SLOVENSKI STANDARD
oSIST prEN 1998-5:2022

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Evrokod 8 - Projektiranje potresnoodpornih konstrukcij - 5. del: Geotehnični vidiki, temelji, oporne in podzemne konstrukcije

Eurocode 8 - Design of structures for earthquake resistance - Part 5: Geotechnical aspects, foundations, retaining and underground structures

Eurocode 8 - Auslegung von Bauwerken gegen Erdbeben - Teil 5: Geotechnische Aspekte, Gründungen, Stütz- und Untertagebauwerke

Eurocode 8 - Calcul des structures pour leur résistance aux séismes - Partie 5 : Aspects géotechniques, fondations, ouvrages de soutènement et structures souterraines

Ta slovenski standard je istoveten z: **prEN 1998-5**

ICS:

91.010.30	Tehnični vidiki	Technical aspects
91.120.25	Zaščita pred potresi in vibracijami	Seismic and vibration protection

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

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Will supersede EN 1998-5:2004

English Version

Eurocode 8 - Design of structures for earthquake resistance - Part 5: Geotechnical aspects, foundations, retaining and underground structures

Eurocode 8 - Calcul des structures pour leur résistance aux séismes - Partie 5 : Aspects géotechniques, fondations, ouvrages de soutènement et structures souterraines

Eurocode 8 - Auslegung von Bauwerken gegen Erdbeben - Teil 5: Geotechnische Aspekte, Gründungen, Stütz- und Untertagebauwerke

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 250.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

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European foreword

This document (prEN 1998-5:2022) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 1998-5:2004.

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 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.

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 Eurocode 8

EN 1998 defines the rules for the seismic design of new buildings and engineering works and the assessment and retrofit of existing ones, including geotechnical aspects, as well as temporary structures.

For the design of structures in seismic regions, the provisions of EN 1998 should be applied in addition to the relevant provisions of EN 1990 to EN 1997 and EN 1999.

By nature, perfect protection (a null seismic risk) against earthquakes is not feasible in practice, in particular because the knowledge of the hazard itself is characterised by a significant uncertainty. Therefore, in Eurocode 8, the seismic action is represented in a conventional form, proportional in amplitude to earthquakes 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 this Standard.

Not only the seismic action cannot be predicted but, in addition, it should be recognised that engineering methods are not perfectly predictive when considering the effects of this specific 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.

0.3 Introduction to prEN 1998-5

This document provides general requirements for earthquake resistant design of geotechnical structures and geotechnical systems, including the definition of the seismic action, of the ground characteristics, general requirements for siting and foundations soils, design of foundation systems, retaining structures and underground structures, as well as rules for consideration of soil-structure interaction.

This document also contains provisions for the assessment of existing geotechnical structures and geotechnical systems.

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 prEN 1998-5

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 1998-5 can have a National Annex containing all national choices to be used for the design of buildings, civil engineering and geotechnical 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 prEN 1998-5 through notes to the following:

4.2(3)	4.2(6)	4.3(3) NOTE 1	4.3(3) NOTE 2
6.5(2)	6.5(3)	7.3.1(2)	9.4.2.1.3(7) NOTE 1

National choice is allowed in prEN 1998-5 on the application of the following informative annexes:

Annex A	Annex B	Annex C	Annex D
Annex E	Annex F	Annex G	Annex H
Annex I			

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 prEN 1998-5

(1) This document establishes general principles for the design and assessment of geotechnical systems in seismic regions. It gives general rules relevant to all families of geotechnical structures, to the design of foundations, retaining structures and underground structures and complements EN 1997-3 for the seismic design situation.

(2) This document contains the basic performance requirements and compliance criteria applicable to geotechnical structures and geotechnical systems in seismic regions.

(3) This document refers to the rules for the representation of seismic actions and the description of the seismic design situations defined in EN 1998-1-1 and provides specific definition of the seismic action applicable to geotechnical structures.

1.2 Assumptions

(1) The general assumptions of prEN 1990:2021, 1.2, are assumed to be applied.

(2) The provisions of this Standard assume that the parties of the project in charge of the analyses, for assessment and possible design of the retrofitting of existing geotechnical structures, have appropriate experience of the type of structures being strengthened or repaired.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

prEN 1990:2021, *Basis of structural and geotechnical design*

prEN 1997-1:2022, *Eurocode 7 — Geotechnical design — Part 1: General rules*

prEN 1997-2:2022, *Eurocode 7 — Geotechnical design — Part 2: Ground investigation*

prEN 1997-3:2022, *Eurocode 7 — Geotechnical design — Part 3: Geotechnical structures*

prEN 1998-1-1:2022, *Eurocode 8 — Design of structures for earthquake resistance — Part 1-1: General rules and seismic action*

prEN 1998-3, *Eurocode 8 — Design of structures for earthquake resistance — Part 3: Assessment and retrofitting of buildings and bridges (under development)*

ISO 80000, *Quantities and units*

3 Terms, definitions and symbols

3.1 Terms and definitions

3.1.1 General

(1) For the purposes of this document, the terms and definitions given in EN 1990 and in prEN 1998-1-1:2022, 3.1, apply.

(2) The terms and definitions in EN 1997-1, EN 1997-2 and EN 1997-3 apply, while the definitions of other geotechnical terms specifically related to earthquakes are given in this standard.

(3) Additional terms in 3.1.2 to 3.1.29 are used in this document with the corresponding definitions.

3.1.2
apparent wave velocity
horizontal surface velocity of the wave field under an incident angle within the ground

Note 1 to entry: It can be closer to the velocity of seismic waves through deep rocks.

3.1.3
clay fraction
percent in dry weight of soil with particle size smaller than 2 μm

3.1.4
coarse-grained soil
soil where particle sizes between 0,063 mm and 63 mm predominate

3.1.5
critical layer
soil layer within a soil profile identified on the basis of its depth, relative density, and thickness, as the most likely to liquefy and be responsible for the greatest amount of damage

3.1.6
critical zone (of piles)
section in a pile where the action effect reaches the elastic limit expressed in terms of stresses or deformations

3.1.7
critical seismic coefficient
minimum value of the seismic coefficient that leads to pseudo-static failure

3.1.8
cyclic undrained shear strength
shear strength of a ground material under the cyclic undrained loading produced by the considered earthquake, also referred to as the cyclic resistance of a material

3.1.9
cyclic stress ratio
CSR
cyclic shear stress normalised by the initial vertical effective stress for a given depth. Described also as the cyclic load on the soil

3.1.10
cyclic resistance ratio
CRR
cyclic undrained shear strength normalised by the initial vertical effective stress for a given depth, described also as the resistance of a soil to liquefaction triggering

3.1.11
displacing retaining structure
retaining structure that is able to undergo permanent seismic displacements

3.1.12
fine-grained soil
soil where particle sizes smaller than 0,063 mm predominate

3.1.13
fines content
percent in dry weight of material smaller than 63 µm

3.1.14
foundation element
structural member of a foundation system

EXAMPLE footings, foundation beams, rafts, pile caps, tie-beams

3.1.15
geotechnical structure
structure that includes ground or a structural member that relies on the ground for resistance

3.1.16
geotechnical system
complex system where one geotechnical structure interacts with other structures or geotechnical structures

EXAMPLE retaining walls with a supported structure at the crest, slopes with a structure at the crest or toe

3.1.17
inertial effect
action effect induced in the seismic design situation by the inertia forces

3.1.18
kinematic effect
action effect induced in the seismic design situation caused by the seismic ground displacement

3.1.19
liquefaction susceptibility
potential for a soil deposit to trigger liquefaction in the seismic design situation

3.1.20
material damping
energy dissipated by the material in cyclic loading

3.1.21
non-displacing retaining structure
retaining structure that is not able to undergo permanent seismic displacements

3.1.22
p-y curve
relationship between the resultant of the normal contact stresses per unit length of the pile and the corresponding horizontal displacement

3.1.23
permanent seismic displacement
seismic induced displacements that remain after the earthquake

3.1.24
pile group effect
modification of the pile group response due to the pile–soil–pile interaction

3.1.25
precarious slope
slope with a low margin of safety in a static situation as calculated according to EN 1997-3 or slopes classified with a geotechnical complexity GCC3 according to prEN 1997-1:2022, 4.1.2.3

3.1.26
radiation damping
energy dissipated in the ground by waves travelling away from the foundation

3.1.27
residual strength
shear strength of a liquefied material, or lower limit of the shear strength of a fine-grained soil reached after extensive shearing and particle reorientation as defined in prEN 1997-2:2022, 3.1.5.6

3.1.28
t-z curve
relationship between the resultant of the shear contact stresses per unit length of the pile and the corresponding vertical displacement

3.1.29
yielding (non-yielding) pile
pile that undergoes (does not undergo) inelastic deformation in the seismic design situation

3.2 Symbols and abbreviations

3.2.1 General

(1) The symbols and abbreviations listed in prEN 1990:2021, 3.2 should be used.

(2) The symbols and abbreviations listed in prEN 1998-1-1:2022, 3.2 should be used.

(3) 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 should be applied.

(4) Further symbols and abbreviations, used in connection with the seismic situation, are defined in the present standard where they occur, for ease of use. However, in addition, the most frequently occurring symbols used in EN 1998-5 are listed and defined in 3.2.2 and additional abbreviations are given in 3.2.3.

3.2.2 Symbols

3.2.2.1 Symbols used in EN 1998–5

3.2.2.1.1 Upper case Latin symbols

A_b	Area of the base of the footing in contact with the ground
A_T	Area of the cross-section of the tunnel
A_{Sw}	Amplitude of the shear wave
B	Foundation width
B_b	Building width
CAV_{dp}	Filtered cumulative absolute velocity
C_E	Hammer energy correction factor in SPTs
C_N	Overburden stress correction factor for normalisation to atmospheric pressure
C_R	Flexibility ratio for tunnels
C_{xx}	Radiation dashpot in the horizontal X direction
C_{yy}	Radiation dashpot in the horizontal Y direction
C_{zz}	Radiation dashpot in the vertical Z direction
C_{rx}	Radiation dashpot around the horizontal X direction
C_{ry}	Radiation dashpot around the horizontal Y direction
C_{rz}	Radiation dashpot around the vertical Z direction
CRR	Cyclic resistance ratio in liquefaction assessment
CSR	Cyclic stress ratio in liquefaction assessment
C_α	Dashpot coefficient for degree of freedom α corresponding to radiation damping
$C_{\alpha\tau}$	Dashpot coefficient for degree of freedom α corresponding to foundation damping (material + radiation)
D_e	Depth from the ground surface to the base of the foundation
D_H	Lateral displacement due to lateral spreading
D_R	Sand relative density in percent
D_S	Settlement under building
Edi	Design value of the action effect on the zone or element i in the seismic design situation
E_{Fd}	Design value of the action effect in the seismic situation
$E_{Fd,G}$	Design value of the action effect in non–seismic situations
$E_{Fd,E}$	Action effect of the design seismic situation calculated from the seismic analysis
E_L	Young's modulus of the tunnel lining
E_P	Pile Young's modulus
ER	Energy ratio, in percent, specific to the testing equipment, in SPTs
$E_R I_R$	Bending stiffness, per unit length, of the retaining wall
E_S	Soil Young's modulus compatible with a representative in space and time shear strain