the relevant parts of Eurocode 8, structures may be verified by the force-based approach given in 6.4, applying a) to e):

- a) the material partial factor values to consider in the verifications at ULS are those of the seismic design situation;
- b) $R_q(T) = 1$ in 6.4.1(6);
- c) $q_v = 1$ in 6.4.1(7);
- d) Clause 5, 6.2.1, 6.2.2, 6.7.1(1), (2), (5) and (6), 6.7.2(4), 6.7.3(5) and (7), are applied;
- e) other conditions should be applied as given in the relevant parts of Eurocode 8.

NOTE This excludes the use of this option for structures not explicitly mentioned in the corresponding parts.

(8) The performance requirements should be defined for the construction phase in terms of consequence class (see 4.2), limit states to be verified (see 4.3) and associated seismic action.

(9) Verification may be neglected for the construction phase, unless such verification is specified by the relevant authorities or, where not specified, agreed for a specific project by the relevant parties.

4.2 Consequence classes

(1) Consequence classes defined in EN 1990:2023, 3.1.2.32 and 4.3(1), shall be used for the application of EN 1998 (all parts).

NOTE Structures belonging to consequence class CC4 are not fully covered by the Eurocodes. The categories of structures of consequence class CC4 where Eurocode 8, or parts of it, apply in a country can be provided in the National Annex.

(2) Structures should be regarded as belonging to consequence class CC2 if not otherwise specified.

(3) Consequence class CC3 may be divided into two subclasses, CC3-a and CC3-b, depending on the importance of the structures for public safety and civil protection in the immediate post-earthquake period.

NOTE For a given type of structure, guidance for classification in CC3-a or CC3-b is given in the relevant part of Eurocode 8.

4.3 Limit states and associated seismic action

(1) The seismic performance of a structure shall be measured by its state of damage under a given seismic action.

(2) The state of damage shall be referred to the four limit states (LS), defined in a) to d), for EN 1998 (all parts):

- a) LS of Near Collapse (NC) shall be defined as one in which the structure is heavily damaged, with large permanent drifts, but retains its vertical load bearing capacity; most ancillary components, where present, have collapsed;

- b) LS of significant damage (SD) shall be defined as one in which the structure is significantly damaged, possibly with moderate permanent drifts, but retains its vertical load bearing capacity; ancillary components, where present, are moderately damaged (e.g. partitions and infills are damaged but have not yet failed out-of-plane). The structure is expected to be repairable but, in some cases, it may be uneconomic to repair;
- c) LS of damage limitation (DL) shall be defined as one in which the structure is only slightly damaged and economic to repair, with negligible permanent drifts, undiminished ability to withstand future earthquakes and structural members retaining their full strength with a limited decrease in stiffness; ancillary components, where present, exhibit only minor damage that can be economically repaired (e.g. partitions and infills may show distributed cracking);
- d) fully operational LS (OP) shall be defined as one in which the structure is only slightly damaged and economic to repair, allowing continuous operation of systems hosted by the structure.

NOTE Quantitative definition of limit states is introduced in some cases at the relevant parts of Eurocode 8.

(3) SD and NC limits states should be considered as Ultimate Limit States. DL and OP limit states should be considered as Serviceability Limit States.

NOTE Ultimate limit states (ULS) and serviceability limit states (SLS) are defined in EN 1990:2023, 5.3 and 5.4, respectively.

(4) Except when (6) is used, seismic actions should be specified in terms of their return periods. The attainment of the performance requirements should be achieved by selecting appropriate return periods, $T_{LS,CC}$, depending on the specified limit states, LS, and consequence class, CC, of the structures.

NOTE 1 For a given type of structure, $T_{LS,CC}$ values are given in the relevant parts of Eurocode 8. For each limit state and consequence class, the return period is related to the target reliability, expressed in terms of target reliability index $\beta_{t,LS,CC}$ in the service life t_L of the structure, as $T_{LS,CC} = -t_L / \ln \Phi(0,8 \beta_{t,LS,CC})$.

NOTE 2 Values of $\beta_{t,LS,CC}$ are given in Annex F, Table F.1 (NDP).

(5) The value of the return period specified for limit state SD and consequence class CC2, $T_{SD,CC2}$ should be considered as the reference return period T_{ref} introduced in 5.2.1(3).

NOTE 1 The seismic action associated to $T_{SD,CC2}$ is designated as the “reference seismic action”.

NOTE 2 A return period T_R corresponds to a given probability of exceedance p in the service life t_L of the structure, as given by $T_R = -t_L / \ln(1 - p)$.

(6) Performance factors, $\gamma_{LS,CC}$, applied as multiplicative factors of the seismic action amplitude, may be used as an alternative to the return periods defined in (4). A value of 1,0 should be assigned to $\gamma_{SD,CC2}$.

NOTE 1 For a given type of structure, $\gamma_{LS,CC}$ values are given in the relevant part of Eurocode 8.

NOTE 2 The values of $\gamma_{LS,CC}$ correspond to the ratios of the intensities characterised by $T_{LS,CC}$ to the intensity characterised by T_{ref} , calculated with a value of the hazard slope $k = 3$, appropriate for the seismicity corresponding

to the moderate seismic action class, as given by $\gamma_{LS,CC} = \left(\frac{T_{LS,CC}}{T_{ref}} \right)^{\frac{1}{k}}$. See also 5.2.1(2) and the note on Formula (F.5).

