Overview of Eurocode 8

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Structural Eurocodes

- **EN1990 Eurocode: *Basis of structural design***
- **EN1991 Eurocode 1: *Actions on structures***
- **EN1992 Eurocode 2: *Design of concrete structures***
- **EN1993 Eurocode 3: *Design of steel structures***
- **EN1994 Eurocode 4: *Design of composite steel and concrete structures***
- **EN1995 Eurocode 5: *Design of timber structures***
- **EN1996 Eurocode 6: *Design of masonry structures***
- **EN1997 Eurocode 7: *Geotechnical design***
- **EN1998 Eurocode 8: *Design of structures for earthquake resistance***
- **EN1999 Eurocode 9: *Design of aluminium structures***

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Nationally Determined Parameters

Parameters which are left open in the Eurocodes for national choice (NDPs - Nationally Determined Parameters):

- ***values and/or classes where alternatives are given in the Eurocode,***
- ***values to be used where a symbol only is given in the Eurocode,***
- ***country specific data (geographical, climatic, etc.), e.g. snow map,***
- ***the procedure to be used where alternative procedures are given in the Eurocode.***

It may also contain

- ***decisions on the application of informative annexes,***
- ***references to non-contradictory complementary information to assist the user to apply the Eurocode.***

To be defined in the National Annexes

Eurocode 8 - Design of structures for earthquake resistance

- EN1998-1: **General** rules, seismic **actions** and rules for **buildings**
- EN1998-2: Bridges
- EN1998-3: **Assessment** and retrofitting of buildings
- EN1998-4: Silos, tanks and pipelines
- EN1998-5: **Foundations**, retaining structures and geotechnical aspects
- EN1998-6: Towers, masts and chimneys

EN1998-1: **General rules, seismic actions and rules for buildings**

EN1998-1 to be applied in combination with other Eurocodes

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1998-1

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ICS 91.120.25

Supersedes ENV 1998-1-1:1994, ENV 1998-1-2:1994, ENV 1998-1-3:1995

English version

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

Eurocode 8: Calcul des structures pour leur résistance aux séismes - Partie 1: Règles générales, actions sismiques et règles pour les bâtiments

Eurocode 8: Auslegung von Bauwerken gegen Erdbeben - Teil 1: Grundlagen, Erdbebeneinwirkungen und Regeln für Hochbauten

This European Standard was approved by CEN on 23 April 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 1998-1:2004: E

Contents of EN 1998-1

- **General**
- **Performance requirements and compliance criteria**
- **Ground conditions and seismic action**
- **Design of buildings**
- **Specific rules for:**

  Concrete buildings

  Steel buildings

  Composite Steel-Concrete buildings

  Timber buildings

  Masonry buildings
- **Base isolation**

Nationally Determined Parameters

Nationally Determined Parameters (NDPs) in EN 1998-1:

General aspects and definition of the seismic action:	11
Modelling, analysis and design of buildings:	7
Concrete buildings:	11
Steel buildings:	6
Composite buildings:	4
Timber buildings:	1
Masonry buildings:	15
Base isolation:	1
TOTAL	56

Objectives

Objectives of seismic design according to Eurocode 8

In the event of earthquakes:

Human lives are protected

Damage is limited

Structures important for civil protection remain operational

Special structures – Nuclear Power Plants, Offshore structures, Large Dams **– outside the scope of EN 1998**

Fundamental requirements

No-collapse requirement:

Withstand the design seismic action **without** local or global **collapse**

Retain structural integrity and **residual load bearing** capacity after the event

Requirement related to the protection of life under a rare event through the prevention of local or global collapse.
After the event a structure may economically unrecoverable but should ensure safe evacuation protection against after shocks

Requirement associated with the **Ultimate Limit State** (ULS) in the framework of the Eurocodes

Fundamental requirements

No-collapse requirement:

For ordinary structures this requirement should be met for a **reference seismic action** with 10 % probability of exceedance in 50 years (recommended value) i.e. with **475 years Return Period**

Fundamental requirements

Damage limitation requirement:

Withstand a more frequent seismic action without damage

Avoid limitations of use with high costs

Requirement related to the reduction of economic losses in frequent earthquakes (structural and non-structural).
The structure should not have permanent deformations and its elements should retain its original strength and stiffness with no need for structural repair. Non-structural damages repairable economically.

Requirement associated with the **Serviceability Limit State** (SLS) in the framework of the Eurocodes

Fundamental requirements

Damage limitation requirement:

For ordinary structures this requirement should be met for a **seismic action** with 10 % probability of exceedance in 10 years (recommended value) i.e. with **95 years Return Period**

Reliability differentiation

Target reliability of requirement depending on consequences of failure

Classify the structures into importance classes

Assign a higher or lower return period to the design seismic action

In operational terms multiply the **reference seismic action** by the **importance factor γ_I**

Importance classes for buildings

EN 1998-1:2004 (E)

Table 4.3 Importance classes for buildings

Importance class	Buildings
I	Buildings of minor importance for public safety, e.g. agricultural buildings, etc.
II	Ordinary buildings, not belonging in the other categories.
III	Buildings whose seismic resistance is of importance in view of the consequences associated with a collapse, e.g. schools, assembly halls, cultural institutions etc.
IV	Buildings whose integrity during earthquakes is of vital importance for civil protection, e.g. hospitals, fire stations, power plants, etc.

NOTE Importance classes I, II and III or IV correspond roughly to consequences classes CC1, CC2 and CC3, respectively, defined in EN 1990:2002, Annex B.

Importance factor and return period

At most sites the annual rate of exceedance, $H(a_{gR})$, of the reference peak ground acceleration a_{gR} may be taken to vary with a_{gR} as:

