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Evrokod 3: Projektiranje jeklenih konstrukcij - 1-4. del: Splošna pravila - Dodatna pravila za nerjavna jekla

Eurocode 3 - Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels

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

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

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

This European Standard was approved by CEN on 9 January 2006.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Contents

Foreword

This European Standard EN 1993-1-4, Eurocode 3: Design of steel structures: Part 1-4 General Rules – Supplementary rules for stainless steels, has been prepared by Technical Committee CEN/TC250 « Structural Eurocodes », the Secretariat of which is held by BSI. CEN/TC250 is responsible for all Structural Eurocodes.

This European Standard shall be given the status of a National Standard, either by publication of an identical text or by endorsement, at the latest by April 2007 and conflicting National Standards shall be withdrawn at latest by March 2010.

This Eurocode supersedes ENV 1993-1-4.

According to the CEN-CENELEC Internal Regulations, the National Standard Organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

National Annex for EN 1993-1-4

This standard gives alternative procedures, values and recommendations with notes indicating where national choices may have to be made. The National Standard implementing EN 1993-1-4 should have a National Annex containing all Nationally Determined Parameters to be used for the design of steel structures to be constructed in the relevant country.

National choice is allowed in EN 1993-1-4 through clauses:

- 2.1.4(2)
- 2.1.5(1)
- 5.1(2)
- 5.5(1)
- 5.6(2)
- 6.1(2)
- 6.2(3)

1 General

1.1 Scope

(1) This Part 1.4 of EN 1993 gives supplementary provisions for the design of buildings and civil engineering works 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, austenitic-ferritic and ferritic stainless steels.

NOTE 1: Information on the durability of stainless steels is given in Annex A.

NOTE 2: The execution of stainless steel structures is covered in EN 1090.

NOTE 3: Guidelines for further treatment, including heat treatment, are given in EN 10088.

1.2 Normative references

This following normative documents contain provisions which, through reference to this text, constitute provisions of this European Standard. For dated references, subsequent amendments to or revisions of any of these publications do not apply. However, parties to agreements based on this European Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

EN 1990	*Eurocode 0: Basis of structural design*
EN 508-3	*Roofing products from metal sheet. Specification for self-supporting products of steel, aluminium or stainless steel sheet. Stainless steel;*
EN 1090-2	*Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures;*
EN 1993-1-1	*Design of steel structures: General rules and rules for buildings;*
EN 1993-1-2	*Design of steel structures: Structural fire design;*
EN 1993-1-3	*Design of steel structures: Cold formed thin gauge members and sheeting;*
EN 1993-1-5	*Design of steel structures: Plated structural elements;*
EN 1993-1-6	*Design of steel structures: Strength and stability of shell structures;*
EN 1993-1-8	*Design of steel structures: Design of joints;*
EN 1993-1-9	*Design of steel structures: Fatigue;*
EN 1993-1-10	*Design of steel structures: Material toughness and through-thickness properties;*
EN 1993-1-11	*Design of steel structures: Design of structures with tension components made of steel;*
EN 1993-1-12	*Design of steel structures: Additional rules for the extension of EN 1993 up to steel grades S 700;*
EN ISO 3506-1	*Mechanical properties of corrosion resistant stainless steel fasteners – Part 1: Bolts, screws and studs;*
EN ISO 3506-2	*Mechanical properties of corrosion resistant stainless steel fasteners – Part 2: Nuts*
EN ISO 3506-3	*Mechanical properties of corrosion resistant stainless steel fasteners – Part 3: Set screws and similar fasteners under tensile tests;*
EN ISO 7089	*Plain washers - Normal series - Product grade A;*
EN ISO 7090	*Plain washers, chamfered - Normal series - Product grade A;*
EN ISO 9445	*Continuously cold-rolled stainless steel narrow strip, wide strip, plate/sheet and cut lengths - Tolerances on dimensions and form*
EN 10029	*Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above;*

EN 10052 *Vocabulary of heat treatment terms for ferrous products;*

EN 10088-1 *Stainless steels – Part 1: List of stainless steels;*

EN 10088-2 *Stainless steels – Part 2: Technical delivery conditions for sheet/plate and strip for general purposes;*

EN 10088-3 *Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods and sections for general purposes;*

EN 10162 *Cold rolled steel sections. Technical delivery conditions. Dimensional and cross-sectional tolerances;*

EN 10219-2 *Cold formed welded structural sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties;*

1.3 Assumptions

(1) In addition to the general assumptions of EN 1990 the following assumptions apply:

- fabrication and erection complies with EN 1090-2.

