SLOVENSKI STANDARD
oSIST prEN 1993-1-14:2023

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Evrokod 3 - Projektiranje jeklenih konstrukcij - 1-14. del: Projektiranje z analizo končnih elementov

Eurocode 3 - Design of steel structures - Part 1-14: Design assisted by finite element analysis

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 1-14: Bemessung mithilfe von Finite-Element-Berechnung

Eurocode 3 - Calcul des structures en acier - Partie 1-14 : Calcul assisté par des analyses par éléments finis

Ta slovenski standard je istoveten z: **prEN 1993-1-14**

ICS:

91.010.30	Tehnični vidiki	Technical aspects
91.080.13	Jeklene konstrukcije	Steel structures

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EUROPEAN STANDARD

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Eurocode 3 - Design of steel structures - Part 1-14: Design assisted by finite element analysis

Eurocode 3 - Calcul des structures en acier - Partie 1-14 : Calcul assisté par des analyses par éléments finis

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 1-14: Bemessung mithilfe von Finite-Element-Berechnung

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

If this draft becomes a European Standard, 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.

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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 1993-1-14:2023) 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 matters by CEN.

This document is currently submitted to the CEN Enquiry.

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.

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, soft-ware 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 1993 (all parts)

EN 1993 (all parts) applies to the design of buildings and civil engineering works in steel. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design and verification that are given in EN 1990 – Basis of structural and geotechnical design.

EN 1993 (all parts) is concerned only with requirements for resistance, serviceability, durability and fire resistance of steel structures. Other requirements, e.g. concerning thermal or sound insulation, are not covered.

EN 1993 is subdivided in various parts:

— EN 1993-1, *Design of steel structures – Part 1: General rules and rules for buildings*

— EN 1993-2, *Design of steel structures – Part 2: Bridges*

— EN 1993-3, *Design of steel structures – Part 3: Towers, masts and chimneys*

— EN 1993-4, *Design of steel structures – Part 4: Silos and tanks*

— EN 1993-5, *Design of steel structures – Part 5: Piling*

— EN 1993-6, *Design of steel structures – Part 6: Crane supporting structures*

— EN 1993-7, *Design of steel structures – Part 7: Sandwich panels* (under preparation).

EN 1993-1 in itself does not exist as a physical document, but comprises the following 14 separate parts, the basic part being EN 1993-1-1:

— EN 1993-1-1, *Design of steel structures – Part 1-1: General rules and rules for buildings*

— EN 1993-1-2, *Design of steel structures – Part 1-2: Structural fire design*

— EN 1993-1-3, *Design of steel structures – Part 1-3: Cold-formed members and sheeting*

NOTE Cold-formed hollow sections supplied according to EN 10219 are covered in EN 1993-1-1.

— EN 1993-1-4, *Design of steel structures – Part 1-4: Stainless steel structures*

— EN 1993-1-5, *Design of steel structures – Part 1-5: Plated structural elements*

— EN 1993-1-6, *Design of steel structures – Part 1-6: Strength and stability of shell structures*

— EN 1993-1-7, *Design of steel structures – Part 1-7: Plate assemblies with elements under transverse loads*

— EN 1993-1-8, *Design of steel structures – Part 1-8: Joints*

— EN 1993-1-9, *Design of steel structures – Part 1-9: Fatigue*

— EN 1993-1-10, *Design of steel structures – Part 1-10: Material toughness and through-thickness properties*

— EN 1993-1-11, *Design of steel structures – Part 1-11: Tension components*

— EN 1993-1-12, *Design of steel structures – Part 1-12: Additional rules for steel grades up to S960*

— EN 1993-1-13, *Design of steel structures – Part 1-13: Beams with large web openings*

— EN 1993-1-14, *Design of steel structures – Part 1-14: Design assisted by finite element analysis*

All parts numbered EN 1993-1-2 to EN 1993-1-14 treat general topics that are independent from the structural type such as structural fire design, cold-formed members and sheeting, stainless steels, plated structural elements, etc.

All parts numbered EN 1993-2 to EN 1993-7 treat topics relevant for a specific structural type such as steel bridges, towers, masts and chimneys, silos and tanks, piling, crane supporting structures, etc. EN 1993-2 to EN 1993-7 refer to the generic rules in EN 1993-1 and supplement, modify or supersede them.