4.4 Primary and secondary seismic members

(1) A certain number of structural members may be designated as secondary seismic members, not forming part of the seismic resisting system of the building.

NOTE The possible secondary seismic members are made explicit in the relevant parts of Eurocode 8.

(2) The strength and stiffness of these members in resisting seismic actions should be neglected in the models for seismic analysis unless specific conditions by type of structure are given in the relevant part.

(3) The secondary seismic members and their connections should be designed and detailed to maintain support to non-seismic actions in the seismic design situation, in particular vertical loads, when subjected to the displacements caused by the most unfavourable seismic design condition. Due allowance for second-order effects ($P-\Delta$ effects), in both the structure and these members, should be made in the design of secondary seismic members.

(4) All structural members not designated as being secondary seismic members should be taken as primary.

(5) The contribution of the lateral stiffness of secondary seismic members to the total stiffness should not significantly affect the dynamic behaviour of the structure.

NOTE 1 To fulfil this requirement, specific conditions by type of structure are given in the relevant parts of Eurocode 8.

NOTE 2 The effects of secondary seismic members on the local distribution of internal forces in primary seismic members are addressed in the relevant parts of Eurocode 8.

4.5 Compliance criteria for new structures

4.5.1 General

(1) To satisfy the seismic performance requirements for new structures according to EN 1998 (all parts):

- the requirements for design verification detailed in 4.5.2 shall be applied;
- the non-exceedance of the SD limit state shall be verified.

NOTE 1 EN 1998 (all parts) is conceived in such a way that, for a large majority of new structures, the SD non-exceedance requirement implies avoiding NC exceedance under a seismic action meaningfully more severe than that of design, as well as avoiding DL exceedance under a seismic action less severe than that of design. Additionally, by taking into account the consequence class of the structures, the SD non-exceedance requirement implicitly contributes, to some extent, to fully operational performance.

NOTE 2 Compliance criteria for assessment of existing structures are given in EN 1998-3.

(2) Limit states should be verified according to 6.7.

NOTE The choice of Limit States, in addition to SD, to be verified for each type of structure can be found in the National Annex to the corresponding part of Eurocode 8.

4.5.2 Design verification principles

(1) In order to ensure sufficient deformation capacity and cumulative energy dissipation capacity that are necessary to meet the performance requirements, brittle failure or the premature formation of unstable mechanisms shall be avoided.

NOTE 1 EN 1998 (all parts) considers that performance requirements are attained by a combination of strength, deformation capacity and cumulative energy dissipation capacity. It also takes into account overstrength resulting from the application of the other relevant Eurocodes.

NOTE 2 Two main approaches are used in Eurocode 8 to verify the adequate combination of strength, deformation capacity and cumulative energy dissipation capacity: the force-based approach and the displacement-based approach (see 6.4 to 6.6). In addition, for structures with energy dissipation systems, a method based on energy balance is applied (see 6.8).

(2) 4.5.2(1) may be considered as satisfied when the capacity design procedure is used, where required in the relevant parts of Eurocode 8. This procedure should be used to obtain the hierarchy of resistance of the various structural components and failure modes necessary for ensuring sufficient deformation capacity and cumulative energy dissipation capacity.

(3) For a proper implementation of the capacity design procedure, the detailing of connections between structural members and of regions where non-linear behaviour is foreseen should receive special care in design.

(4) Structures should be categorised into three ductility classes, based on their deformation capacity and cumulative energy dissipation capacity: DC1 (Ductility Class 1), DC2 (Ductility Class 2) and DC3 (Ductility Class 3).

NOTE 1 In DC1, the overstrength capacity is taken into account, while the inelastic deformation capacity and energy dissipation capacity are disregarded.

NOTE 2 In DC2, the local overstrength capacity, the local deformation capacity and the local energy dissipation capacity are taken into account. Global plastic mechanisms are controlled by limited verifications.

NOTE 3 In DC3, the ability of the structure to form a global plastic mechanism at SD limit state is verified and its local overstrength capacity, local deformation capacity and local energy dissipation capacity are taken into account.

(5) Categorisation of a structure as DC1, DC2 or DC3 should be based on its compliance with provisions that are specified in the relevant part of Eurocode 8.

(6) In order to meet the performance requirements, it should be verified that all structural members, as well as their connections and relevant ancillary elements have a resistance not lower than the corresponding action effects in the seismic design situation (see 6.7).

(7) Calculation of action effects and resistances should depend on the selected approach (force-based or displacement-based, see 6.1) and on the ductility class.

NOTE Rules applicable to a given type of structures are given in the relevant parts of Eurocode 8.

(8) The foundations should transmit the actions received from the superstructure to the ground as uniformly as possible.

NOTE This implies a sufficient stiffness of the foundation elements according to EN 1998-5.

(9) In addition to 4.1(3), ancillary elements should be designed in such a way that they do not have a detrimental effect on the dynamic response of the structure.

(10) In the seismic design situation, fastenings to concrete shall be designed according to Annex G.