SLOVENSKI STANDARD
oSIST prEN 1998-2:2023

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Evrokod 8 - Projektiranje konstrukcij na potresnih območjih - 2. del: Mostovi

Eurocode 8 - Design of structures for earthquake resistance - Part 2: Bridges

Eurocode 8 - Auslegung von Bauwerken gegen Erdbeben - Teil 2: Brücken

Eurocode 8 - Calcul des structures pour leur résistance aux séismes - Partie 2: Ponts

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Eurocode 8 - Design of structures for earthquake resistance - Part 2: Bridges

Eurocode 8 - Calcul des structures pour leur résistance aux séismes - Partie 2: Ponts

Eurocode 8 - Auslegung von Bauwerken gegen Erdbeben - Teil 2: Brücken

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 1998-2:2022) 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 will supersede EN 1998-2:2005.

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 recognize 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.

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.

NOTE This standard also covers the verification of structures in the seismic situation during construction, when required.

Attention has to be paid to the fact that, 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. In particular, EN 1998 should be applied to structures of consequence classes CC1, CC2 and CC3, as defined in prEN 1990:2021, 4.3. Structures of consequence class CC4 are not fully covered by the Eurocodes but may be required to follow EN 1998, or parts of it, by the relevant authorities.

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 characterized 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 recognized that engineering methods are not perfectly predictive when considering the effects of this specific action, under which structures are assumed to respond in the nonlinear 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 EN 1998-2

EN 1998-2 provides general requirements for earthquake resistant design of new bridges. Except where otherwise specified in this Part, the seismic actions are as defined in prEN 1998-1-1:2022, 5. The scope of this Part of EN 1998 is defined in 1.1.

Since the seismic action is mainly resisted by the piers and the latter are usually constructed of reinforced concrete, a greater emphasis has been given to such piers. Additionally, bearings are in many cases important parts of the seismic resisting system of a bridge and are therefore treated accordingly. The same holds for seismic isolation devices.

EN 1998-2 is subdivided in ten clauses and includes four annexes, where Annexes A to C are informative and Annex D is normative.

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 1998-2

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 1998-2 can have a National Annex containing all national choices to be used for the design of new bridges 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 1998-2 through notes to the following:

4.1(4)	4.2.1(1)	4.3.5(8)	4.3.7(1)
6.3.2(2)			

National choice is allowed in EN 1998-2 on the application of the following informative annexes:

Annex A	Annex B	Annex C

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 1998-2

(1) This document is applicable to the design and verification of new bridges in seismic regions. It gives general rules for the design and verification relevant to bridges of consequence classes CC1, CC2 and CC3, as defined in prEN 1990:2021, A.2.

NOTE 1 EN 1998-2 covers the design of reinforced concrete, steel and composite steel-concrete bridges, with the exception of prestressed piers. Guidance for design of timber bridges is given in Informative Annex C.

NOTE 2 The assessment of existing bridges is covered in EN 1998-3.

(2) Unless specifically stated, prEN 1998-1-1:2022 and prEN 1998-5:2022 apply.

(3) EN 1998-2 is applicable in complement to the other relevant Eurocodes.

NOTE EN 1998-2 contains only those provisions that, in addition to the provisions of the other relevant Eurocodes, are used for the design of new bridges in seismic regions. EN 1998-2 complements in this respect the other Eurocodes.

(4) EN 1998-2 provides basic performance requirements and compliance criteria applicable to new bridges in seismic regions.

(5) EN 1998-2 is applicable to the seismic design of bridges exploiting ductility in structural members or through the use of antiseismic devices.

(6) EN 1998-2 gives detailing rules for ductility of the structural members in bridges designed to exploit ductility as a means of seismic protection. When ductility is exploited, EN 1998-2 primarily covers bridges in which the horizontal seismic actions are mainly resisted through bending of the piers or at the abutments, i.e. of bridges composed of vertical or nearly vertical pier systems supporting the traffic deck superstructure.

(7) EN 1998-2 gives specific rules for bridges equipped with antiseismic devices, for cable-stayed and extradosed bridges and for integral abutment bridges.

(8) EN 1998-2 is also applicable to the seismic design of arched bridges, although its provisions should not be considered as fully covering these cases.

NOTE Suspension bridges and masonry bridges, moveable bridges and floating bridges are not included in the scope of this Part.

1.2 Assumptions

(1) The assumptions of prEN 1998-1-1:2022, 1.2, are assumed to be applied.

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

prEN 1998-5:2022, *Eurocode 8 – Design of structures for earthquake resistance – Part 5: Geotechnical aspects, foundations, retaining and underground structures*

ISO 80000 (all parts), *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, prEN 1998-1-1:2022, 3.1 and the following apply.

3.1.1
positive linkage
connection implemented by seismic links

3.1.2
spatial variability (of seismic action)
situation in which the ground motion at different supports of the bridge differs and, hence, the seismic action cannot be based on the characterisation of the motion at a single point

3.1.3
longitudinal and transverse directions of the bridge
the longitudinal direction x is defined by the line connecting the centres of the two end-sections of the deck. The transverse direction y is assumed to be orthogonal to the longitudinal direction

Note 1 to entry: In skew bridges, the above defined horizontal directions generally do not coincide with the bearings' principal axes of inertia, which can underestimate seismic effects if the two directions are considered independently. For this reason, it is important that the skew is properly accounted for in the numerical model and that the two horizontal directions of seismic action are properly combined.

3.1.4
seismic links
restrainers through which part or all of the seismic action may be transmitted. Used in combination with bearings, they can be provided with appropriate slack, so as to be activated only in the case when the design seismic displacement is exceeded

3.1.5
minimum overlap length
safety measure in the form of a minimum distance between the inner edge of the supported and the outer edge of the supporting member. The minimum overlap is intended to ensure that the function of the support is maintained under extreme seismic displacements

3.1.6
design seismic displacement
displacement induced by the design seismic actions

3.1.7
total design displacement in the seismic design situation
displacement used to determine adequate clearances for the protection of critical or major structural members. It includes the design seismic displacement, the displacement due to the long-term effect of the permanent and quasi-permanent actions and an appropriate fraction of the displacement due to thermal movements

3.1.8
critical region, critical zone
region/zone of a primary seismic member, where the most adverse combination of action effects (M, N, V, T) occurs and where plastic hinges can form

Note 1 to entry: In concrete bridge piers, critical regions are potential dissipative zones such as defined in prEN 1998-1-1:2022, 3.1.10. The length of the critical region is defined in 7.2.1.

3.1.9
skew bridge
bridge whose spans are not perpendicular to the axis of the supports, with an angle of skew (3.2.2.2) larger than 20°

3.1.10
curved bridge
bridge with an angle between the initial and final tangents to the curved longitudinal axis larger than 25°. All other bridges are considered straight

3.1.11
ductile member
primary seismic member where a plastic hinge can form

3.2 Symbols and abbreviations

3.2.1 General

The symbols and abbreviations listed in prEN 1990:2021, 3.2 and in prEN 1998-1-1:2022, 3.2, apply.

For the symbols related to materials, as well as for symbols not specifically related to the seismic situation, the provisions of the relevant Eurocodes should be applied.

Further symbols and abbreviations, used in connection with seismic actions, are defined in the present standard where they occur, for ease of use. However, in addition, the most frequently occurring symbols used in EN 1998-2 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 4

3.2.2.1.1 Lower case Latin symbols

d_E Design seismic displacement (due only to the design seismic action)

d_{Ed} Total design displacement in the seismic design situation

d_G Long-term relative displacement due to permanent and quasi-permanent actions

d_T Displacement due to thermal movements

k_u, k_d Stiffness of timber fasteners or connectors

3.2.2.1.2 Lower case Greek symbols

η_k Normalised axial force

ψ_2 Combination factor for the quasi-permanent value of the thermal action

3.2.2.2 Symbols used in 5

3.2.2.2.1 Upper case Latin symbols

A_c Concrete area of the cross-section

B Width of the deck

E_d Seismic action effects

E_{di} Deformation energy induced in component *i* by the seismic action

E_d^S Quasi-static part of the seismic action effect

E_d^D Dynamic part of the seismic action effect

E_{dk}^S Contribution of the *k*-th static mode under the peak ground displacement at support *k*.

$E_{d,i}$ Seismic action effects due to higher quasi-antisymmetric modes

$E_{d,u}$ Seismic action effects due to uniform excitation

E_{di}^D Contribution of the *i*-th mode under the design seismic action

E_{dik}^D *i*-th mode response to the seismic input (response spectrum) at the *k*-th support

F Horizontal force

F_i Static force on pier *i* in the lateral forces method

F_i Static forces due to the contribution of higher quasi-antisymmetric modes

F_b Seismic base shear force

L Total length of the continuous deck

L_{lim} Total length of the bridge

M Total bridge mass above the foundations

M_1 Equivalent modal mass

$M_{Ed,i}$ Maximum value of design moment at the intended plastic hinge location of ductile member *i* as derived from the analysis for the seismic design situation

$M_{Rd,i}$ Design flexural resistance of the same section with its actual reinforcement under the concurrent action of the non-seismic action effects in the seismic design situation

M_t Equivalent static moment

N_{Ed} Axial force at the plastic hinge seismic design situation

N_S, N_D Number of static and dynamic modes used in the analysis of long bridges on non-uniform soil

P_{tot} Total vertical force acting at the top of the pier

$Q_{k,i}$ Variable gravity loads as appearing in the seismic design situation

$\overline{SF}_i$ Mode amplification factor

T_1 Fundamental period in the considered direction

T_i Fundamental period of the *i*-th pier or *i*-th modal period from modal analysis

V_p Shear force acting on the pier in the seismic design situation

3.2.2.2.2 Lower case Latin symbols

a_s Shear span ratio ($=L_V/h$)

$d_{E,p}$ Design pier top displacement under the design seismic action

d_m Average of the piers top displacements under a transverse uniformly distributed load on the deck

e Total eccentricity ($e_a + e_d$)

e_o Theoretical eccentricity between the centre of stiffness of the supporting members and the centre of mass of the deck

e_a Accidental eccentricity

e_d Additional eccentricity reflecting the dynamic effect of simultaneous translational and torsional vibration

f_{ck} Characteristic concrete strength

h Depth of basin or pier height

q' Reduced value of q-factor

$q_{D,N}$ Reduced value of the ductility-related q-factor component due to axial force

$q_{D,SSI}$ Reduced value of the ductility-related q-factor component due to soil-structure interaction

m_i Mass over the *i*-th support

r_i Parameter defined as $r_i = q\dfrac{M_{Ed,i}}{M_{Rd,i}}$

r_{ij} Correlation coefficient between dynamic modes

r_k Vector collecting the *k*-th static mode

r_{min} Minimum value of r_i among all ductile members *i*

r_{max} Maximum value of r_i among all ductile members *i*

s_i Displacement over the *i*-th support in the horizontal direction when the structure is acted upon by the acceleration of gravity

3.2.2.2.3 Upper case Greek symbols

Γ_i *i*-th modal participation factor due to spatially variable excitation

Δd Maximum difference in displacement between any two pier tops under a transverse uniformly distributed load on the deck

3.2.2.2.4 Lower case Greek symbols

η Damping correction factor for the elastic response spectrum

η_k Normalised axial force

θ Pier top displacement sensitivity coefficient

λ Factor for the calculation of behaviour factor q

ξ Equivalent viscous damping ratio

ξ_i Equivalent viscous damping ratio of component i

ξ_{eff} Effective viscous damping of the structure

ρ, ρ_o Parameters for regular seismic behaviour

ρ_{kl} Correlation coefficient between seismic input motion at different supports

φ Parameter for calculating ψ_{Ei} or skew angle (angle between the longitudinal axis of the bridge and a line perpendicular to the alignment of intermediate or end supports)

φ_i *i*-th modal shape from modal analysis

$\psi_{E,i}$ Combination coefficients

3.2.2.3 Symbols used in 6

3.2.2.3.1 Upper case Latin symbols

A_{Ed} Design action effects in the seismic design situation

$A_{j,eff}$ Effective area of the joint

M_{Ed} Design moment in the seismic design situation

M_o Overstrength moment

M_{Rd} Design value of the flexural resistance of the section

N_{cG} Axial force of the pier under the non-seismic actions in the seismic design situation

N_{Ed} Axial force in the seismic design situation

N_{jz} Vertical axial joint force

N_{jx} Horizontal axial joint force

N_{jy} Horizontal axial joint force in the transverse direction

T_{Rc} Resultant force of the tensile reinforcement of the pier corresponding to the design flexural resistance, M_{Rd}, of the plastic hinge

V_{b1C} Shear force of the horizontal member adjacent to the tensile face of the pier,