0.3 Introduction to prEN 1993-1-14

prEN 1993-1-14 gives principles and requirements for the use of numerical methods in the design of steel structures, more specifically for the ultimate limit state (including fatigue) and serviceability limit state verifications. It also gives principles and requirements for the application of advanced finite element and similar modelling techniques for research purposes, which may also be used in design processes.

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 1993-1-14

National choice is allowed in this standard where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing prEN 1993-1-14 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this standard is to be used.

When no national choice is made and no default is given in this standard, 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 1993-1-14 through notes to the following clauses:

4(11)	4(15)	5.4.2(1)	7.1(2)
7.2(2)	7.3(1)	7.3(3)	7.3(6)
8.1.2(3)	8.1.2(5)	8.1.5(2)	8.1.5(3)
C.3(1)			

National choice is allowed in prEN 1993-1-14 on the application of the following informative annexes:

Annex A Annex B

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 1993-1-14

(1) This document gives principles and requirements for the use of numerical methods in the design of steel structures, more specifically for the ultimate limit state (including fatigue) and serviceability limit state verifications. It also gives principles and requirements for the application of advanced finite element (FE) and similar modelling techniques for numerical simulation which also covers safety assessment.

(2) This document covers general methodologies such as the finite element method (FEM), finite strip method (FSM) or generalized beam theory (GBT) for modelling, analysis and design of steel structures made of the following members and joint configurations:

a) hot-rolled profiles,

b) cold-formed members and sheeting,

c) welded plated profiles,

d) stainless steel profiles,

e) plate assemblies,

f) shell structures,

g) welded and bolted joints.

In addition to the general design rules, specific additional rules can also be found in the relevant standard parts in EN 1993.

(3) This document contains harmonized design rules in terms of the application of the numerical modelling methods, development of the numerical models, application of analysis types, result evaluation methods, and determination of the resistance of steel structures for different limit states.

1.2 Assumptions

(1) This document gives rules intended for engineers who are experienced in the use of FE.

(2) It is recognized that structural analysis, based upon the laws of physics, has been successfully researched, developed, historically or currently used for the design and verification of elements or whole structural frames. This remains appropriate for many structural solutions. However, when a more detailed understanding of structural behaviour is required, the methods described in this document can be useful for the professional design.

(3) Unless specifically stated, EN 1990, EN 1991 (all parts) and the other relevant parts of EN 1993-1 apply.

(4) The design methods given in prEN 1993-1-14 are applicable if

— the execution quality is as specified in EN 1090-2 and/or EN 1090-4, and

— the construction materials and products used are as specified in the relevant parts of EN 1993, or in the relevant material and product specifications.

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. through 'should' clauses) and permissions (i.e. through 'may' clauses).

EN 1090-2, *Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures*

EN 1090-4, *Execution of steel structures and aluminium structures - Part 4: Technical requirements for cold-formed structural steel elements and cold-formed structures for roof, ceiling, floor and wall applications*

EN 1990:2023, *Eurocode - Basis of structural and geotechnical design*

EN 1991 (all parts), *Eurocode 1 - Actions on structures*

EN 1993 (all parts), Eurocode 3 - *Design of steel structures*

3 Terms, definitions and symbols

For the purposes of this document, the following terms, definitions and symbols apply.

3.1 Terms and definitions

3.1.1
analysis requiring subsequent design check
analysis (e.g. LA, LBA, GNA, GNIA, MNA) performed for design checks, which results are different system response quantities to be further used in the static check of the analysed structure

3.1.2
benchmark case
offers the inputs and outputs of the analytical or numerical solutions to verify the results by comparison on simplified model, or experimental tests used to check the quality of the numerical model to be validated

3.1.3
degree of freedom
DOF
number of independent motions that are allowed to the structure

Note 1 to entry: DOF can be defined as DOF per node (1 to 7 – maximum 3 translational, 3 rotational and warping) and total number of DOFs for the whole structure as sum of all node's DOFs.

