

# **Eurocode 8: Design of structures for earthquake resistance —**

## **Part 1: General rules, seismic actions and rules for buildings**

The European Standard EN 1998-1:2004 has the status of a  
British Standard

ICS 91.120.25

## National foreword

This British Standard is the official English language version of EN 1998-1:2004. It supersedes DD ENV 1998-1-1:1996, DD ENV 1998-1-2:1996 and DD ENV 1998-1-3:1996 which are withdrawn.

The structural Eurocodes are divided into packages by grouping Eurocodes for each of the main materials, concrete, steel, composite concrete and steel, timber, masonry and aluminium. This is to enable a common date of withdrawal (DOW) for all the relevant parts that are needed for a particular design. The conflicting national standards will be withdrawn at the end of the coexistence period, after all the EN Eurocodes of a package are available.

Following publication of the EN, there is a period of 2 years allowed for the national calibration period during which the national annex is issued, followed by a three year coexistence period. During the coexistence period Member States will be encouraged to adapt their national provisions to withdraw conflicting national rules before the end of the coexistent period. The Commission in consultation with Member States is expected to agree the end of the coexistence period for each package of Eurocodes.

The UK participation in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/8, Structures in seismic regions, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Where a normative part of this EN allows for a choice to be made at the national level, the range and possible choice will be given in the normative text, and a note will qualify it as a Nationally Determined Parameter (NDP). NDPs can be specific value for a factor, a specific level or class, a particular method or a particular application rule if several are proposed in the EN.

To enable EN 1998 to be used in the UK, the NDPs will be published in a National Annex, which will be made available by BSI in due course, after public consultation has taken place.

There are generally no requirements in the UK to consider seismic loading, and the whole of the UK may be considered an area of very low seismicity in which the provisions of EN 1998 need not apply. However, certain types of structure, by reason of their function, location or form, may warrant an explicit consideration of seismic actions. It is the intention in due course to publish separately background information on the circumstances in which this might apply in the UK.

### Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

### Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 229 and a back cover.

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### Amendments issued since publication

Amd. No.	Date	Comments

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.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



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

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

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## Foreword

This European Standard EN 1998-1, Eurocode 8: Design of structures for earthquake resistance: General rules, seismic actions and rules for buildings, 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.

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 June 2005, and conflicting national standards shall be withdrawn at latest by March 2010.

This document supersedes ENV 1998-1-1:1994, ENV 1998-1-2:1994 and ENV 1998-1-3:1995.

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

## Background of the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonisation of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonised technical rules for the design of construction works which, in a first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980's.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement<sup>1</sup> between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links *de facto* the Eurocodes with the provisions of all the Council's Directives and/or Commission's Decisions dealing with European standards (*e.g.* the Council Directive 89/106/EEC on construction products - CPD - and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

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<sup>1</sup> Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on EUROCODES for the design of building and civil engineering works (BC/CEN/03/89).

The Structural Eurocode programme comprises the following standards generally consisting of a number of Parts:

- EN 1990 Eurocode: Basis of structural 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

Eurocode standards recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level where these continue to vary from State to State.

### **Status and field of application of Eurocodes**

The Member States of the EU and EFTA recognise that Eurocodes serve as reference documents for the following purposes:

- as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 - Mechanical resistance and stability - and Essential Requirement N°2 - Safety in case of fire;
- as a basis for specifying contracts for construction works and related engineering services;
- as a framework for drawing up harmonised technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents<sup>2</sup> referred to in Article 12 of the CPD, although they are of a different nature from harmonised product standards<sup>3</sup>. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by

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<sup>2</sup> According to Art. 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for hENs and ETAGs/ETAs.

<sup>3</sup> According to Art. 12 of the CPD the interpretative documents shall :

- a) give concrete form to the essential requirements by harmonising the terminology and the technical bases and indicating classes or levels for each requirement where necessary ;
- b) indicate methods of correlating these classes or levels of requirement with the technical specifications, e.g. methods of calculation and of proof, technical rules for project design, etc. ;
- c) serve as a reference for the establishment of harmonised standards and guidelines for European technical approvals.

The Eurocodes, *de facto*, play a similar role in the field of the ER 1 and a part of ER 2.

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CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving a full compatibility of these technical specifications with the Eurocodes.

The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

### **National Standards implementing Eurocodes**

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National annex (informative).

The National annex may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, i.e. :

- 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.

### **Links between Eurocodes and harmonised technical specifications (ENs and ETAs) for products**

There is a need for consistency between the harmonised technical specifications for construction products and the technical rules for works<sup>4</sup>. Furthermore, all the information accompanying the CE Marking of the construction products which refer to Eurocodes shall clearly mention which Nationally Determined Parameters have been taken into account.

### **Additional information specific to EN 1998-1**

The scope of EN 1998 is defined in **1.1.1** and the scope of this Part of EN 1998 is defined in **1.1.2**. Additional Parts of EN 1998 are listed in **1.1.3**.

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<sup>4</sup> See Art.3.3 and Art.12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

EN 1998-1 was developed from the merger of ENV 1998-1-1:1994, ENV 1998-1-2:1994 and ENV 1998-1-3:1995. As mentioned in **1.1.1**, attention must be paid to the fact that for the design of structures in seismic regions the provisions of EN 1998 are to be applied in addition to the provisions of the other relevant EN 1990 to EN 1997 and EN 1999.

One fundamental issue in EN 1998-1 is the definition of the seismic action. Given the wide difference of seismic hazard and seismo-genetic characteristics in the various member countries, the seismic action is herein defined in general terms. The definition allows various Nationally Determined Parameters (NDP) which should be confirmed or modified in the National Annexes.

It is however considered that, by the use of a common basic model for the representation of the seismic action, an important step is taken in EN 1998-1 in terms of Code harmonisation.

EN 1998-1 contains in its section related to masonry buildings specific provisions which simplify the design of "simple masonry buildings".

### National annex for EN 1998-1

This standard gives alternative procedures, values and recommendations for classes with notes indicating where national choices may be made. Therefore the National Standard implementing EN 1998-1 should have a National Annex containing all Nationally Determined Parameters to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

National choice is allowed in EN 1998-1:2004 through clauses:

Reference	Item
1.1.2(7)	Informative Annexes A and B.
2.1(1)P	Reference return period $T_{NCR}$ of seismic action for the no-collapse requirement (or, equivalently, reference probability of exceedance in 50 years, $P_{NCR}$ ).
2.1(1)P	Reference return period $T_{DLR}$ of seismic action for the damage limitation requirement. (or, equivalently, reference probability of exceedance in 10 years, $P_{DLR}$ ).
3.1.1(4)	Conditions under which ground investigations additional to those necessary for design for non-seismic actions may be omitted and default ground classification may be used.
3.1.2(1)	Ground classification scheme accounting for deep geology, including values of parameters $S$ , $T_B$ , $T_C$ and $T_D$ defining horizontal and vertical elastic response spectra in accordance with <b>3.2.2.2</b> and <b>3.2.2.3</b> .
3.2.1(1), (2),(3)	Seismic zone maps and reference ground accelerations therein.
3.2.1(4)	Governing parameter (identification and value) for threshold of low seismicity .

3.2.1(5)	Governing parameter (identification and value) for threshold of very low seismicity .
3.2.2.1(4), 3.2.2.2(1)P	Parameters $S$ , $T_B$ , $T_C$ , $T_D$ defining shape of horizontal elastic response spectra.
3.2.2.3(1)P	Parameters $a_{vg}$ , $T_B$ , $T_C$ , $T_D$ defining shape of vertical elastic response spectra.
3.2.2.5(4)P	Lower bound factor $\beta$ on design spectral values.
4.2.3.2(8)	Reference to definitions of centre of stiffness and of torsional radius in multi-storey buildings meeting or not conditions (a) and (b) of <b>4.2.3.2(8)</b>
4.2.4(2)P	Values of $\varphi$ for buildings.
4.2.5(5)P	Importance factor $\gamma_I$ for buildings.
4.3.3.1 (4)	Decision on whether nonlinear methods of analysis may be applied for the design of non-base-isolated buildings. Reference to information on member deformation capacities and the associated partial factors for the Ultimate Limit State for design or evaluation on the basis of nonlinear analysis methods.
4.3.3.1 (8)	Threshold value of importance factor, $\gamma_I$ , relating to the permitted use of analysis with two planar models.
4.4.2.5 (2).	Overstrength factor $\gamma_{Rd}$ for diaphragms.
4.4.3.2 (2)	Reduction factor $\nu$ for displacements at damage limitation limit state
5.2.1(5)	Geographical limitations on use of ductility classes for concrete buildings.
5.2.2.2(10)	$q_o$ -value for concrete buildings subjected to special Quality System Plan.
5.2.4(1), (3)	Material partial factors for concrete buildings in the seismic design situation.
5.4.3.5.2(1)	Minimum web reinforcement of large lightly reinforced concrete walls
5.8.2(3)	Minimum cross-sectional dimensions of concrete foundation beams.
5.8.2(4)	Minimum thickness and reinforcement ratio of concrete foundation slabs.
5.8.2(5)	Minimum reinforcement ratio of concrete foundation beams.
5.11.1.3.2(3)	Ductility class of precast wall panel systems.
5.11.1.4	$q$ -factors of precast systems.
5.11.1.5(2)	Seismic action during erection of precast structures.
5.11.3.4(7)e	Minimum longitudinal steel in grouted connections of large panel

	walls.
6.1.2(1)	Upper limit of $q$ for low-dissipative structural behaviour concept; limitations on structural behaviour concept; geographical limitations on use of ductility classes for steel buildings.
6.1.3(1)	Material partial factors for steel buildings in the seismic design situation.
6.2(3)	Overstrength factor for capacity design of steel buildings.
6.2 (7)	Information as to how EN 1993-1-10:2004 may be used in the seismic design situation
6.5.5(7)	Reference to complementary rules on acceptable connection design
6.7.4(2)	Residual post-buckling resistance of compression diagonals in steel frames with $V$ -bracings.
7.1.2(1)	Upper limit of $q$ for low-dissipative structural behaviour concept; limitations on structural behaviour concept; geographical limitations on use of ductility classes for composite steel-concrete buildings.
7.1.3(1), (3)	Material partial factors for composite steel-concrete buildings in the seismic design situation.
7.1.3(4)	Overstrength factor for capacity design of composite steel-concrete buildings
7.7.2(4)	Stiffness reduction factor for concrete part of a composite steel-concrete column section
8.3(1)	Ductility class for timber buildings.
9.2.1(1)	Type of masonry units with sufficient robustness.
9.2.2(1)	Minimum strength of masonry units.
9.2.3(1)	Minimum strength of mortar in masonry buildings.
9.2.4(1)	Alternative classes for perpend joints in masonry
9.3(2)	Conditions for use of unreinforced masonry satisfying provisions of EN 1996 alone.
9.3(2)	Minimum effective thickness of unreinforced masonry walls satisfying provisions of EN 1996 alone.
9.3(3)	Maximum value of ground acceleration for the use of unreinforced masonry satisfying provisions of EN. 1998-1
9.3(4), Table 9.1	$q$ -factor values in masonry buildings.
9.3(4), Table 9.1	$q$ -factors for buildings with masonry systems which provide enhanced ductility.
9.5.1(5)	Geometric requirements for masonry shear walls.
9.6(3)	Material partial factors in masonry buildings in the seismic design situation.

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9.7.2(1)	Maximum number of storeys and minimum area of shear walls of “simple masonry building”.
9.7.2(2)b	Minimum aspect ratio in plan of “simple masonry buildings”.
9.7.2(2)c	Maximum floor area of recesses in plan for “simple masonry buildings”.
9.7.2(5)	Maximum difference in mass and wall area between adjacent storeys of “simple masonry buildings”.
10.3(2)P	Magnification factor on seismic displacements for isolation devices.



## 1 GENERAL

### 1.1 Scope

#### 1.1.1 Scope of EN 1998

(1)P EN 1998 applies to the design and construction of buildings and civil engineering works in seismic regions. Its purpose is to ensure that in the event of earthquakes:

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

NOTE The random nature of the seismic events and the limited resources available to counter their effects are such as to make the attainment of these goals only partially possible and only measurable in probabilistic terms. The extent of the protection that can be provided to different categories of buildings, which is only measurable in probabilistic terms, is a matter of optimal allocation of resources and is therefore expected to vary from country to country, depending on the relative importance of the seismic risk with respect to risks of other origin and on the global economic resources.

(2)P Special structures, such as nuclear power plants, offshore structures and large dams, are beyond the scope of EN 1998.

(3)P EN 1998 contains only those provisions that, in addition to the provisions of the other relevant Eurocodes, must be observed for the design of structures in seismic regions. It complements in this respect the other Eurocodes.

(4) EN 1998 is subdivided into various separate Parts (see **1.1.2** and **1.1.3**).

#### 1.1.2 Scope of EN 1998-1

(1) EN 1998-1 applies to the design of buildings and civil engineering works in seismic regions. It is subdivided in 10 Sections, some of which are specifically devoted to the design of buildings.

(2) Section **2** of EN 1998-1 contains the basic performance requirements and compliance criteria applicable to buildings and civil engineering works in seismic regions.

(3) Section **3** of EN 1998-1 gives the rules for the representation of seismic actions and for their combination with other actions. Certain types of structures, dealt with in EN 1998-2 to EN 1998-6, need complementing rules which are given in those Parts.

(4) Section **4** of EN 1998-1 contains general design rules relevant specifically to buildings.

(5) Sections **5** to **9** of EN 1998-1 contain specific rules for various structural materials and elements, relevant specifically to buildings as follows:

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- Section 5: Specific rules for concrete buildings;
- Section 6: Specific rules for steel buildings;
- Section 7: Specific rules for composite steel-concrete buildings;
- Section 8: Specific rules for timber buildings;
- Section 9: Specific rules for masonry buildings.

(6) Section 10 contains the fundamental requirements and other relevant aspects of design and safety related to base isolation of structures and specifically to base isolation of buildings.

NOTE Specific rules for isolation of bridges are developed in EN 1998-2.

(7) Annex C contains additional elements related to the design of slab reinforcement in steel-concrete composite beams at beam-column joints of moment frames.

NOTE Informative Annex A and informative Annex B contain additional elements related to the elastic displacement response spectrum and to target displacement for pushover analysis.

### **1.1.3 Further Parts of EN 1998**

(1)P Further Parts of EN 1998 include, in addition to EN 1998-1, the following:

- EN 1998-2 contains specific provisions relevant to bridges;
- EN 1998-3 contains provisions for the seismic assessment and retrofitting of existing buildings;
- EN 1998-4 contains specific provisions relevant to silos, tanks and pipelines;
- EN 1998-5 contains specific provisions relevant to foundations, retaining structures and geotechnical aspects;
- EN 1998-6 contains specific provisions relevant to towers, masts and chimneys.

## **1.2 Normative References**

(1)P This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

### **1.2.1 General reference standards**

EN 1990 Eurocode - Basis of structural design

EN 1992-1-1 Eurocode 2 – Design of concrete structures – Part 1-1: General – Common rules for building and civil engineering structures

EN 1993-1-1 Eurocode 3 – Design of steel structures – Part 1-1: General – General rules