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Eurokod 3: Dimensionering av stålkonstruktioner – Del 1-3: Kallformade profiler och profilerad plåt

Eurocode 3: Design of steel structures – Part 1-3: General rules – Supplementary rules for cold-formed members and sheeting

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1993-1-3

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ICS 91.010.30

Supersedes ENV 1993-1-3:1996

English Version

Eurocode 3 - Design of steel structures - Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting

Eurocode 3 - Calcul des structures en acier - Partie 1-3: Règles générales - Règles supplémentarires pour les profilés et plaques à parois minces formés à froid

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 1-3: Allgemeine Regeln - Ergänzende Regeln für kaltgeformte dünnwandige Bauteile und Bleche

This European Standard was approved by CEN on 16 January 2006.

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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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Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 1993-1-3:2006: E

Content

Foreword

This European Standard EN 1993-1-3, Eurocode 3: Design of steel structures: Part 1-3 General rules – Supplementary rules for cold formed members and sheeting, 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of an identical text or by endorsement, at the latest by April 2007, and conflicting National Standards shall be withdrawn at latest by March 2010.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 1993-1-3.

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 1993-1-3

This standard gives alternative procedures, values and recommendations for classes with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1993-1-3 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 1993-1-3 through clauses:

- 2(3)P
- 2(5)
- 3.1(3) Note 1 and Note 2
- 3.2.4(1)
- 5.3(4)
- 8.3(5)
- 8.3(13), Table 8.1
- 8.3(13), Table 8.2
- 8.3(13), Table 8.3
- 8.3(13), Table 8.4
- 8.4(5)
- 8.5.1(4)
- 9(2)
- 10.1.1(1)
- 10.1.4.2(1)
- A.1(1), NOTE 2
- A.1(1), NOTE 3
- A.6.4(4)
- E(1)

1 Introduction

1.1 Scope

(1) EN 1993-1-3 gives design requirements for cold-formed thin gauge members and sheeting. It applies to cold-formed steel products made from coated or uncoated thin gauge hot or cold rolled sheet or strip, that have been cold-formed by such processes as cold-rolled forming or press-braking. It may also be used for the design of profiled steel sheeting for composite steel and concrete slabs at the construction stage, see EN 1994. The execution of steel structures made of cold-formed thin gauge members and sheeting is covered in EN 1090.

NOTE: The rules in this part complement the rules in other parts of EN 1993-1.

(2) Methods are also given for stressed-skin design using steel sheeting as a structural diaphragm.

(3) This part does not apply to cold-formed circular and rectangular structural hollow sections supplied to EN 10219, for which reference should be made to EN 1993-1-1 and EN 1993-1-8.

(4) EN 1993-1-3 gives methods for design by calculation and for design assisted by testing. The methods for design by calculation apply only within stated ranges of material properties and geometrical proportions for which sufficient experience and test evidence is available. These limitations do not apply to design assisted by testing.

(5) EN 1993-1-3 does not cover load arrangement for testing for loads during execution and maintenance.

(6) The calculation rules given in this standard are only valid if the tolerances of the cold formed members comply with EN 1090-2

1.2 Normative references

The following normative documents contain provisions which, through reference in 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 1993 *Eurocode 3 – Design of steel structures*

Part 1-1 to part 1-12

EN 10002 *Metallic materials - Tensile testing:*

Part 1: *Method of test (at ambient temperature)*;

EN 10025-1 *Hot-rolled products of structural steels - Part 1: General delivery conditions;*

EN 10025-2 *Hot-rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels;*

EN 10025-3 *Hot-rolled products of structural steels - Part 3: Technical delivery conditions for normalized / normalized rolled weldable fine grain structural steels;*

EN 10025-4 *Hot-rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels;*

EN 10025-5 *Hot-rolled products of structural steels - Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance;*

EN 10143 *Continuously hot-dip metal coated steel sheet and strip - Tolerances on dimensions and shape*;

EN 10149 *Hot rolled flat products made of high yield strength steels for cold-forming:*

Part 2: *Delivery conditions for normalized/normalized rolled steels*;

Part 3: *Delivery conditions for thermomechanical rolled steels*;

EN 10204 *Metallic products. Types of inspection documents (includes amendment A 1:1995);*

EN 10268 *Cold-rolled flat products made of high yield strength micro-alloyed steels for cold forming - General delivery conditions;*

EN 10292 *Continuously hot-dip coated strip and sheet of steels with higher yield strength for cold forming - Technical delivery conditions;*

EN 10326 *Continuously hot-dip coated strip and sheet of structural steels - Technical delivery conditions;*

EN 10327 *Continuously hot-dip coated strip and sheet of low carbon steels for cold forming - Technical delivery conditions;*

EN-ISO 12944-2 *Paints and vanishes. Corrosion protection of steel structures by protective paint systems. Part 2: Classification of environments (ISO 12944-2:1998);*

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

EN 1994 *Eurocode 4: Design of composite steel and concrete structures;*

EN ISO 1478 *Tapping screws thread;*

EN ISO 1479 *Hexagon head tapping screws;*

EN ISO 2702 *Heat-treated steel tapping screws - Mechanical properties;*

EN ISO 7049 *Cross recessed pan head tapping screws;*

EN ISO 10684 *Fasteners – hot deep galvanized coatings*

ISO 4997 *Cold reduced steel sheet of structural quality*;

EN 508-1 *Roofing products from metal sheet - Specification for self-supporting products of steel, aluminium or stainless steel sheet - Part 1: Steel;*

FEM 10.2.02 *Federation Europeenne de la manutention, Secion X, Equipment et proceedes de stockage, FEM 10.2.02, The design of static steel pallet racking, Racking design code, April 2001 Version 1.02.*

1.3 Terms and definitions

Supplementary to EN 1993-1-1, for the purposes of this Part 1-3 of EN 1993, the following terms and definitions apply:

1.3.1
basic material
The flat sheet steel material out of which cold-formed sections and profiled sheets are made by cold-forming.

1.3.2
basic yield strength
The tensile yield strength of the basic material.

1.3.3
diaphragm action
Structural behaviour involving in-plane shear in the sheeting.

1.3.4
liner tray
Profiled sheet with large lipped edge stiffeners, suitable for interlocking with adjacent liner trays to form a plane of ribbed sheeting that is capable of supporting a parallel plane of profiled sheeting spanning perpendicular to the span of the liner trays.

1.3.5
partial restraint
Restriction of the lateral or rotational movement, or the torsional or warping deformation, of a member or element, that increases its buckling resistance in a similar way to a spring support, but to a lesser extent than a rigid support.

1.3.6
relative slenderness
A normalized non-dimensional slenderness ratio.

1.3.7
restraint
Restriction of the lateral or rotational movement, or the torsional or warping deformation, of a member or element, that increases its buckling resistance to the same extent as a rigid support.

1.3.8
stressed-skin design
A design method that allows for the contribution made by diaphragm action in the sheeting to the stiffness and strength of a structure.

1.3.9
support
A location at which a member is able to transfer forces or moments to a foundation, or to another member or other structural component.

1.3.10
nominal thickness
A target average thickness inclusive zinc and other metallic coating layers when present rolled and defined by the steel supplier (t_{nom} not including organic coatings).

1.3.11
steel core thickness
A nominal thickness minus zinc and other metallic coating layers (t_{cor}).

1.3.12
design thickness
the steel core thickness used in design by calculation according to 1.5.3(6) and 3.2.4.

1.4 Symbols

(1) In addition to those given in EN 1993-1-1, the following main symbols are used:

f_y yield strength

f_{ya} average yield strength

f_{yb} basic yield strength

t design core thickness of steel material before cold forming, exclusive of metal and organic coating

t_{nom} nominal sheet thickness after cold forming inclusive of zinc and other metallic coating not including organic coating

t_{cor} the nominal thickness minus zinc and other metallic coating

K spring stiffness for displacement

C spring stiffness for rotation

(2) Additional symbols are defined where they first occur.

(3) A symbol may have several meanings in this part.

1.5 Terminology and conventions for dimensions

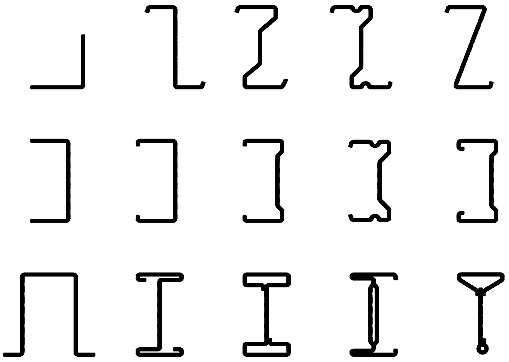
1.5.1 Form of sections

(1) Cold-formed members and profiled sheets have within the permitted tolerances a constant nominal thickness over their entire length and may have either a uniform cross section or a tapering cross section along their length.

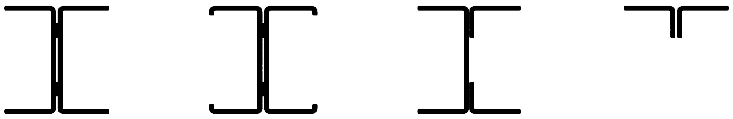
(2) The cross-sections of cold-formed members and profiled sheets essentially comprise a number of plane elements joined by curved elements.

(3) Typical forms of sections for cold-formed members are shown in figure 1.1.

NOTE: The calculation methods of this Part 1-3 of EN 1993 does not cover all the cases shown in figures 1.1-1.2.



a) Single open sections



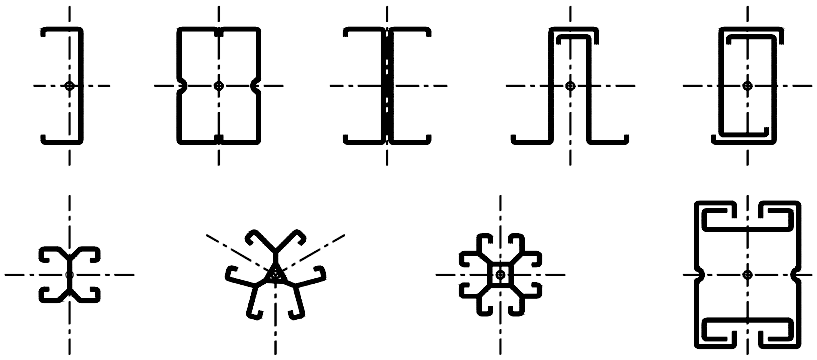
b) Open built-up sections

c) Closed built-up sections

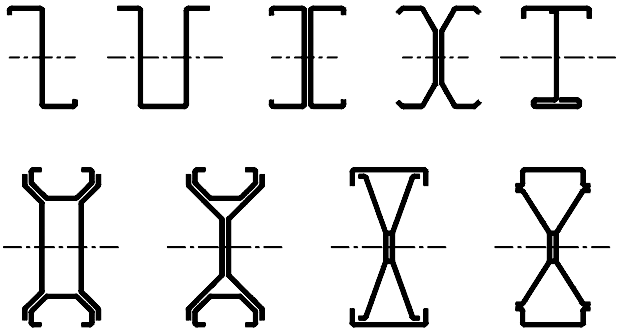
Figure 1.1: Typical forms of sections for cold-formed members

(4) Examples of cross-sections for cold-formed members and sheets are illustrated in figure 1.2.

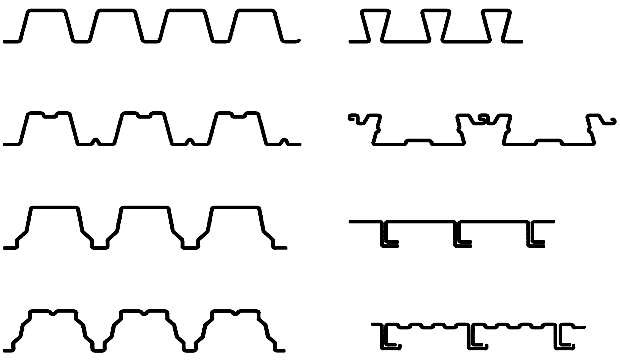
NOTE: All rules in this Part 1-3 of EN 1993 relate to the main axis properties, which are defined by the main axes y - y and z - z for symmetrical sections and u - u and v - v for unsymmetrical sections as e.g. angles and Zed-sections. In some cases the bending axis is imposed by connected structural elements whether the cross-section is symmetric or not.



a) Compression members and tension members



b) Beams and other members subject to bending



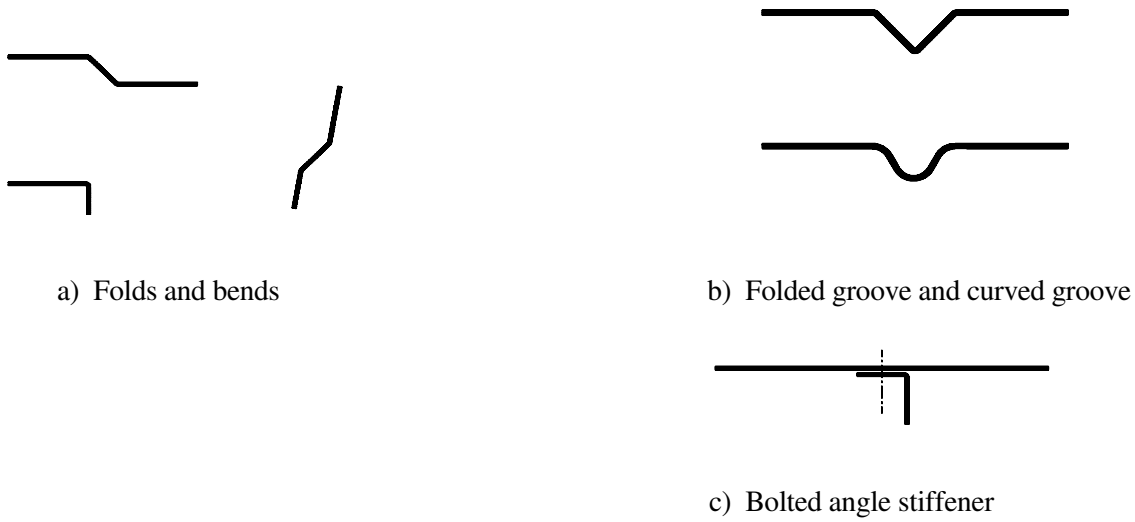
c) Profiled sheets and liner trays

Figure 1.2: Examples of cold-formed members and profiled sheets

(5) Cross-sections of cold-formed members and sheets may either be unstiffened or incorporate longitudinal stiffeners in their webs or flanges, or in both.

1.5.2 Form of stiffeners

(1) Typical forms of stiffeners for cold-formed members and sheets are shown in figure 1.3.



a) Folds and bends

b) Folded groove and curved groove

c) Bolted angle stiffener

Figure 1.3: Typical forms of stiffeners for cold-formed members and sheeting

(2) Longitudinal flange stiffeners may be either edge stiffeners or intermediate stiffeners.

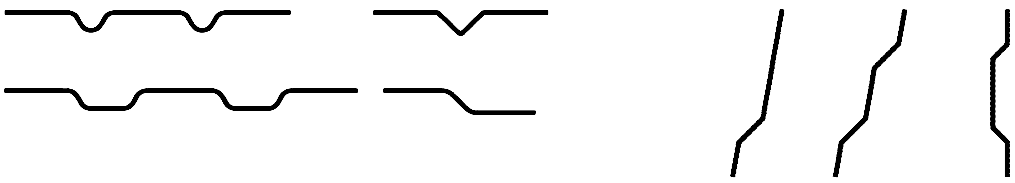
(3) Typical edge stiffeners are shown in figure 1.4.

a) Single edge fold stiffeners

b) Double edge fold stiffeners

Figure 1.4: Typical edge stiffeners

(4) Typical intermediate longitudinal stiffeners are illustrated in figure 1.5.



a) Intermediate flange stiffeners

b) Intermediate web stiffeners

Figure 1.5: Typical intermediate longitudinal stiffeners

1.5.3 Cross-section dimensions

(1) Overall dimensions of cold-formed members and sheeting, including overall width b, overall height h, internal bend radius r and other external dimensions denoted by symbols without subscripts, such as a, c or d, are measured to the face of the material, unless stated otherwise, as illustrated in figure 1.6.

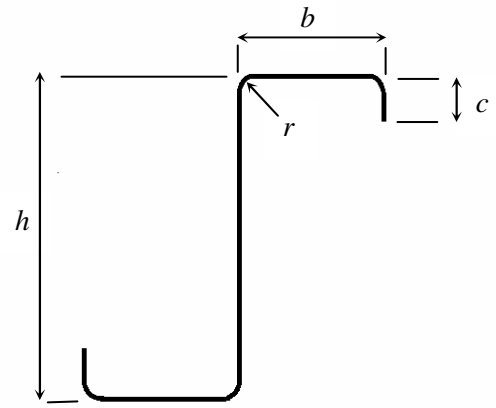


Figure 1.6: Dimensions of typical cross-section

(2) Unless stated otherwise, the other cross-sectional dimensions of cold-formed members and sheeting, denoted by symbols with subscripts, such as b_d, h_w or s_w, are measured either to the midline of the material or the midpoint of the corner.

(3) In the case of sloping elements, such as webs of trapezoidal profiled sheets, the slant height s is measured parallel to the slope. The slope is straight line between intersection points of flanges and web.

(4) The developed height of a web is measured along its midline, including any web stiffeners.

(5) The developed width of a flange is measured along its midline, including any intermediate stiffeners.

(6) The thickness t is a steel design thickness (the steel core thickness extracted minus tolerance if needed as specified in clause 3.2.4), if not otherwise stated.

1.5.4 Convention for member axes

(1) In general the conventions for members is as used in Part 1-1 of EN 1993, see Figure 1.7.

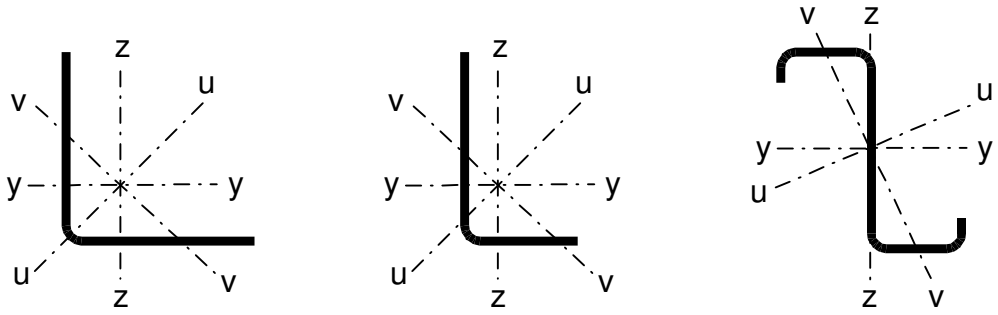


Figure 1.7: Axis convention

(2) For profiled sheets and liner trays the following axis convention is used:

- y - y axis parallel to the plane of sheeting;
- z - z axis perpendicular to the plane of sheeting.

2 Basis of design

(1) The design of cold formed members and sheeting should be in accordance with the general rules given in EN 1990 and EN 1993-1-1. For a general approach with FE-methods (or others) see EN 1993-1-5, Annex C.

(2)P Appropriate partial factors shall be adopted for ultimate limit states and serviceability limit states.

(3)P For verifications by calculation at ultimate limit states the partial factor γ_M shall be taken as follows:

- resistance of cross-sections to excessive yielding including local and distortional buckling: γ_{M0}
- resistance of members and sheeting where failure is caused by global buckling: γ_{M1}
- resistance of net sections at fastener holes: γ_{M2}

NOTE: Numerical values for γ_{Mi} may be defined in the National Annex. The following numerical values are recommended for the use in buildings:

$\gamma_{M0} = 1{,}00$;

$\gamma_{M1} = 1{,}00$;

$\gamma_{M2} = 1{,}25$.

(4) For values of γ_M for resistance of connections, see Section 8.

(5) For verifications at serviceability limit states the partial factor $\gamma_{M,ser}$ should be used.

NOTE: Numerical value for $\gamma_{M,ser}$ may be defined in the National Annex. The following numerical value is recommended for the use in buildings:

$\gamma_{M,ser} = 1{,}00$.

(6) For the design of structures made of cold formed members and sheeting a distinction should be made between “structural classes” associated with failure consequences according to EN 1990 – Annex B defined as follows:

Structural Class I: Construction where cold-formed members and sheeting are designed to contribute to the overall strength and stability of a structure;

Structural Class II: Construction where cold-formed members and sheeting are designed to contribute to the strength and stability of individual structural elements;

Structural Class III: Construction where cold-formed sheeting is used as an element that only transfers loads to the structure.

NOTE 1: During different construction stages different structural classes may be considered.
NOTE 2: For requirements for execution of sheeting see EN 1090.

3 Materials

3.1 General

(1) All steels used for cold-formed members and profiled sheets should be suitable for cold-forming and welding, if needed. Steels used for members and sheets to be galvanized should also be suitable for galvanizing.

(2) The nominal values of material properties given in this Section should be adopted as characteristic values in design calculations.

(3) This part of EN 1993 covers the design of cold formed members and profiles sheets fabricated from steel material conforming to the steel grades listed in table 3.1a.

Table 3.1a: Nominal values of basic yield strength f_{yb} and ultimate tensile strength f_u

Type of steel	Standard	Grade	f_{yb} N/mm^2	f_u N/mm^2
Hot rolled products of non-alloy structural steels. Part 2: Technical delivery conditions for non alloy structural steels	EN 10025: Part 2	S 235	235	360
		S 275	275	430
		S 355	355	510
Hot-rolled products of structural steels. Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels	EN 10025: Part 3	S 275 N	275	370
		S 355 N	355	470
		S 420 N	420	520
		S 460 N	460	550
		S 275 NL	275	370
		S 355 NL	355	470
		S 420 NL	420	520
		S 460 NL	460	550
Hot-rolled products of structural steels. Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels	EN 10025: Part 4	S 275 M	275	360
		S 355 M	355	450
		S 420 M	420	500
		S 460 M	460	530
		S 275 ML	275	360
		S 355 ML	355	450
		S 420 ML	420	500
		S 460 ML	460	530

NOTE 1: For steel strip less than 3 mm thick conforming to EN 10025, if the width of the original strip is greater than or equal to 600 mm, the characteristic values may be given in the National Annex. Values equal to 0,9 times those given in Table 3.1a are recommended.

NOTE 2: For other steel materials and products see the National Annex. Examples for steel grades that may conform to the requirements of this standard are given in Table 3.1b.

Table 3.1b: Nominal values of basic yield strength f_{yb} and ultimate tensile strength f_u

Type of steel	Standard	Grade	f_{yb} N/mm^2	f_u N/mm^2
Cold reduced steel sheet of structural quality	ISO 4997	CR 220	220	300
		CR 250	250	330
		CR 320	320	400
Continuous hot dip zinc coated carbon steel sheet of structural quality	EN 10326	S220GD+Z	220	300
		S250GD+Z	250	330
		S280GD+Z	280	360
		S320GD+Z	320	390
		S350GD+Z	350	420
Hot-rolled flat products made of high yield strength steels for cold forming. Part 2: Delivery conditions for thermomechanically rolled steels	EN 10149: Part 2	S 315 MC	315	390
		S 355 MC	355	430
		S 420 MC	420	480
		S 460 MC	460	520
		S 500 MC	500	550
		S 550 MC	550	600
		S 600 MC	600	650
		S 650 MC	650	700
		S 700 MC	700	750
	EN 10149: Part 3	S 260 NC	260	370
		S 315 NC	315	430
		S 355 NC	355	470
		S 420 NC	420	530
Cold-rolled flat products made of high yield strength micro-alloyed steels for cold forming	EN 10268	H240LA	240	340
		H280LA	280	370
		H320LA	320	400
		H360LA	360	430
		H400LA	400	460
Continuously hot-dip coated strip and sheet of steels with higher yield strength for cold forming	EN 10292	H260LAD	240 2)	340 2)
		H300LAD	280 2)	370 2)
		H340LAD	320 2)	400 2)
		H380LAD	360 2)	430 2)
		H420LAD	400 2)	460 2)
Continuously hot-dipped zinc-aluminium (ZA) coated steel strip and sheet	EN 10326	S220GD+ZA	220	300
		S250GD+ZA	250	330
		S280GD+ZA	280	360
		S320GD+ZA	320	390
		S350GD+ZA	350	420
Continuously hot-dipped aluminium-zinc (AZ) coated steel strip and sheet	EN 10326	S220GD+AZ	220	300
		S250GD+AZ	250	330
		S280GD+AZ	280	360
		S320GD+AZ	320	390
		S350GD+AZ	350	420
Continuously hot-dipped zinc coated strip and sheet of mild steel for cold forming	EN 10327	DX51D+Z	140 1)	270 1)
		DX52D+Z	140 1)	270 1)
		DX53D+Z	140 1)	270 1)

1) Minimum values of the yield strength and ultimate tensile strength are not given in the standard. For all steel grades a minimum value of 140 N/mm^2 for yield strength and 270 N/mm^2 for ultimate tensile strength may be assumed.

2) The yield strength values given in the names of the materials correspond to transversal tension. The values for longitudinal tension are given in the table.

3.2 Structural steel

3.2.1 Material properties of base material

(1) The nominal values of yield strength f_{yb} or tensile strength f_u should be obtained

a) either by adopting the values $f_y = R_{eh}$ or $R_{p0,2}$ and $f_u = R_m$ direct from product standards, or

b) by using the values given in Table 3.1a and b

c) by appropriate tests.

(2) Where the characteristic values are determined from tests, such tests should be carried out in accordance with EN 10002-1. The number of test coupons should be at least 5 and should be taken from a lot in following way:

1. Coils: a. For a lot from one production (one pot of melted steel) at least one coupon per coil of 30% of the number of coils;

   b. For a lot from different productions at least one coupon per coil;

2. Strips: At least one coupon per 2000 kg from one production.

The coupons should be taken at random from the concerned lot of steel and the orientation should be in the length of the structural element. The characteristic values should be determined on basis of a statistical evaluation in accordance with EN 1990 Annex D.

(3) It may be assumed that the properties of steel in compression are the same as those in tension.

(4) The ductility requirements should comply with 3.2.2 of EN 1993-1-1.

(5) The design values for material coefficients should be taken as given in 3.2.6 of EN 1993-1-1

(6) The material properties for elevated temperatures are given in EN 1993-1-2.

3.2.2 Material properties of cold formed sections and sheeting

(1) Where the yield strength is specified using the symbol f_y the average yield strength f_{ya} may be used if (4) to (8) apply. In other cases the basic yield strength f_{yb} should be used. Where the yield strength is specified using the symbol f_{yb} the basic yield strength f_{yb} should be used.

(2) The average yield strength f_{ya} of a cross-section due to cold working may be determined from the results of full size tests.

(3) Alternatively the increased average yield strength f_{ya} may be determined by calculation using:

$$f_{ya} = f_{yb} + (f_u - f_{yb})\frac{knt^2}{A_g} \qquad \text{but} \qquad f_{ya} \le \frac{(f_u + f_{yb})}{2} \qquad \ldots (3.1)$$

where:

A_g is the gross cross-sectional area;

k is a numerical coefficient that depends on the type of forming as follows:

- $k = 7$ for roll forming;
- $k = 5$ for other methods of forming;

n is the number of $90°$ bends in the cross-section with an internal radius $r \le 5t$ (fractions of $90°$ bends should be counted as fractions of n);

t is the design core thickness of the steel material before cold-forming, exclusive of metal and organic coatings, see 3.2.4.

(4) The increased yield strength due to cold forming may be taken into account as follows: