

Eurocode 8 :

Design provisions for earthquake resistance of structures

**Part 5. Foundations, retaining structures
and geotechnical aspects**

ICS 91.060; 91.120.20; 93.020

Committees responsible for this Draft for Development

The preparation of this Draft for Development was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/8, Structures in seismic regions, upon which the following bodies were represented:

- Association of Consulting Engineers
- British Geological Survey
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Property and Building Directorate)
- Federation of Civil Engineering Contractors
- Institution of Civil Engineers
- Steel Construction Institute

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National foreword

This Draft for Development has been prepared by Subcommittee B/525/8 and is the English language version of ENV 1998-5 : 1994 *Eurocode 8 : Design provisions for earthquake resistance of structures Part 5 : Foundations, retaining structures and geotechnical aspects* published by the European Committee for Standardization (CEN).

ENV 1998-5 : 1994 results from a programme of work sponsored by the European Commission to make available a common set of rules for the structural and geotechnical design of buildings and civil engineering works. The full range of codes covers the basis of design and actions, the design of structures in concrete, steel, composite construction, timber, masonry and aluminium alloy, and also geotechnical and seismic design.

This publication is not to be regarded as a British Standard.

An ENV or European Prestandard is made available for provisional application, but it does not have the status of a European Standard. The aim is to use the experience gained to modify the ENV so that it can be adopted as a European Standard (EN).

There is no existing British Standard equivalent to ENV 1998-5 and there is no requirement in the Building Regulations to consider seismic actions on buildings and civil engineering works in the UK.

ENV 1998-1-1 states that the provisions of Eurocode 8 may be simplified or not observed in regions of low seismicity. Within the UK, the application of Eurocode 8 should not be necessary, unless the client or user of the works assesses that the associated seismic risk is such that it needs to be addressed.

Users of this document are invited to comment on its technical content, ease of use and any ambiguities or anomalies, both with respect to use in the UK and also in other more actively seismic areas. These comments will be taken into account when preparing the UK national response to CEN on the question of whether the ENV can be converted into an EN.

Comments should be sent in writing to the Secretary of B/525/8 at BSI, 389 Chiswick High Road, London W4 4AL, quoting the document reference, the relevant clause and, where possible, a proposed revision, by 30 April 1997. Comments after this time will still be possible through corporate bodies, such as the engineering institutions.

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English version

**Eurocode 8 —
Design provisions for earthquake resistance of structures —
Part 5 : Foundations, retaining structures and geotechnical
aspects**

Eurocode 8 — Conception et dimensionnement
des structures pour la résistance aux séismes —
Partie 5 : Fondations, structures de soutènement
et aspects géotechniques

Eurocode 8 — Auslegung von Bauwerken gegen
Erdbeben —
Teil 5 : Gründungen, Stützbauwerke

This European Prestandard (ENV) was approved by CEN on 1994-06-03 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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FOREWORD

Objectives of the Eurocodes

- (1) The "Structural Eurocodes" comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.
- (2) They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship needed to comply with the assumptions of the design rules.
- (3) Until the necessary set of harmonized technical specifications for products and for methods of testing their performance is available, some of the Structural Eurocodes cover some of these aspects in informative annexes.

Background to the Eurocode Programme

- (4) The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building and civil engineering works which would initially serve as an alternative to the different rules in force in the various Member States and would ultimately replace them. These technical rules became known as the "Structural Eurocodes".
- (5) In 1990, after consulting their respective Member States, the CEC transferred work of further development, issue and updates of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.
- (6) CEN Technical Committee CEN/TC 250 is responsible for all Structural Eurocodes.

Eurocode Programme

- (7) Work is in hand on the following Structural Eurocodes, each generally consisting of a number of parts:

EN 1991 Eurocode 1 - Basis of design and 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 provisions for earthquake resistance of structures
EN 1999 Eurocode 9 - Design of aluminum alloy structures

- (8) Separate sub-committees have been formed by CEN/TC 250 for the various

Eurocodes listed above.

(9) This Part 5 of Eurocode 8 is being published as an European Prestandard (ENV) with an initial life of three years.

(10) This Pre-standard is intended for experimental application and for the submission of comments.

(11) After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future actions.

(12) Meanwhile, feedback and comments on this Pre-standard should be sent to the Secretariat of CEN/TC250/SC8 at the following address:

IPQ c/o LNEC
Avenida do Brasil 101
P-1799 LISBOA Codex
PORTUGAL

or to your national Standard Organization

National Application Documents (NAD's)

(13) In view of the responsibilities of authorities in member countries for safety, health and other matters covered by the essential requirements of the Construction Products Directive (CPD), certain safety elements in this ENV have been assigned indicative values which are identified by [] ("boxed values"). The authorities in each member country are expected to review the "boxed" values and may substitute alternative definitive values for these safety elements for use in national application.

(14) Some of the supporting European or International standards may not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving any substitute definitive values for safety elements, referencing compatible supporting standards and providing guidance on the national application of this Prestandard, will be issued by each member country or its Standards Organisation.

(15) It is intended that this Pre-standard is used in conjunction with the NAD valid in the country where the building or civil engineering works is located.

Matters specific to this Prestandard

(16) The scope of Eurocode 8 is defined in ENV 1998-1-1 clause 1.1.1 and the scope of this Part of Eurocode 8 is defined in clause 1.1. Additional Parts of Eurocode 8 which are planned are indicated in clause 1.1.3 of Part 1-1.

(17) For the design of structures in seismic regions the provisions of this Prestandard are to be applied in addition to the provisions of the other relevant parts of Eurocode 8 and the other relevant Eurocodes. In particular, the provisions of this Prestandard complement those of Eurocode 7, which do not cover the special requirements of seismic design.

(18) Owing to the combination of uncertainties in seismic actions and material properties Part 5 may not cover in detail all design situations, and its proper use may require specialized engineering judgement and experience.

1 GENERAL

1.1 Scope of Part 5 of Eurocode 8

(1)P This Part 5 of Eurocode 8 establishes the requirements, criteria, and rules for siting and foundation soil. It covers the design of different foundation systems, earth retaining structures and soil-structure interaction under seismic actions. As such it complements the rules of Eurocode 7, which do not cover the special requirements of seismic design.

(2)P The provisions of Part 5 generally apply to buildings (Parts 1-1, 1-2, 1-3), bridges (Part 2), towers, masts and chimneys (Part 3), silos, tanks and pipelines (Part 4).

(3)P Specialized design requirements for the foundation of certain types of structures, when necessary, shall be found in the relevant Parts of Eurocode 8.

1.2 Definitions

1.2.1 Terms common to all Eurocodes

(1)P Clause 1.4.1 of Part 1-1 applies for terms common to all Eurocodes.

1.3 Special terms used in Part 5

(1)P The definition of **ground** shall be found in clause 1.4.2 of Eurocode 7, while that of other geotechnical terms specifically related to earthquakes, such as **liquefaction**, is given in the text.

(2) Other special, earthquake-related terms of structural significance used in Part 5 are defined in clause 1.4.2 of Part 1-1.

1.4 S.I. Units

- (1)P S.I. Units shall be used in accordance with ISO 1000.
- (2) In addition to the units recommended in clause 1.5 of Part 1-1, for geotechnical calculations reference should be made to clause 1.5 of Eurocode 7.

1.5 Symbols

- (1) All symbols used in Part 5 are defined in the text when they first occur, for ease of use. In addition, a list of the notation is given below.

E_d	= Total design earth pressure on retaining structures
E_{pd}	= Lateral resistance on the side of footing due to passive earth pressure
ER	= Measured energy ratio in Standard Penetration Test (SPT)
F_H	= Design seismic horizontal inertia force
F_V	= Design seismic vertical inertia force
$F_{fr,d}$	= Design shear resistance between horizontal base of footing and the ground
G	= Shear modulus
G_{max}	= Average shear modulus at small strain
k_h	= Horizontal seismic coefficient
k_v	= Vertical seismic coefficient
L_e	= Distance of anchors from wall due to dynamic conditions
L_s	= Distance of anchors from wall due to static conditions
M_{sd}	= Design action in terms of moments
N_{spt}	= Measured number of blows in standard penetration tests
$N_1(60)$	= Standard penetration value normalised for overburden effects and for energy ratio
N_{sd}	= Design normal action force on the horizontal base
PI	= Plasticity Index of soil
R_d	= Design resistance of the soil
S	= Soil profile parameter
S_d	= Design action effects on the soil
V_{sd}	= Design horizontal shear force
W	= Weight of sliding mass
c	= Cohesion of soil in terms of total stress
c'	= Cohesion of soil in terms of effective strength
c_u	= Undrained shear strength
d	= Pile diameter
d_r	= Displacement of retaining walls
g	= Acceleration due to gravity
q_c	= Measured value of cone penetration resistance
q_{c1}	= Cone penetration resistance normalised for effective overburden pressure
r	= Coefficient for design ground acceleration ratio
v_s	= Velocity of shear wave propagation
$v_{s,max}$	= Average v_s value at small strain ($\leq 10^{-5}$)
α	= Ground acceleration ratio, i.e. ratio between the design acceleration a_g and