1.4 Distinction between principles and application rules

(1) The rules in EN 1990 clause 1.4 apply.

1.5 Definitions

(1) The rules in EN 1990 clause 1.5 apply.

(2) Unless otherwise stated, the vocabulary of treatment terms for ferrous products used in EN 10052 applies.

1.6 Symbols

In addition to those given in EN 1990, EN 1993-1-1, EN 1993-1-3, EN 1993-1-5 and 1993-1-8, the following symbols are used:

$f_{u,red}$ reduced value of bearing strength
$E_{s,ser}$ 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
$\sigma_{1,Ed,ser}$ serviceability design stress
n coefficient

2 Materials

2.1 Structural stainless steels

2.1.1 General

(1) The provisions given in this Part 1.4 should be applied only to design using austenitic, austenitic-ferritic and ferritic stainless steels.

(2) The nominal values of the material properties given in 2.1.2 should be used as characteristic values in structural design calculations.

(3) For further information about material properties reference should be made to EN 10088.

(4) The design provisions specified in this Part 1.4 are applicable for material of nominal yield strength f_y up to and including 480 N/mm^2.

NOTE: Rules for the use of work hardened material with $f_y > 480$ N/mm^2 are given in Informative Annex B.

(5) The higher strength of other materials (see 2.1.2 and Annex B) may be taken into account in the design provided that doing so is justified by appropriate tests in accordance with Section 7.

2.1.2 Material properties for stainless steel

(1) In design calculations the values should be taken as follows, independent of the direction of rolling:

- **yield strength f_y:** the nominal stress (0,2% proof stress) specified in Table 2.1;
- **ultimate tensile strength f_u:** the nominal ultimate tensile strength specified in Table 2.1.

(2) The ductility requirements in EN 1993-1-1, clause 3.2.2 also apply to stainless steels. Steels conforming with one of the steel grades listed in Table 2.1 should be accepted as satisfying these requirements.

(3) For structural hollow sections, the strength values given in Table 2.1 for the relevant product form of the base material (cold-rolled strip, hot rolled strip or hot rolled plate) should be used.

(4) Higher strength values derived from cold working the base material may be used in design provided they are verified by tests on coupons taken from the structural hollow section in accordance with Section 7.

(5) For cold worked material, the material tests given in the material certificate required according to EN 1090, should be in such a direction that the strength values used in design are independent of the direction of rolling or stretching.

Table 2.1: Nominal values of the yield strength f_y and the ultimate tensile strength f_u for structural stainless steels to EN 10088 [1)]

Type of stainless steel	Grade	Product form							
		Cold rolled strip		Hot rolled strip		Hot rolled plate		Bars, rods and sections	
		Nominal thickness t							
		$t \le 6$ mm		$t \le 12$ mm		$t \le 75$ mm		$t \le 250$ mm	
		f_y N/mm^2	f_u N/mm^2	f_y N/mm^2	f_u N/mm^2	f_y N/mm^2	f_u N/mm^2	f_y N/mm^2	f_u N/mm^2
Ferritic steels	1.4003	280	450	280	450	250[3)]	450[3)]	260[4)]	450[4)]
	1.4016	260	450	240	450	240[3)]	430[3)]	240[4)]	400[4)]
	1.4512	210	380	210	380	-	-	-	-
Austenitic steels	1.4306	220	520	200	520	200	500	180	460
	1.4307							175	450
	1.4541							190	500
	1.4301	230	540	210	520	210	520		
	1.4401	240	530	220	530	220	520	200	500
	1.4404								
	1.4539							230	530
	1.4571		540		540			200	500
	1.4432	240	550	220	550	220	520		
	1.4435								
	1.4311	290	550	270	550	270	550	270	550
	1.4406	300	580	280	580	280	580	280	580
	1.4439	290		270		270			
	1.4529	300	650	300	650	300	650		
	1.4547	320	650	300	650	300	650	300	650
	1.4318	350	650	330	650	330	630	-	-
Austenitic -ferritic steels	1.4362	420	600	400	600	400	630	400 [2)]	600 [2)]
	1.4462	480	660	460	660	460	640	450	650

[1)] The nominal values of f_y and f_u given in this table may be used in design without taking special account of anisotropy or strain hardening effects.

[2)] $t \le 160$ mm

[3)] $t \le 25$ mm

[4)] $t \le 100$ mm

2.1.3 Design values of material coefficients

(1) The following values of the material coefficients may be assumed for the global analysis and in determining the resistances of members and cross-sections:

- Modulus of elasticity, E:

  E = 200 000 N/mm^2 for the austenitic and austenitic-ferritic grades in Table 2.1 excluding grades 1.4539, 1.4529 and 1.4547

  E = 195 000 N/mm^2 for the austenitic grades 1.4539, 1.4529 and 1.4547

  E = 220 000 N/mm^2 for the ferritic grades in Table 2.1

- Shear modulus, G, where $G = \dfrac{E}{2(1+\nu)}$

- Poisson's ratio in elastic stage, $\nu = 0{,}3$

Alternatively, stress-strain curves according to Annex C may be used for materials in the annealed condition to describe the material behaviour.

(2) For calculating deflections in individual members, the secant modulus appropriate to the stress in the member at the serviceability limit state may be used, see 4.2(5).

2.1.4 Fracture toughness

(1) The austenitic and austenitic-ferritic stainless steels covered in this Part 1.4 may be assumed to be adequately tough and not susceptible to brittle fracture for service temperatures down to -40°C.

NOTE: Austenitic steels may also be used for temperatures below -40°C, but the requirements should be determined for each particular case.

NOTE: See Annex A.5.3 concerning embrittlement due to contact with zinc in fire.

(2) For ferritic stainless steels, the rules in EN 1993-1-10 give guidance. Required testing temperature and required CVN-values may be determined from Table 2.1 of EN 1993-1-10.

NOTE 1: Ferritic steels are not classified into sub-grades.

NOTE 2: The National Annex may provide further information on fracture toughness of ferritic stainless steels.

2.1.5 Through-thickness properties

(1) Guidance on the choice of through-thickness properties is given in EN 1993-1-10.

NOTE: The National Annex may provide further information on the choice of through thickness properties.

2.1.6 Tolerances

(1) The dimensional and mass tolerances of rolled steel sections, structural hollow sections and plates should conform with the relevant product standard unless more severe tolerances are specified.

NOTE: For information about tolerances for thickness of cold rolled stainless steel, reference should be made to EN ISO 9445: 2006. For plates see EN 10029

(2) For welded components the tolerances given in EN 1090-2 should be applied.

(3) For structural analysis and design, the nominal values of dimensions should be used except that the design thickness of strips should be determined according to 3.2.4(3) of EN 1993-1-3.

2.2 Bolts

2.2.1 General

(1) Stainless steel bolts and nuts should conform with EN ISO 3506 - 1,2,3. Washers should be of stainless steel and should conform with EN ISO 7089 or EN ISO 7090, as appropriate. The corrosion resistance of the bolts should be equivalent to, or better than, the corrosion resistance of the parent material.

(2) The nominal yield strength f_{yb} and ultimate tensile strength f_{ub} for stainless steel bolts should be obtained from Table 2.2.

(3) Pending the issue of an appropriate European Standard, the specified properties should be verified using a recognised quality control system, with samples from each batch of fasteners.

Table 2.2: Nominal values of f_{yb} and f_{ub} for stainless steel bolts

Material groups	Property class to EN ISO 3506	Range of sizes	Yield strength f_{yb} N/mm^2	Ultimate tensile strength f_{ub} N/mm^2
Austenitic and austenitic-ferritic	50	≤ M 39	210	500
	70	≤ M 24	450	700
	80	≤ M 24	600	800

2.2.2 Preloaded bolts

NOTE: High strength bolts made of stainless steel should not be used as preloaded bolts designed for a specific slip resistance, unless their acceptability in a particular application can be demonstrated from test results.

2.2.3 Other types of mechanical fastener

(1) Requirements for other types of mechanical fasteners are given in EN 1993-1-3.

2.3 Welding consumables

(1) General requirements for welding consumables are given in EN 1993-1-8.

(2) In addition to the requirements of EN 1993-1-8, the welding electrodes should be capable of producing a weld with a corrosion resistance that is adequate for the service environment, provided that the correct welding procedure is used.

(3) The welding electrodes may be assumed to be adequate if the corrosion resistance of the deposited metal and weld metal is not less than that of the material to be welded.

NOTE: Professional advice is recommended on the selection of welding procedure for jointing stainless steels

3 Durability

(1) The requirements for durability given in Section 4 of EN 1993-1-1 should also be applied for stainless steels.

(2) An appropriate grade of stainless steel should be selected according to the corrosion resistance required for the environment in which the structural members are to be used.

NOTE: Guidance on the selection of materials for corrosion resistance is given in Annex A.

(3) In cosmetic applications, the possible minor changes in surface appearance that might take place as a result of dirt deposits (which in adverse circumstances can create crevices and lead to surface micro-pitting) should also be taken into account. A suitable corrosion-resistant grade of stainless steel should be used to ensure that only superficial surface attack takes place within the design life of the component.

NOTE: Surface aspect features of hot rolled plates are described in EN 10163.

(4) If necessary, a suitable cleaning regime should be specified to maintain surface appearance.

(5) Although, under benign atmospheric exposure conditions, the requirements given in (3) can be satisfied by most stainless steels, expert advice should be sought if stainless steel is required to be exposed to environments that contain chemicals, including atmospheres associated with certain industrial processes, in swimming pool buildings, sea water and salt spray from road de-icing or the like.

NOTE: Additional information on design for corrosion control is given in Annex A.

4 Serviceability limit states

4.1 General

(1) The requirements for serviceability given in Section 7 of EN 1993-1-1 should be applied for stainless steels.

(2) Deflections in members should be estimated in accordance with 4.2.

4.2 Determination of deflections

(1) The effects of the non-linear stress-strain behaviour of stainless steels, and the effectiveness of the cross-section, should be taken into account in estimating deflections.

NOTE: Guidance for the description of the non-linear material behaviour of annealed material is given in Informative Annex C.

(2) The basic requirements for serviceability limit states are given in clause 3.4 of EN 1990.

NOTE: EN 1990 gives the appropriate combinations of actions to use in the following situations:

- for calculating deflections under permanent and/or variable actions;
- when long term deformations due to shrinkage, relaxation or creep need to be considered;
- if the appearance of the structure or the comfort of the user or functioning of machinery are being considered.

(3) The effective cross-section may conservatively be based on effective widths of compression elements in Class 4 cross-sections determined using 5.2.3. Alternatively, the more accurate method in 4.4(4) of EN 1993-1-5 may be used.

(4) In the case of members subject to shear lag, the effective cross-section may be based on effective widths determined using 3.2 in EN 1993-1-5.

(5) Deflections should be estimated using the secant modulus of elasticity $E_{s,ser}$ determined taking account of the stresses in the member under the load combination for the relevant serviceability limit state and the orientation of the rolling direction. If the orientation of the rolling direction is not known, or cannot be ensured, then the value for the longitudinal direction should be used. Alternatively, the FE-methods given in Annex C of EN 1993-1-5 may be used with the description of the non-linear material behaviour given in Annex C of this document.

(6) The value of the secant modulus of elasticity $E_{s,ser}$ may be obtained from:

$$E_{s,ser} = \frac{(E_{s,1} + E_{s,2})}{2} \tag{4.1}$$

where:

$E_{s,1}$ is the secant modulus corresponding to the stress σ_1 in the tension flange;

$E_{s,2}$ is the secant modulus corresponding to the stress σ_2 in the compression flange.

(7) The values of $E_{s,1}$ and $E_{s,2}$ for the appropriate serviceability design stress $\sigma_{i,Ed,ser}$ and rolling direction may be estimated using: