SLOVENSKI STANDARD
oSIST prEN 1993-1-4:2023

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Evrokod 3 - Projektiranje jeklenih konstrukcij - 1-4. del: Nerjavne jeklene konstrukcije

Eurocode 3 - Design of steel structures - Part 1-4: Stainless steel structures

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 1-4: Tragwerke aus nichtrostenden Stählen

Eurocode 3 - Calcul des structures en acier - Partie 1-4: Structures en aciers inoxydables

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91.010.30	Tehnični vidiki	Technical aspects
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Eurocode 3 - Design of steel structures - Part 1-4: Stainless steel structures

Eurocode 3 - Calcul des structures en acier - Partie 1-4: Règles générales - Règles supplémentaires pour les aciers inoxydables

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 1-4: Allgemeine Bemessungsregeln - Ergänzende Regeln zur Anwendung von nichtrostender Stählen

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 1993-1-4:2023) 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 design matters by CEN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 1993-1-4:2006 and its amendments.

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, 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 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 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: Steel 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: Design of sandwich panels*.

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: Strength and stability of planar plated structures transversely loaded*;

EN 1993-1-8, *Design of Steel Structures — Part 1-8: Design of 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: Design of structures with 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 subsequent parts 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 subsequent 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 1993-1-4

prEN 1993-1-4 gives supplementary rules for the structural design of steel structures that extend and modify the application of EN 1993-1-1, EN 1993-1-3, EN 1993-1-5 and EN 1993-1-8 to stainless steels. The focus is on design methods and design rules for members and skeletal structures regarding resistance and stability.

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 1993-1-4

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 1993-1-4 can have a National Annex containing all national choices to be used for the design of steel structures 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 1993-1-4 through the following clauses:

5.1.1(1)	5.2.2(1)	7.2.1(1)	7.4.3.5(3)
8.1(1)	A.2(8)	A.3, Table A.4	

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 1993-1-4

This document provides supplementary rules for the structural design of steel structures that extend and modify the application of EN 1993-1-1, EN 1993-1-3, EN 1993-1-5 and EN 1993-1-8 to austenitic, duplex (austenitic-ferritic) and ferritic stainless steels.

NOTE 1 Austenitic-ferritic stainless steels are commonly known as duplex stainless steels. The term duplex stainless steel is used in this document.

NOTE 2 Information on the durability of stainless steels is given in Annex A.

NOTE 3 The execution of stainless steel structures is covered in EN 1090-2 and EN 1090-4.

1.2 Assumptions

Unless specifically stated, EN 1990, EN 1991 (all parts), EN 1993-1-1, EN 1993-1-3, EN 1993-1-5 and EN 1993-1-8 apply.

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

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

— the construction materials and products used are as specified in EN 1993-1-1, EN 1993-1-3, EN 1993-1-5 and EN 1993-1-8, 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, *Basis of structural and geotechnical design*

EN 1991 (all parts), *Actions on structures*

EN 1993-1-1, *Design of Steel Structures — Part 1-1: General rules and rules for buildings*

EN 1993-1-3, *Design of Steel Structures — Part 1-3: Cold-formed members and sheeting*

EN 1993-1-5, *Design of Steel Structures — Part 1-5: Plated structural elements*

EN 1993-1-8, *Design of Steel Structures — Part 1-9: Fatigue*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1990, EN 1993-1-1, EN 1993-1-3, EN 1993-1-5 and EN 1993-1-8 apply.

3.2 Symbols and abbreviations

3.2.1 General

For the purposes of this document, the symbols given in EN 1990, EN 1993-1-1, EN 1993-1-3, EN 1993-1-5 and EN 1993-1-8 and the following apply.

3.2.2 Latin upper-case symbols

A_c	total corner cross-sectional area of the section
CRF	corrosion resistance factor
CSM	continuous strength method
C_1, C_2, C_3	material coefficients used to define the CSM material model
E_s	secant modulus
E_{sh}	strain hardening modulus
$E_{s,ser}$	secant modulus of elasticity used for serviceability limit state calculations
$E_{s,1}$	secant modulus corresponding to the stress in the tension flange
$E_{s,2}$	secant modulus corresponding to the stress in the compression flange
$F_{p,S}$	preloading force for bolts
F_{Rd}	design value of the resistance of the structure calculated from F_{Rk}
F_{Rk}	characteristic value of the resistance of the structure, taken at the peak load factor attained during the plastic zone analysis or the point at which the CSM strain limit is reached, whichever is the lesser
F_1	risk of exposure to chlorides from salt water or deicing salts
F_2	risk of exposure to sulfur dioxide
F_3	cleaning regime or exposure to washing by rain
K	initial lateral stiffness of the structure
K_s	secant lateral stiffness of the structure at the design load level
KV	impact energy in Joule [J] from a Charpy V notch specimen
$L_{b,cs}$	local buckling half-wavelength
M	distance from the sea

$M_{csm,Rd}$	design value of the CSM resistance to bending moment about one principal axis of a cross-section
$M_{csm,y,Rd}$	design value of the CSM bending moment resistance about major (y-y) axis
$M_{csm,z,Rd}$	design value of the CSM bending moment resistance about minor (z-z) axis
$M_{N,csm,y,Rd}$	design value of the reduced CSM bending moment resistance about major (y-y) axis making allowance for the presence of axial force
$M_{N,csm,z,Rd}$	design value of the reduced CSM bending moment resistance about minor (z-z) axis making allowance for the presence of axial force
$N_{csm,Rd}$	design value of the CSM resistance to axial force of the cross-section for uniform compression
$N_{csm,t,Rd}$	design value of the CSM resistance to tension axial force
$R_{p0,2}$	stress at which the plastic extension is 0,2 % (i.e. 0,2 % proof strength), taken from the product standard
S	distance from roads with deicing salts
Y	factor that approximates loss of stiffness due to second order effects

3.2.3 Latin lower-case symbols

f_{ua}	average ultimate tensile strength, accounting for work hardening due to cold-forming
f_{ub}	nominal ultimate tensile strength of stainless steel bolts
f_{yb}	nominal yield strength of stainless steel bolts
f_{yCHS}	enhanced yield strength of a cold rolled circular hollow section
f_{yc}	enhanced yield strength of the corner region
f_{yf}	enhanced yield strength of the flat portions of cold-rolled rectangular hollow sections
k_s	coefficient for calculating the slip resistance of preloaded bolts
n	strain hardening exponent
n_c	number of 90° corners in the section
n_{csm}	ratio of the design compression force N_{Ed} to the CSM compression resistance $N_{csm,Rd}$
n_p	is the exponent used in the calculation of the enhanced yield strength

3.2.4 Greek upper-case symbols

Ω	a project specific parameter that defines the permissible level of plastic deformation

3.2.5 Greek lower-case symbols

α	CSM bending parameter
$\alpha_{cr,sw,mod}$	modified factor by which the design load would have to be increased to cause elastic instability in a global (sway) mode to account for the influence of plasticity on the sway stiffness of frame
α_{csm}	CSM interaction coefficient for biaxial bending
β_{csm}	CSM interaction coefficient for biaxial bending
β_{w}	correlation factor for fillet welded connections
ε_{CHS}	strain induced in a circular hollow section during section forming
ε_{c}	strain induced in the corner region during section forming
ε_{csm}	limiting compressive strain from the continuous strength method
$\varepsilon_{csm,max}$	maximum design CSM strain
$\varepsilon_{csm,t}$	maximum attainable CSM tensile strain
ε_{Ed}	design strain
ε_{f}	strain induced in the flat faces of rectangular hollow sections during section forming
$\varepsilon_{p0,2}$	is the total strain corresponding to the 0,2 % proof strength
ε_{u}	ultimate strain, corresponding to the ultimate tensile strength f_u
ε_{y}	elastic strain at the yield strength
$\bar{\lambda}_{0}$	limiting relative slenderness
$\bar{\lambda}_{m}$	relative slenderness of the member determined at the critical cross-section m
$\bar{\lambda}_{c,cs}$	cross-section slenderness for circular hollow sections
$\bar{\lambda}_{p,cs}$	cross-section slenderness for sections comprising flat plates
μ	slip factor
ρ_{csm}	reduction factor to account for the interaction between bending and shear
$\sigma_{cr,c}$	elastic buckling stress of the full cross-section of the circular hollow section
$\sigma_{cr,cs}$	elastic local buckling stress of the full cross-section
$\sigma_{i,Ed,ser}$	serviceability design stress

4 Basis of design

4.1 General rules

4.1.1 Basic requirements

(1) The design of stainless steel structures shall be in accordance with the general rules given in EN 1990 and EN 1991 (all parts) and the specific design provisions for steel structures given in EN 1993-1-1, EN 1993-1-3, EN 1993-1-5 and EN 1993-1-8.

(2) Steel structures designed according to this document shall be executed according to EN 1090-2 and EN 1090-4 with construction materials and products used as specified in the relevant parts of EN 1993, or in the relevant material and product specifications.

4.2 Design assisted by testing

(1) Prototypes for testing should be produced in a similar manner to the components of the final product, such that they reflect the same levels of work hardening.

(2) Due to the anisotropy of cold worked stainless steels, test specimens should be prepared from the plate or sheet in the same orientation (i.e. transverse or parallel to the rolling direction) as intended for the final structure. If the final orientation is unknown or cannot be guaranteed, tests should be conducted for both orientations and the less favourable result should be adopted.

5 Materials

5.1 Structural stainless steels

5.1.1 General

(1) For the design of austenitic, duplex and ferritic stainless steel structures according to this document, the material should conform with one of the grades in Table A.3, and with one of the following product standards: EN 10088, EN 10028-7, 10296-2 and 10297-2.

NOTE 1 The most common stainless steel grades from Table A.3 are listed in Table 5.1 in accordance with their Corrosion Resistance Class and Strength Class.

NOTE 2 Other stainless steel grades and products can be defined in the National Annex.

(2) If other stainless steel grades than those mentioned in (1) are used, their mechanical properties shall conform to the conditions given in 5.1.2.1(4), 5.1.3 and 5.1.4 when tested in accordance with the relevant EN, ISO or EN ISO testing standards. If relevant, specialist advice should be sought regarding the durability, fabrication, weldability, fatigue resistance and high temperature performance of these grades.

Table 5.1 — Strength and corrosion classes for common stainless steels

Corrosion Resistance Class (see Annex A)	Strength Class			
	SC210		SC450	
	f_y (N/mm²)	f_u (N/mm²)	f_y (N/mm²)	f_u (N/mm²)
	210	500	450	650
I	1.4003[a] (F)			
II	1.4301 (A) 1.4307 (A)		1.4482 (D)	
III	1.4401 (A) 1.4404 (A) 1.4435 (A) 1.4571 (A)		1.4162 (D) 1.4362[b] (D) 1.4062 (D)	
IV			1.4462 (D) 1.4662 (D)	
V			1.4410 (D) 1.4501 (D)	

NOTE 1 F = ferritic, A = austenitic and D = duplex stainless steels.

NOTE 2 The most common austenitic stainless steels are 1.4301/1.4307 and 1.4401/1.4404.

NOTE 3 The strengths apply to sheet, plate, and strip, and products fabricated from sheet, plate and strip. The strengths also apply to cold-formed hollow sections where the strength enhancement arising from fabrication is not taken into account.

NOTE 4 For rods, bars, hot rolled open sections and seamless tubes, f_y = 180 N/mm² for the grades in Strength Class SC210, and EN 10088 gives values for f_y for grades in Strength Class SC450.

NOTE 5 Table A.3 categorises a wider selection of stainless steels into Corrosion Resistance Classes.

a f_y = 250-280 N/mm² for 1.4003, depending on the product form, and f_u = 450 N/mm². For rod, only f_u values apply.

b f_y = 400 N/mm²

5.1.2 Material properties

5.1.2.1 General

(1) The nominal values of the yield strength f_y and the ultimate tensile strength f_u for stainless steel should be obtained:

a) either by using the Strength Classes given in Table 5.1;

b) or by adopting the values $f_y = R_{p0,2}$ and $f_u = R_m$ (as lower bound of the given range) directly from the product standard.

NOTE The product standard can give higher strength values than Table 5.1, depending on the product form.

The strength of grades not listed in Table 5.1 should be taken from the product standard.

(2) Higher strength values may be derived from cold working of the sheet material, as given in 5.1.2.2 and Table 5.2 or during fabrication of cold-formed sections, as given in 5.1.2.3.