	the gravity acceleration
γ	= Unit weight of soil
γ_w	= Unit weight of water
δ	= Design angle of shearing resistance between the ground and the footing or retaining wall
ϕ	= Angle of shearing resistance in terms of total stress
ϕ'	= Angle of shearing resistance in terms of effective strength
σ_{vo}	= Total overburden pressure, same as total vertical stress
σ'_{vo}	= Effective overburden pressure, same as effective vertical stress
τ_e	= Seismic shear stress

2 SEISMIC ACTION

2.1 Definition of the seismic action

(1)P The seismic action shall generally be consistent with the basic concepts and definitions given in clause 4.2 of Part 1-1 taking into account the provisions given in 4.2.2. below.

(2)P Combinations of seismic action with other actions shall be done according to clause 4.4 of Part 1-1.

(3) Allowable simplifications in the choice of the seismic action are introduced wherever appropriate.

2.2 Time-history representation

(1)P If time-domain analyses are performed, both artificial accelerograms and real strong motion recordings can be used; their peak value and frequency content shall be as specified in clause 4.3.2 of Part 1-1.

(2) In verifications of dynamic stability involving calculations of permanent ground deformations the excitation should preferably consist of accelerograms recorded on soil sites in real earthquakes, as they possess realistic low frequency content and proper time correlation between horizontal and vertical components of motion. The strong motion duration should be selected in a manner generally consistent with Table 4.3 of Part 1-1.

3 GROUND PROPERTIES

3.1 Strength parameters

(1) The value of the soil strength parameters applicable under static undrained conditions i.e. the undrained shear strength c_u or the total stress parameters c and $\tan$

ϕ , can generally be used. Alternatively, effective strength parameters with appropriate pore water pressure generated during cyclic loading may be used.

(2) The recommended values of the safety factor γ_m are [1,3] for c_u , [1,2] for c and [1,1] for $\tan \phi$. For effective stress analysis, the recommended values of clause 2.4.3 of Eurocode 7 may be adopted.

3.2 Stiffness and damping parameters

(1) Due to its influence on the design seismic actions, the main stiffness parameter of the ground under earthquake loading is the shear modulus G , given by

$$G = \frac{\gamma}{g} v_s^2 \quad (3.1)$$

where γ is the unit weight and v_s the shear wave propagation velocity of the ground, while g is the acceleration due to gravity.

(2) Criteria for the determination of v_s , including its dependence on the soil strain level, are given in 4.2.2 and 4.2.3 below.

(3) Damping should be considered as an additional ground property in the cases where the effects of soil-structure interaction are to be taken into account, specified in Section 6.

(4) Internal damping, caused by inelastic soil behaviour under cyclic loading, and radiation damping, caused by seismic waves propagating away from the foundation, should be considered separately.

4 REQUIREMENTS FOR SITING AND FOUNDATION SOILS

4.1 Siting

(1)P The site of construction and the nature of the supporting ground shall be such as to minimise hazards of rupture, slope instability, liquefaction, and high densification susceptibility, in the event of an earthquake.

(2)P The possibility of occurrence of these adverse phenomena shall be investigated as specified in the following clauses.

4.1.1 Proximity to seismically active faults.

(1)P Buildings of importance categories [I, II, III] defined in clause 3.7 of Part 1-2 shall generally not be erected in the immediate vicinity of tectonic faults recognized