3.1.4
direct resistance check
analysis (e.g. MNA, GMNA, GMNIA) performed for design checks, which result is the ultimate resistance of the analysed structure

3.1.5
follower load
load changing direction as a function of the deformation of the analysed structure in a non-linear analysis

3.1.6
global analysis
structural analysis of the complete structure or part of the structure under investigation, rather than individual structural members or components treated separately

3.1.7
numerical model
numerical idealization to simulate and predict aspects of behaviour of a system used to represent the structural behaviour of the analysed structure or a part of it

3.1.8
multi-level or combined model
modelling of the entire structure using different types of elements (e.g. coupling of beam, plate, shell or solid elements) within one model, making the DOFs compatible at the intersection regions

3.1.9
numerical design calculation
numerical model and analysis type used for the static design check of a structure or a part of it

Note 1 to entry: Results of the numerical model can be (i) different system response quantities (SRQs) to be used for further evaluation or (ii) resistances to be used for direct resistance check.

3.1.10
numerical simulation
complementation or extension of physical experiments to determine the direct resistance of a structure

3.1.11
second order analysis
geometrically non-linear analysis based on second order approximations (geometric stiffness or stress stiffening approach)

3.1.12
standard design case
numerical model-based design check of failure modes for which Eurocode based design resistance model also exists

3.1.13
sub-model
part of the entire structure modelled using equivalent support conditions representing the neglected part of the structure

3.1.14
system response quantity
SRQ
relevant output value resulting from a certain analysis; it reflects the main objective of the analysis by selecting the major parameters and the limitation of their errors in both validation and verification

3.1.15
validation
comparison of the numerical solution and the experimental behaviour (or known accurate solutions)

3.1.16
verification
comparison of the numerical solutions and accurate analytical or numerical results

3.2 Symbols and abbreviations

3.2.1 Latin upper-case symbols

A	elongation after fracture defined in the relevant material specification
C_1, C_2	material coefficient for hot-rolled steels
E	modulus of elasticity
E_1, E_2, E_3	strain hardening modulus of the stress-strain curve for cold-formed structures covered by prEN 1993-1-3
$E_{0.2}$	tangent modulus of the stress-strain curve at the yield strength for cold-formed steel and stainless steels
E_{sh}	strain hardening modulus for hot-rolled steels
H	total section depth of welded box-sections
L	member length
$L_{r,min}$, $L_{r,max}$	limits of the extrapolation region for tubular joints in fatigue design situation
R_{comp}	structural resistance computed by the numerical model
$R_{b,d}$	design buckling resistance
$R_{b,k}$	characteristic buckling resistance
R_{check}	computed resistance for the check structural resistance case
R_{cr}	lowest elastic critical bifurcation load of the examined structure
R_{GMNA}	calculated plastic resistances based on GMNA analysis
R_{GMNIA}	calculated buckling resistances based on GMNIA analysis
$R_{k,known}$	calculated or known characteristic structural resistance
$R_{test,known}$	known test result
R_{MNA}	calculated plastic resistance based on MNA analysis
R_{pl}	plastic resistance of the examined structure or cross-section
$R_{pl,d}$	design plastic resistance of the examined structure
$R_{pl,k}$	characteristic plastic resistance of the examined structure
V_X	coefficient of variation of the ratio of the measured (or known) and computed results

V_{Ed} design value of the shear force

$V_{pl,Rd}$ design value of the plastic resistance to shear force

3.2.2 Latin lower-case symbols

a length of a panel or sub-panel

b width of a panel or sub-panel

b_f flange width

a_{rs}, b_{rs}, c_{rs}, d_{rs}, e_{rs}, f_{rs}, g_{rs}, h_{rs} geometrical parameters of the residual stress patterns

e_0 amplitude of the equivalent geometric imperfection

$e_{0,dist}$ imperfection magnitude for distortional buckling mode

f_u ultimate tensile strength

f_y yield stress

f_{yb} basic yield strength of cold-formed steel

h_w web depth

k_n characteristic fractile factor

m second strain hardening exponent for the Ramberg-Osgood type material model cold-formed steel and stainless steels

m_X mean value of the ratio of the measured (or known) and computed results

n material coefficient for the Ramberg-Osgood type material model for cold-formed steel and stainless steels

r radius of notch in fatigue design situation

t plate thickness

t_w web thickness

t_0 chord member wall thickness in tubular joints

t_1 brace member wall thickness in tubular joints

3.2.3 Greek upper-case symbols

Θ flank angle of the weld model in fatigue design situation

Ω project specific parameter that defines the maximum permissible level of plastic strain in the structure