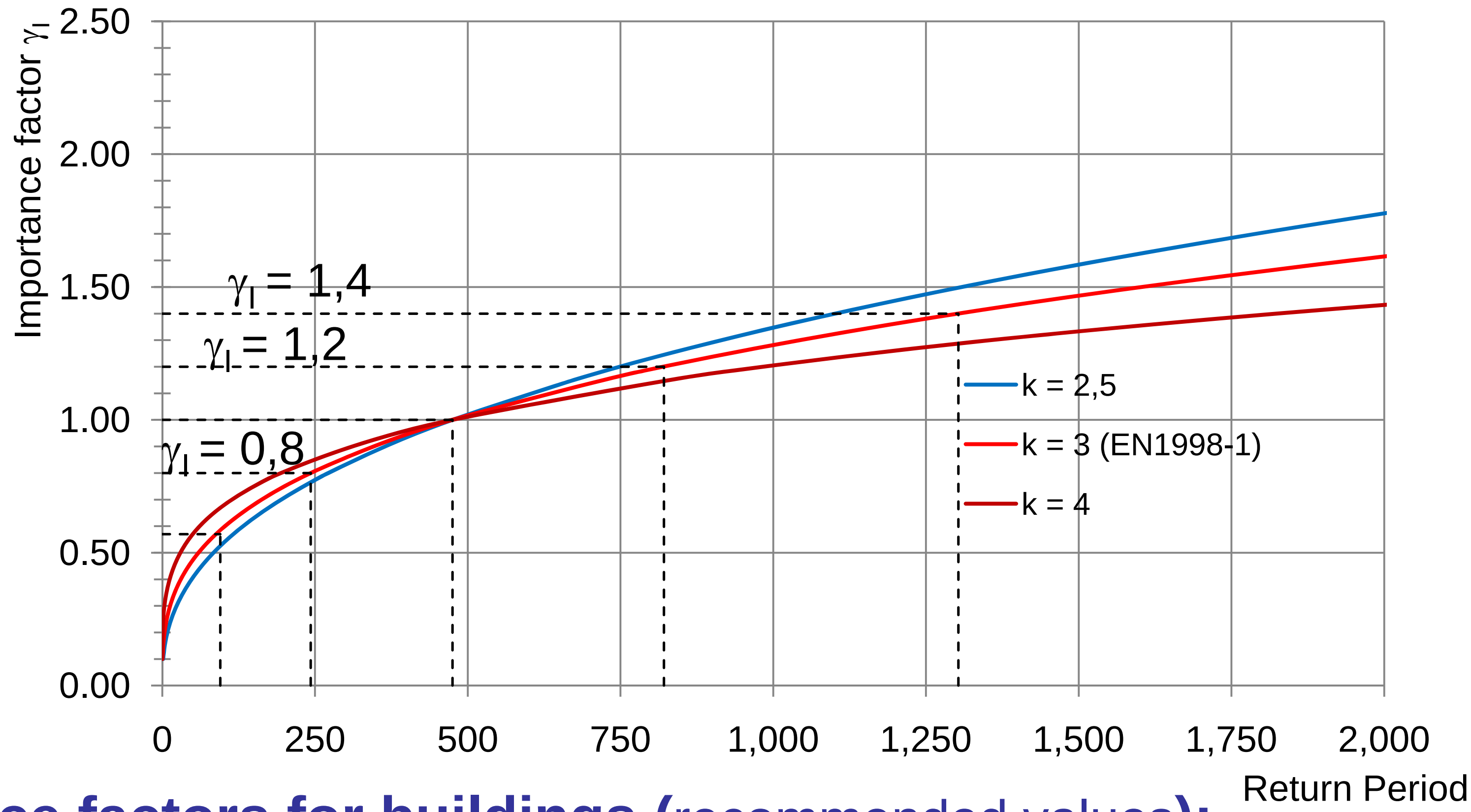
$$H(a_{gR}) \sim k_0 \, a_{gR}^{-k}$$

with the value of the exponent k depending on seismicity, but being generally of the order of 3.

If the seismic action is defined in terms of the reference peak ground acceleration a_{gR}, the value of the importance factor γ_I multiplying the reference seismic action to achieve the same probability of exceedance in T_L years as in the T_{LR} years for which the reference seismic action is defined, may be computed as

$$\gamma_I \sim (T_{LR}/T_L)^{-1/k}.$$

Importance factor and return period



Importance factors for buildings (recommended values**):**

$$\gamma_I = 0{,}8\ (I);\ 1{,}0\ (II);\ 1{,}2\ (III)\ \text{and}\ 1{,}4\ (IV)$$

Reduction factor (recommended values) **to account for the lower return period for damage limitation verification:**

$$\nu = 0{,}4\ (III\ \text{and}\ IV)\ \text{or}\ 0{,}5\ (I\ \text{and}\ II)$$

Compliance criteria

Ultimate limit state (ULS)

The resistance and energy-dissipation capacity to be assigned to the structure are related to the extent to which its non-linear response is to be exploited

In operational terms such balance between resistance and energy-dissipation capacity is characterised by the values of the behaviour factor q and the associated ductility classes

Compliance criteria

Ultimate limit state (ULS)

As a limiting case, for the design of structures classified as low-dissipative, no account is taken of any hysteretic energy dissipation and the behaviour factor may not be taken, in general, as being greater than the value of 1,5 considered to account for overstrengths

For dissipative structures the behaviour factor is taken as being greater than this limiting values, accounting for the hysteretic energy dissipation that mainly occurs in specifically designed zones, called dissipative zones or critical regions

Compliance criteria

Design verifications

Ultimate limit state (ULS)

Resistance and **Energy dissipation** capacity

Ductility classes and **Behaviour factor** values

Overturning and sliding **stability check**

Resistance of foundation elements and soil

Second order effects

Non detrimental effect of **non structural elements**

Simplified checks for **low seismicity** cases (a_g < 0,08 g)

No application of EN 1998 for **very low seismicity** cases (a_g < 0,04 g)

Compliance criteria

Design verifications

Damage limitation state (DLS/SLS)

Deformation limits (Maximum interstorey drift due to the "frequent" earthquake):

- **0,5 %** for **brittle** non structural elements **attached** to the structure
- **0,75 %** for **ductile** non structural elements **attached** to the structure
- **1,0 %** for non structural elements **not interfering** with the structure

Sufficient stiffness of the structure for the operationality of vital services and equipment

DLS may control the design in many cases

Compliance criteria

Design verifications

Take <u>Specific Measures</u> intended to reduce the uncertainty and promote a good behaviour of the structure, even under seismic actions more severe than the design seismic action

Implicitly equivalent to the satisfaction of a third performance requirement:

Prevention of global collapse* *under a very rare event (1.500 to 2.000 years return period).

Denoted Near Collapse (NC) Limit State in EN 1998-3, very close to the actual collapse of the structure and corresponds to the full exploitation of the deformation capacity of the structural elements

Compliance criteria

Specific measures

Simple and regular forms (plan and elevation)

Control the **hierarchy of resistances** and sequence of failure modes (capacity design)

Avoid brittle failures

Control the behaviour of **critical regions** (detailing)

Use **adequate structural model** (soil deformability and non strutural elements if appropriate)

In zones of **high seismicity** formal **Quality Plan** for **Design, Construction** and **Use** is **recommended**