

Eurocode 3: Design of steel structures —

**Part 1.3: General rules —
Supplementary rules for cold formed
thin gauge members and sheeting**

**(together with United Kingdom
National Application Document)**

ICS 91.010.30; 91.080.10

Committees responsible for this Draft for Development

The preparation of this Draft for Development was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/31, Structural use of steel, upon which the following bodies were represented:

British Constructional Steelwork Association
Cold Rolled Sections Association
Confederation of British Forgers
Department of the Environment, Transport and the Regions
Department of the Environment, Transport and the Regions —
Construction Directorate
Department of the Environment, Transport and the Regions —
Highways Agency
Health and Safety Executive
Institution of Civil Engineers
Institution of Structural Engineers
Steel Construction Institute
UK Steel Association
Welding Institute

This Draft for Development, having been prepared under the direction of the Sector Committee for Building and Civil Engineering was published under the authority of the Standards Committee and comes into effect on 15 July 2001

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The following BSI references relate to the work on this Draft for Development:
Committee reference B/525/31

ISBN 0 580 33219 5

Amendments issued since publication

Amd. No	Date	Comments
13403 Corr. No. 1	22 August 2001	Indicated by a sideline

Contents

Committees responsible	Inside front cover
National foreword	ii
Text of National Application Document	iii
Text of ENV 1993-1-2	2

National foreword

This publication has been prepared by Subcommittee B/525/31 and is the English language version of ENV 1993-1-3:1996, *Eurocode 3: Design of steel structures — Part 1.3: General rules — Supplementary rules for cold formed thin gauge members and sheeting* incorporating its corrigendum of October 1997, as published by the European Committee for Standardization (CEN). This Draft for Development also includes the United Kingdom (UK) National Application Document (NAD) to be used with the ENV in the design of buildings to be constructed in the UK.

ENV 1993-1-3:1996 results from a programme of work sponsored by the European Commission to make available a common set of rules for the design of building and civil engineering works.

This publication should not be regarded as a British Standard.

An ENV is made available for provisional application, but does not have the status of a European Standard. The aim is to use the experience gained to modify the ENV so that it can be adopted as a European Standard.

The value for certain parameters in the ENV Eurocodes may be set by CEN members so as to meet the requirements of national regulations. These parameters are designated by □ (boxed values) in the ENV.

During the ENV period of validity, reference should be made to the supporting documents listed in the NAD.

The purpose of the NAD is to provide essential information, particularly in relation to safety, to enable the ENV to be used for buildings constructed in the UK. The NAD takes precedence over corresponding provisions in the ENV.

The Building Regulations 1991, Approved Document A 1992 (published December 1991)¹⁾, draws designers' attention to the potential use of ENV Eurocodes as an alternative approach to Building Regulation compliance. ENV 1993-1-3:1996 has been thoroughly examined over a period of several years and is considered to offer such an alternative approach, when used in conjunction with this NAD.

Compliance with DD ENV 1993-1-3:2001 does not of itself confer immunity from legal obligations.

Users of this document are invited to comment on its technical content, ease of use and any ambiguities or anomalies. These comments will be taken into account when preparing the UK national response to CEN on the question of whether the ENV can be converted into an EN.

Comments should be sent in writing to BSI, 389 Chiswick High Road, London W4 4AL, quoting the document reference, the relevant clause and, where possible, proposed revised wording.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to xvi, the ENV title page, pages 2 to 128 and a back cover.

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¹⁾ Available from The Stationery Office, PO Box 29, St Crispins House, Duke Street, Norwich NR3 1GN.

National Application Document

**for use in the UK with
ENV 1993-1-3:1996**

Contents of National Application Document

Introduction	v
1 Scope	v
2 Normative references	v
3 Partial safety factors and other factors	v
4 Loading codes	vi
5 Reference standards	vi
6 Additional recommendations	vii
Bibliography	xvi
Table 1 — Partial safety factors (γ_M)	vi
Table 2 — Directly reference supporting standards in ENV 1993-1-3	vii
Table 3 — Values of factor k	ix

Introduction

This National Application Document (NAD) has been prepared by Subcommittee B/525/31. It has been developed from:

- a) a textual examination of ENV 1993-1-3:1996;
- b) calibration against UK practice, supporting standards and test data.

NOTE *Design of cold formed steel sections and sheeting to Eurocode 3:Part 1.3* [1] gives a series of worked examples based on ENV 1993-1-3:1996 and this NAD.

It should be noted that this NAD, in common with ENV 1993-1-3 and supporting CEN standards, uses a comma (,) where a decimal point (.) would be traditionally used in the UK.

1 Scope

This NAD provides information required to enable ENV 1993-1-3:1996 to be used for the fire resistant design of buildings to be constructed in the UK.

2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this NAD. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 648:1964 (all parts), *Schedule of weights of building materials*.

BS 6399-1:1996, *Loadings for buildings — Part 1: Code of practice for dead and imposed loads*.

BS 6399-3:1988, *Loadings for buildings — Part 3: Code of practice for imposed roof loads*.

CP 3:Chapter V:Part 2:1972, *Code of basic data for the design of buildings — Loading — Wind loads*.

3 Partial safety factors and other factors

3.1 Material factors

The values for the partial safety factor γ_M for use with ENV 1993-1-3:1996 should be as given in Table 1 of this NAD.

The values for the load factors for acceptance tests are given in **6.10** of this NAD.

Table 1 — Partial safety factors (γ_M)

Reference in ENV 1993-1-3	Definition	Symbol	Condition	Value	
				Boxed ENV value	Value for UK use
2.2(3)P	Partial safety factor for verification at the ultimate limit state.	γ_{M0}	Resistance of cross-section where failure is caused by yielding.	1,10	1,05
		γ_{M1}	Resistance of members and sheeting where failure is caused by buckling.	1,10	1,05
		γ_{M2}	Resistance of net section of bolt holes.	1,25	1,20
2.3(3)P	Partial safety factor for verifications at serviceability limit state.	$\gamma_{M,ser}$	—	1,00	1,00
8.4(6)P	Partial safety factor for calculating the design resistance of mechanical fasteners.	γ_{M2}	Bolts	1,25	1,35
			Rivets	1,25	1,35
			Pins	1,25	1,35
			Spot welds	1,25	1,35
			Lap welds	1,25	1,35
10.2.2.1(1)	Partial safety factor for steel liner trays restrained by sheeting.	γ_{M2}	Wide flange in compression	1,25	1,20
10.2.2.2(1)	Partial safety factor for steel liner trays restrained by sheeting.	γ_{M2}	Wide flange in tension	1,25	1,20
A.6.4	Partial factor for difference in behaviour under test conditions and service conditions.	γ_{sys}	—	1,0	1,0

4 Loading codes

The loading codes to be used are:

BS 648:1964 (all parts), *Schedule of weights of building materials*.

BS 6399-1:1996, *Loadings for buildings — Code of practice for dead and imposed loads*.

BS 6399-3:1988, *Loadings for buildings — Code of practice for imposed roof loads*.

CP3:Chapter V:Part 2:1972, *Code of basic data for the design of buildings — Loading — Wind loads*.

In using these documents with ENV 1993-1-3:1996, the following modifications should be noted.

a) The imposed floor loads of a building should be treated as one variable action to which the reduction factors given in clause 5 of BS 6399-1:1984 are applicable.

b) The wind loading should be taken as 90 % of the value obtained from clause 4.3 of CP3:Chapter V:Part 2:1972.

NOTE Although it is intended that BS 6399-2 will eventually replace CP3:Chapter V:Part 2, wind loads for structures designed in accordance with ENV 1993-1-3:1996 should continue to be determined in accordance with CP3:Chapter V:Part 2 rather than in accordance with BS 6399-2 until such time as CP3:Chapter V:Part 2 is withdrawn. In such cases, local wind pressure and suction need not be considered in the design of purlins and sheeting rails.

c) The design for structural integrity should follow the provisions in 6.2a) of this NAD.

d) Reference should be made to clause 12 of BS 6399-1:1996 for the determination of accidental loads.

5 Reference standards

Where ENs are directly referred to by ENV 1993-1-3:1996, the appropriate BS ENs should be used. The remaining supporting standards to be used for construction with cold formed thin gauge members and sheeting designed in accordance with ENV 1993-1-3:1996 are given in Table 2 of this NAD.

Table 2 — Directly referenced supporting standards in ENV 1993-1-3

ENV 1993-1-3:1996 calls up	UK supporting standard
BS EN 10149-2	BS EN 10149-2
BS EN 10149-3	BS EN 10149-3
ENV 1090-2	DD ENV 1090-2 ^a BS 5950-7
ENV 1991-1	BS 6399, CP3:Chapter V:Part 2 ^a
ENV 1993-1-1	DD ENV 1993-1-1:1992
ISO 4997	ISO 4997
ISO 1000	ISO 1000 (BS 5555)
^a Currently in preparation.	
^a See the note in clause 4 of this NAD.	

6 Additional recommendations

6.1 Chapter 1 General

a) 1.1 Scope

Cold formed thin gauge members may be either open or closed and should be made up of flat elements bounded either by free edges or by bends with included angles not exceeding 135° and internal radii not exceeding $5t$ where t is the material thickness. ENV 1993-1-3:1995 does not apply to cold formed structural hollow sections complying with EN 10219, for which reference should be made to ENV 1993-1-1:1992.

The designer responsible for the overall stability of the structure should be clearly identified. This designer should ensure the compatibility of the structural design and detailing between all those structural parts and components that are needed for overall stability, even if some or all of the structural design and detailing of those structural parts and components is carried out by another designer.

b) 1.1(3)

The detailed design of stressed-skin constructions should be in accordance with BS 5950-9.

c) 1.1(5)

The limitations that do not apply to design assisted by testing are:

- 1) b/t ratio;
- 2) thickness;
- 3) material properties.

d) 1.5(3)

System lines of flanges means mid-lines of flanges.

e) 1.7.4(2)

To simplify the design rules for torsional and torsional-flexural buckling in 6.2.3 of ENV 1993-1-3:1996, the convention for member axes differs from that used in ENV 1993-1-1:1992 and it may also change depending on the design situation.

6.2 Chapter 2 Basis of design

a) 2.1 General

- 1) Structures constructed using cold formed thin gauge members and sheeting should be designed to fulfil, with due regard to economy, their intended function and should sustain the design loads for their intended life. The design should also facilitate fabrication, erection and future maintenance.
- 2) A structure should also be designed so that it should not be damaged by events, explosions, impact or the consequences of human error, to an extent disproportionate to the original cause. Design rules to provide structural integrity by limiting the effects of accidental damage are given in Annex A of the NAD for ENV 1993-1-1:1992.

In construction where vertical loads are resisted by an assembly of closely spaced elements, (e.g. cold formed steel framing) the tying members should be distributed to ensure that the entire assembly is effectively tied. In such cases the forces for anchoring the vertical elements at the periphery should be based on the spacing of the elements or taken as 1 % of the factored vertical load in the element without applying the minimum value of 75 kN or 40 kN to the individual elements, provided that each tying member and its connections are designed to resist the appropriate loading.

NOTE 1 The above recommendations should be met by the choice of suitable materials, by appropriate design and detailing and by specifying control procedures for production, construction and use as relevant for the particular project

NOTE 2 Further guidance on methods of reducing the sensitivity of buildings to disproportionate collapse in the event of an accident are given in Approved Document A of the Building Regulations [2].

b) 2.1(4)P

The values of partial factors given in this NAD should be adopted for Construction Clauses I, II and III.

c) 2.2(1)P

- 1) Where it is necessary to take account of changes in temperature in the design of a structure, it may be assumed that in the UK the average temperature of internal steelwork varies from -5°C to $+35^{\circ}\text{C}$. The actual range, however, depends on the location, type and purpose of the structure and special consideration may be necessary for structures in other environments.
- 2) When designing for the accidental situation in Table 2.1 of ENV 1993-1-1:1992, the values of ψ_1 and ψ_2 should be determined from Table 4 of the NAD for ENV 1993-1-1:1992. For the determination of the accidental load (A_k), reference should be made to BS 6399-1 where appropriate.

The accidental total A_k should be multiplied by a γ_A factor of 1,05 and the γ_{GA} factor should be taken as 1,05, except where the dead load is considered to consist of unfavourable and favourable parts. In this case, the favourable part should be multiplied by a γ_{GA} factor of 0,9 and the unfavourable part should be multiplied by a factor of 1,05.

6.3 Chapter 3 Properties of materials and cross-sections

a) 3.1.1(7)P

Although the real value for the modulus of elasticity for cold formed steel is less, the value of $210\,000\text{ N/m}^2$ should be used because the formulae have been developed and calibrated using this value.

b) 2.1.2(3)P

For cross-sections which are not fully effective, the increase in yield strength due to cold forming may be calculated using the recommendations given in BS 5950-5.

c) 3.1.2(7)P

The increase in yield strength due to cold working should not be utilized for members which undergo welding, annealing, galvanizing or any other heat treatment after forming that may produce softening.

d) 3.1.3(1)P

For steel sheeting, the upper limit for the nominal core thickness (t_{cor}) may be taken as 8.0 mm. No lower limit is needed for the sheeting providing that it can be demonstrated to have adequate resistance to denting from construction and maintenance traffic. ENV 1993-1-1:1992 may be used for steel with a nominal core thickness t_{cor} exclusive of zinc or organic coating greater than 5 mm. No lower limit is necessary for the nominal core thickness of members.

e) 313(3)P and 313(4)P

The design thickness should be obtained from the following expression:

$$t = k \times t_{\text{cor}}$$

where

k is obtained from Table 3 of this NAD.

f) 3.1.3(5)

The nominal core thickness (t_{cor}) should be calculated using the following expression:

$$t_{\text{cor}} = t_{\text{nom}} - t_{\text{coating}}$$

where

t_{nom} is the nominal thickness;

t_{coating} is the thickness of the coating (i.e. zinc, paint, etc.)

Table 3 — Values of factor k

Nominal thickness t_{cor}	Members		Sheeting	
	Normal tolerances	Special tolerances	Normal tolerances	Special tolerances
$1,0 \leq t_{\text{nom}}$	1,0	— ^a	1,0	— ^a
$0,6 \leq t_{\text{nom}} < 1,0$	0,95	1,0	1,0	— ^a
$0,4 \leq t_{\text{nom}} < 0,6$	0,9	0,95	0,95	1,0

^a Not applicable.

6.4 Chapter 4 local buckling

a) 4.2(5)

Alternative 1 should be used and Alternative 2 should be ignored.

NOTE Alternative 1 is based on the ultimate limit state.

b) 4.2(6)

Alternative 2 should be used and Alternative 1 should be ignored.

NOTE Alternative 2 is based on the serviceability limit state.

c) 4.2(9)

Values of effective section properties obtained without iteration may be used. Alternatively, the iteration process may be used if it gives a larger value.

NOTE Under some circumstances iteration may give a smaller value. If this is the case, the initial value may be used.

d) 4.3.2.1(1)

Provided that the conditions given in 4.3.2.1(2)P of ENV 1993-1-3:1996 and modified by the conditions given in 6.4c) of this NAD are met, the effectiveness of a multiple edge fold stiffener may be determined from the procedures given in 4.3.2.1(3) of ENV 1993-1-3:1996.

e) 4.3.2.1(2)P

It is not necessary to limit c such that:

$$c \leq 0,2b_p$$

f) Figure 4.7

For the figure showing one stiffener, $S_{\text{eff},4}$ should read $S_{\text{eff},n}$, and for the figure showing two stiffeners, $S_{\text{eff},6}$ should read $S_{\text{eff},n}$.

g) 4.3.2.2(8) and 4.3.2.2(9)

The value of χ may be obtained without iteration. Alternatively, the iteration process may be used if it gives a higher value.

h) 4.3.2.3(3)

The values of 0,5 and 1,0 for χ should be changed to 0,45 and 0,9 respectively.

i) 4.3.3.1

The general procedure in 4.3.3.2 of ENV 1993-1-3:1996 and the simplified procedure in 4.3.3.3 of ENV 1993-1-3:1996 do not include the effects of flange curling and give inaccurate results for members subject to bending actions. These procedures should not be used for beams where the ratio of b/t is greater than 300.

j) 4.3.4.2 *Flanges with intermediate stiffeners*

The procedure in 4.3.4.2 of ENV 1993-1-3:1996 does not include the effects of flange curling and gives inaccurate results for sheeting subjected to bending actions. This procedure should not be used for beams where the ratio of b/t is greater than 300.

k) 4.3.4.2(3)

The expression for b_e is incorrect and should be replaced with the following correct expression:

$$b_e = 2b_{p,1} + b_{p,2} + 2b_s$$

l) *Figure 4.3*

When considering this figure, it should be noted that c_{eff} is not necessarily equal to c .

6.5 Chapter 5 Resistance of cross-sections

a) 5.1 *General*

Attention is drawn to the fact that the following four different cross-sectional properties are used in ENV 1993-1-3:1996:

- 1) gross cross-sectional properties;
- 2) effective area;
- 3) effective section modulus about the major axis;
- 4) effective section modulus about the minor axis.

b) *Figure 5.1*

In Figure 5.1, the applied axial force N_{Sd} is assumed to act at the centroid of the gross cross-section, whereas the resistance to axial force N_{Rd} is assumed to act at the centroid of the effective cross-section. Thus the force N_{Sd} should be treated as being applied at an eccentricity equal to the shift e_N of the centroid.

c) 5.4.2 *Partial plastic resistance*

If the section conforms to the requirements for a class 1 cross-section given in clause 5.3 of ENV 1993-1-1:1992, the method given in 5.2.3.1 of BS 5950-5:1998 for calculating the plastic bending category may be used.

d) 5.4.2(2)

A bilinear distribution is shown in the right hand diagram in Figure 5.3.

e) 5.4.2(4)

Alternatively, the provisions given in 7.2 may be demonstrated by calculation in appropriate cases.

f) 5.4.3(1)*P*

The effects of shear lag should be taken into account if the length L_m is less than $20b_0$ for simply-supported beams with a uniformly-distributed load, and less than $50b_0$ for all other cases.

g) *Table 5.1 Reduction factors β_i for shear lag*

It should be noted that L_m is the distance between points of contraflexure.

h) 5.6(2)*P*

The definitions for e_{N_y} and e_{N_z} are incorrect — e_{N_y} and e_{N_z} are shifts of the y-y and z-z centroid axes respectively, under axial loading.

i) 5.8(5)P

When using Table 5.2, the value of f_{bv} should be calculated using the formulae for webs without stiffening at the support, irrespective of whether stiffeners are present or not.

j) 5.8(6)

The correct interpretation for k_r is:

$$k_r = 5,34 + \frac{2,10}{t} \left[\frac{I_s}{s_d} \right]^{1/3}$$

k) 5.9.2

For I-beams with restraint against web rotation, the method given in 5.3 of BS 5950-5:1998 may be used.

6.6 Chapter 6 Buckling resistance

a) Expression 6.4a

Expression 6.4a is incorrect and should be replaced by the following expression

$$\bar{\lambda} = (f_{yb}/\sigma_{cr})^{0,5} [\beta_A]^{0,5}$$

b) 6.2.3 Torsional buckling and torsional-flexural buckling

All sections should be checked for torsional, torsional-flexural and flexural buckling.

c) 6.2.3(1)P

An example of a point-symmetric open cross-section is a Z-section with similar flanges.

d) 6.2.3(7)P

For non-symmetrical cross-sections, the maximum stress should be determined by second-order analysis.

e) 6.3(1)P

Alternatively, M_{cr} can be obtained from 6.6.2.2 of BS 5950-5:1998, its value being that of M_E .

f) 6.4 Distortional buckling

For distortional buckling, reference should be made to AS/NZS 4600:1996 or a geometrical non-linear analysis could be carried out using suitable initial imperfections.

g) 6.5 Bending and axial compression

All members subject to combined bending and axial compression should be designed in accordance with the recommendations given in 6.4 of BS 5950-5:1998.

6.7 Chapter 7 Serviceability limit states

a) 7.3 Deflections

The designs for deflections should follow the provisions in clause 4, in particular, Table 4.1 and 4.2.3 of ENV 1993-1-1:1992.

b) 7.3(3)

There is no limit to the deflection of purlins, provided the provisions in 4.2.3 of ENV 1993-1-1:1992 are complied with in respect of the supporting structure.

c) 7.4(2)

Serviceability limits for sheeting should be obtained from BS 5427-1 and BS 5950-6.

6.8 Chapter 8 Joints and connections

NOTE Design guidance for butt and V-flared welds is given in 6.6.2(6) of ENV 1993-1-1:1992,

a) Table 8.4 Bearing resistance

The bearing resistance given in Table 8.4 can only be used if washers are used under both the head and nut of the bolt.

b) 8.4(10)

If both $F_{t,Rd}$ and $F_{v,Rd}$ are obtained by calculation, the following equation may be used:

$$\frac{F_{t,Sd}}{F_{t,Rd}} + \frac{F_{v,Sd}}{1,4F_{v,Rd}} \leq 1$$

where

$$F_{v,Sd} \leq F_{v,Rd}$$

If either $F_{v,Sd}$ or $F_{v,Rd}$ is obtained by testing, the linear equation given by expression 8.2 should be used.

Alternatively, combined tension and shear testing may be carried out.

c) 8.5(7)P

The thickness t of the test specimen should be the same as the thickness of the specimens used in practice.

d) 8.6.2

The values of $L_{w,e}$ and $L_{w,s}$ used in expressions 8.4a and 8.4b respectively for calculating the design resistance $F_{w,Rd}$ of a fillet weld, should not exceed the width of the connected part or sheet, b.

e) 8.6.3(5)P

1) The minimum distance measured parallel to the direction of force transfer, from the centreline of an arc spot weld to the nearest edge of an adjacent weld or to the end of the connected part towards which the force is directed, should not be less than the value of $e_{\min}$ given by the following.

$$\text{If } \frac{f_u}{f_y} \geq 1,15$$

$$e_{\min} = 1,8 \times \frac{F_{wSd}}{tf_u/\gamma_{M2}}$$

$$\text{If } \frac{f_u}{f_y} \leq 1,15$$

$$e_{\min} = 2,1 \times \frac{F_{wSd}}{tf_u/\gamma_{M2}}$$

2) The minimum distance from the centreline of a circular arc spot weld to the end or edge of the connected sheet should not be less than $1,5d_w$ where d_w is the visible diameter of the arc spot weld.

3) The minimum clear distance between an elongated arc spot weld and the end of the sheet and between the weld and the edge of the sheet should not be less than $1,0d_w$.

f) 8.6.3(6)

This clause should be replaced by the following.

The design shear resistance $F_{W,Rd}$ of a circular arc spot weld should be determined using the following expression:

$$F_{W,Rd} = \frac{\pi}{4} d_s^2 \times 0,625 \frac{f_{uw}}{\gamma_{M2}}$$

where

f_{uw} is the minimum ultimate tensile strength of the welding electrodes.

$F_{W,Rd}$ should not be taken as more than the peripheral resistance given by the following expression:

$$\text{If } \leq 18 \times \left(\frac{420}{f_u} \right)^{0,5}$$

$$F_{W,Rd} = 1,5 d_p \Sigma t f_u / \gamma_{M2}$$

The minimum distance from the centreline of a circular arc spot weld to the end or edge of the connected sheet should be not less than $1,5 d_w$, where d_w is the visible diameter of the arc spot weld.

The minimum clear distance between an elongated arc spot weld and the end of the sheet and between the weld and the edge of the sheet should be not less than $1,0 d_w$.

$$\text{If } 18 \times \left(\frac{420}{f_u} \right)^{0,5} < \frac{d_p}{\Sigma t} < 30 \times \left(\frac{420}{f_u} \right)^{0,5}$$

$$F_{W,Rd} = 27 (420/f_u)^{0,5} (\Sigma t)^2 f_u / \gamma_{M2}$$

$$\text{If } \frac{d_p}{\Sigma t} \geq 30 \times \left(\frac{420}{f_u} \right)^{0,5}$$

$$F_w = 0,9 d_p \Sigma t f_u / \gamma_{M2}$$

g) 8.6.3(7)

This clause should be replaced by the following.

The interface diameter d_s of an arc spot weld (see Figure 8.6), should be obtained from the following expression:

$$d_s = 0,7 d_w - 1,5 \Sigma t$$

where

$$d_s \leq 0,55 d_w;$$

d_w is the visible diameter of the arc spot weld (see Figure 8.6).

h) 8.6.3(9)

This clause should be replaced by the following.

The design shear resistance $F_{W,Rd}$ of an elongation arc spot weld should be determined from the following expression:

$$F_{W,Rd} = \left[\left(\frac{\pi}{4} \right) \times d_s^2 + L_w \times d_s \right] \times \left[0,625 \times \frac{f_{uw}}{\gamma_{M2}} \right]$$

where

$F_{W,Rd}$ should not be taken as more than the peripheral resistance given by:

$$F_{W,Rd} = (0,5 L_w + 1,67 d_p) \Sigma t f_u / \gamma_{M2}$$

where

L_w is the length of the elongated arc spot weld, measured as shown in Figure 8.7.

6.9 Particular applications

a) 10.1.3.4(2)

Alternatively, the characteristics may be determined by calculation.

b) Figure 10.7

The orientation of the members is not dependent on the number of spans (i.e. the left hand diagram is not related to the right hand diagram).

c) 10.3 Stressed skin design

The detailed design of stressed-skin construction should also be in accordance with BS 5950-9.

6.10 Annex A Testing procedures

a) Table A.1 Number of tests

When the general shape of the buckling curve is obtained from prior knowledge, a smaller number of tests may be carried out, providing it contains a significant number of tests at $\bar{\lambda} = 1,0$.

b) A.3.4(2)

Lateral means in any direction at a right angle to the longitudinal axis.

c) A.4.1 Acceptance tests

The values for the load factors for acceptance tests for use with ENV 1993-1-3:1996 should be taken as equal to the sum of:

- 1) $1,0 \times$ the actual self-weight present during the test;
- 2) one of the following as appropriate:
 - i) $1,25 \times$ (the imposed load) + $1,15 \times$ (the remainder of the permanent load);
 - ii) $1,15 \times$ (the remainder of the permanent load) + $1,25 \times$ (the wind load);
 - iii) $1,25 \times$ (the wind uplift) – $1,0 \times$ (the remainder of the permanent load);
 - iv) $1,15 \times$ (the remainder of the permanent load) + $1,0 \times$ (the imposed load and the wind load).

d) A.4.1(6)

On the attainment of the acceptance test load, it should be maintained at a near constant value to allow repeat measurements for the detection of possible creep. The loads and deflections should be measured at regular checking intervals of at least 5 min. The loading should be adjusted to remain constant until there is no significant increase in deflection during at least three checking intervals subsequent to the attainment of the acceptance test load.

e) A.5.2.3 Interpretation of test results

The factor of 0,9 need not be applied if the procedure in A.6 of ENV 1993-1-3:1996 is followed. Figure A.9 and A.10 are for illustration only. The procedure can be applied to sheeting.

f) A.6.2(6) Resistance adjustment coefficient

If $f_{yb,obs} > f_{yb}$,

$\alpha = 1,0$ should be used in all cases.

g) *A.6.3 Characteristic values*

Replace expression A.11 with the following expression:

$$R_k = 1,1 \times (R_m - k_g)$$

where

$$R_k \leq R_m$$

h) *A.6.3.3 Characteristic values based on a small number of tests*

For calculation of the characteristic value of resistance (R_k) the value of η_k should be taken as 0,9 for all modes of failure

If two or three tests are performed, the characteristic value of resistance should be obtained from the following expression:

$$R_k = \eta_k \times R_{\min}$$

Bibliography

BS 5427-1, *Code of practice for the use of profiled sheet for roof and wall cladding on buildings — Part 1: Design.*

BS 5950-6, *Structural use of steelwork in building — Part 6: Code of practice for design of light gauge profiled steel sheeting.*

BS 5950-7, *Structural use of steelwork in building — Part 7: Specification for materials and workmanship: cold formed sections.*

BS EN 10149-2, *Specification for hot-rolled products made of high yield strength steels for cold forming — Part 2: Delivery conditions for thermomechanically rolled steels.*

BS EN 10149-3, *Specification for hot-rolled products made of high yield strength steels for cold forming — Part 3: Delivery conditions for normalized or normalized rolled steels.*

BS EN 10219, *Cold formed welded structural sections of non-alloy and fine grain steels.*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units.*

ISO 4997, *Cold-reduced steel sheet of structural quality.*

[1] COUCHMAN, G.H. *Design of cold formed steel sections and sheeting to Eurocode 3:Part 1.3:1999*²⁾. ISBN 1 85942 086 9.

[2] GREAT BRITAIN. *The Building Regulations 1991, Approved Document A 1992.* London: The Stationery Office³⁾.

²⁾ Available from The Steel Construction Institute, Silwood Park, Ascot, Berkshire SL5 7QN.

³⁾ Available from the Stationery Office, PO Box 29, St Crispins House, Duke Street, Norwich NR3 1GN.

English version
Version Française
Deutsche Fassung

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

Eurocode 3: Calcul des structures en acier
- Partie 1-3: Règles générales - Règles
supplémentaires pour les éléments minces
formés à froid - Produits longs et produits
plats

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

This corrigendum becomes effective on 2 October 1997 for incorporation in the official English version of the ENV.

Ce corrigendum prendra effet le 2 octobre 1997 pour incorporation dans la version anglaise officielle de la ENV.

Die Berichtigung tritt am 2. Oktober 1997 in Kraft zur Einarbeitung der offiziellen Englischen Fassung der ENV einzufügen.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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The following editorial corrections should be made to ENV 1993-1-3.

Page 24, clause 3.5, below 3.5(1) and above table 3.3, insert paragraph (2) reading:

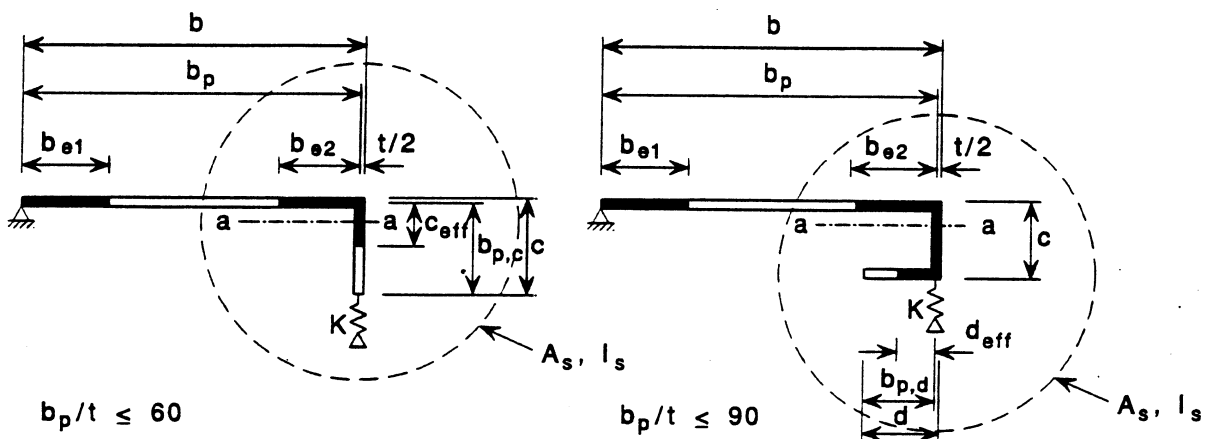
(2) The mutual influence of multiple stiffeners should be taken into account.

Page 27, table 4.2, row 4, column 4, replace 1 by -1.

Page 27, table 4.2, row 5, last column should read:

$$0,57 - 0,21\psi + 0,07\psi^2$$

Page 30, figure 4.2 should be replaced by:



a) single edge fold

b) double edge fold

Figure 4.2: Edge stiffeners

Page 31, paragraph 4.3.2.2(4), expression (4.10c) should read:

$$k_{\sigma} = 0,5 + 0,83 \times \sqrt[3]{(b_{p,c}/b_p - 0,35)^2} \quad \dots (4.10c)$$

Page 33, paragraph 4.3.2.3(2), line 4 should read:

ρ should be obtained from 4.2(5) with $\sigma_{\text{com.Ed}}$ equal to $\chi f_{yb}/\gamma_{M1}$, so that:

Page 33, paragraph 4.3.2.2(10), replace expression (4.14) by two lines reading:

$$A_{s,red} = \chi A_s \left[\frac{f_{yb}/\gamma_{M1}}{\sigma_{com,Ed}} \right] \quad \text{but} \quad A_{s,red} \leq A_s \quad \dots (4.14)$$

in which $\sigma_{com,Ed}$ is the calculated stress at the centreline of the stiffener.

Page 33, paragraph 4.3.2.2(11), modify line 2 to read:

by using a reduced thickness $t_{red} = t A_{s,red}/A_s$ for all the elements included in A_s .

Page 33, paragraph 4.3.2.3(4), replace expression (4.19) by two lines reading:

$$A_{s,red} = \chi A_s \left[\frac{f_{yb}/\gamma_{M1}}{\sigma_{com,Ed}} \right] \quad \text{but} \quad A_{s,red} \leq A_s \quad \dots (4.19)$$

in which $\sigma_{com,Ed}$ is the calculated stress at the centreline of the stiffener.

Page 33, paragraph 4.3.2.3(5), modify line 2 to read:

by using a reduced thickness $t_{red} = t A_{s,red}/A_s$ for all the elements included in A_s .

Page 35, paragraph 4.3.3.2(9), replace expression (4.23) by two lines reading:

$$A_{s,red} = \chi A_s \left[\frac{f_{yb}/\gamma_{M1}}{\sigma_{com,Ed}} \right] \quad \text{but} \quad A_{s,red} \leq A_s \quad \dots (4.23)$$

in which $\sigma_{com,Ed}$ is the calculated stress at the centreline of the stiffener.

Page 35, paragraph 4.3.3.2(10), modify line 2 to read:

by using a reduced thickness $t_{red} = t A_{s,red}/A_s$ for all the elements included in A_s .

Page 35, paragraph 4.3.3.3(3), line 1 should start:

The effective widths $b_{1,e2}$ and $b_{2,e1}$ should

and line 3 should read:

to $\chi f_{yb}/\gamma_{M1}$, so that:

Page 37, paragraph 4.3.3.3(5), replace expression (4.28) by two lines reading:

$$A_{s,red} = \chi A_s \left[\frac{f_{yb}/\gamma_{M1}}{\sigma_{com,Ed}} \right] \quad \text{but} \quad A_{s,red} \leq A_s \quad \dots (4.28)$$

in which $\sigma_{com,Ed}$ is the calculated stress at the centreline of the stiffener.

Page 37, paragraph 4.3.3.3(6), modify line 2 to read:

by using a reduced thickness $t_{red} = t A_{s,red}/A_s$ for all the elements included in A_s .

Page 45, paragraph 5.4.1(1)P, expression (5.3b) should read:

$$M_{c,Rd} = f_{ya} W_{ct} / \gamma_{M0} \quad \dots (5.3b)$$

Page 53, paragraph 5.8(6)P, expression (5.15a) should read:

$$\bar{\lambda}_w = \sqrt{\frac{f_{yb}/\sqrt{3}}{\tau_{cr}}} \equiv \frac{s_w}{t} \sqrt{\frac{12(1 - \nu^2)f_{yb}}{\sqrt{3} \pi^2 E k_\tau}} \quad \dots (5.15a)$$

Page 57, paragraph 5.9.3(2), delete line 6 reading:

s_s is the actual length of stiff bearing;

Page 58, paragraph 5.9.3(4), insert after line 8:

where:

s_s is the actual length of stiff bearing;

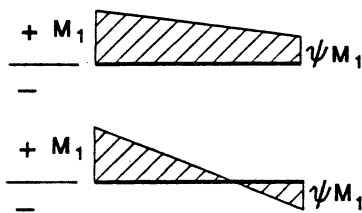
Page 60, paragraph 5.9.4(2), expression (5.24) should read:

$$\kappa_{a,s} = 1,45 - 0,05 e_{max}/t \quad \text{but} \quad \kappa_{a,s} \leq 0,95 + 35\,000 t^2 e_{min}/(b_d^2 s_p) \quad \dots (5.24)$$

Page 68, paragraph 6.3(1)P, line 4 should read:

in which χ_{LT} is obtained from the following:

Page 71, table 6.4, column 1, row 2, replace the second and third sketches by:



Page 77, figure 8.2 should be replaced by:

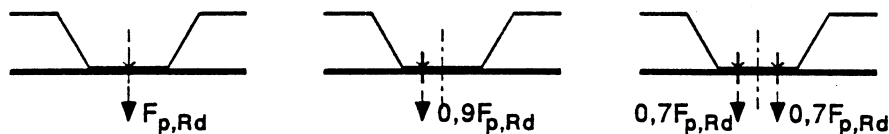


Figure 8.2: Reduction of tension resistance due to the position of fasteners

Page 81, table 8.4, row 2, line 2 should read:

$$F_{b,Rd} = 2,5 d t f_u / \gamma_{M2} \quad \text{but} \quad F_{b,Rd} \leq (e_1 t / 1,2) (f_u / \gamma_{M2})$$

Page 82, table 8.5, row 2, lines 3 to 5 should read:

$$F_{tb,Rd} = 2,7 \sqrt{t} d_s f_u / \gamma_{M2} \quad [\text{with } t \text{ in mm}]$$

- if $t_1 > 2,5t$:

$$F_{tb,Rd} = 2,7 \sqrt{t} d_s f_u / \gamma_{M2} \quad \text{but} \quad F_{tb,Rd} \leq 0,7 d_s^2 f_u / \gamma_{M2} \quad \text{and} \quad F_{tb,Rd} \leq 3,1 t d_s f_u / \gamma_{M2}$$

Page 84, paragraph 8.6.3(3)P should read:

Arc spot welds shall have an interface diameter d_s of not less than 10 mm.

Page 101, paragraph 10.1.5.2(10), expression (10.18) should read:

$$C_{D,A} = \frac{h^2}{(1/K_A + 1/K_B) - 4(1 - \nu^2) h^2 (h_d + e) / (E t^3)} \quad \dots (10.18)$$

Page 105, paragraph 10.2.2.2(1), in step 2 the last line should read:

I_a is the second moment of area of the wide flange, about its own centroid, see figure 10.8.

Page 105, paragraph 10.2.2.2(2), the first sentence should read:

The effects of shear lag need not be considered if $L/b_{u,eff} \geq 20$.

Page 109, paragraph 10.3.5(4), lines 2 to 4 should read:

$$T_{v,Rd} = 6 E \sqrt[4]{I_a (t/b_u)^9} \quad \dots (10.22)$$

where:

I_a is the second moment of area of the wide flange, about its own centroid, see figure 10.8;

EUROPEAN PRESTANDARD

ENV 1993-1-3

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

April 1996

ICS 91.040.00; 91.080.10

Descriptors: steel construction, structural steels, cold-working, flat bars, computation, rules of calculation, mechanical strength

English version

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

Eurocode 3: Calcul des structures en acier -
Partie 1-3: Règles générales - Règles
supplémentaires pour les éléments minces formés
à froid - Produits longs et produits plats

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

This European Prestandard (ENV) was approved by CEN on 1993-06-04 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into an European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

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European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Contents	Page
Foreword	4
1 General	6
1.1 Scope	6
1.2 Distinction between principles and application rules	6
1.3 Normative references	7
1.4 Definitions	8
1.5 Symbols	8
1.6 Units	9
1.7 Terminology	9
2 Basis of design	14
2.1 General	14
2.2 Ultimate limit states	14
2.3 Serviceability limit states	14
2.4 Design assisted by testing	15
2.5 Durability	15
3 Properties of materials and cross-sections	16
3.1 Structural steel	16
3.2 Connecting devices	19
3.3 Section properties	19
3.4 Geometrical proportions	23
3.5 Modelling for cross-section analysis	24
4 Local buckling	25
4.1 General	25
4.2 Plane elements without stiffeners	25
4.3 Plane elements with edge or intermediate stiffeners	29
5 Resistance of cross-sections	44
5.1 General	44
5.2 Axial tension	44
5.3 Axial compression	45
5.4 Bending moment	45
5.5 Combined tension and bending	50
5.6 Combined compression and bending	51
5.7 Torsional moment	51
5.8 Shear force	52
5.9 Local transverse forces	54
5.10 Combined shear force and bending moment	60
5.11 Combined bending moment and local load or support reaction	61
6 Buckling resistance	62
6.1 General	62
6.2 Axial compression	63
6.3 Lateral-torsional buckling of members subject to bending	68
6.4 Distortional buckling	68
6.5 Bending and axial compression	69

7	Serviceability limit states	73
7.1	General	73
7.2	Plastic deformation	73
7.3	Deflections	73
7.4	Sheeting	73
8	Joints and connections	74
8.1	General	74
8.2	Requirements for joints	74
8.3	Splices and end connections of members subject to compression	75
8.4	Connections with mechanical fasteners	76
8.5	Spot welds	82
8.6	Lap welds	83
9	Design assisted by testing	87
9.1	Basis	87
9.2	Conditions	88
9.3	Load tables based on testing	89
10	Particular applications	90
10.1	Beams restrained by sheeting	90
10.2	Liner trays restrained by sheeting	103
10.3	Stressed skin design	106
10.4	Perforated sheeting	110
Annex A	[informative] Testing procedures	111
A.1	General	111
A.2	Tests on profiled sheets and liner trays	111
A.3	Tests on cold formed members	116
A.4	Tests on structures and portions of structures	119
A.5	Tests on beams torsionally restrained by sheeting	121
A.6	Evaluation of test results	125



Foreword

Objectives of the Eurocodes

- (1) The “Structural Eurocodes” comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.
- (2) They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship, needed to comply with the assumptions of the design rules.
- (3) Until the necessary set of harmonized technical specifications for products and for methods of testing their performance is available, some of the Structural Eurocodes cover some of these aspects in informative annexes.

Background to the Eurocode programme

- (4) The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building and civil engineering works which would initially serve as an alternative to the different rules in force in the various member states and would ultimately replace them. These technical rules became known as the “Structural Eurocodes”.
- (5) In 1990, after consulting their respective member states, the CEC transferred the work of further development, issue and updating of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.
- (6) CEN Technical Committee CEN/TC 250 is responsible for all Structural Eurocodes.

Eurocode programme

- (7) Work is in hand on the following Structural Eurocodes, each generally consisting of a number of parts:

EN 1991	Eurocode 1	Basis of design and 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 provisions for earthquake resistance of structures;
EN 1999	Eurocode 9	Design of aluminium alloy structures.
- (8) Separate sub-committees have been formed by CEN/TC 250 for the various Eurocodes listed above.
- (9) This Part 1.3 of Eurocode 3 is published by CEN as a European Prestandard (ENV) with an initial life of three years.
- (10) This Prestandard is intended for experimental application and for the submission of comments.
- (11) After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future actions.

(12) Meanwhile feedback and comments on this Prestandard should be sent to the secretariat of CEN/TC 250/SC 3 at the following address:

BSI Standards
British Standards House
389 Chiswick High Road
London W4 4AL
England

or to your national standards organization.

National Application Documents (NAD's)

(13) In view of the responsibilities of the authorities in member countries for safety, health and other matters covered by the essential requirements of the Construction Products Directive (CPD), certain safety elements in this ENV have been assigned indicative values which are identified by ("boxed values"). The authorities in each member country are expected to review the "boxed values" and may substitute alternative definitive values for these safety elements for use in national application.

(14) Some of the supporting European or International Standards might not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving any substitute definitive values for safety elements, referencing compatible supporting standards and providing guidance on the national application of this Prestandard, will be issued by each member country or its Standards Organization.

(15) It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the building or civil engineering works is located.

Matters specific to this Prestandard

(16) The Parts of ENV 1993 that are currently envisaged are:

- ENV 1993-1-1 General rules and rules for buildings;
- ENV 1993-1-2 Supplementary rules for structural fire design;
- ENV 1993-1-3 Supplementary rules for cold formed thin gauge members and sheeting;
- ENV 1993-1-4 Supplementary rules for stainless steels;
- ENV 1993-2 Bridges and plated structures;
- ENV 1993-3 Towers, masts and chimneys;
- ENV 1993-4 Silos, tanks and pipelines;
- ENV 1993-5 Piling;
- ENV 1993-6 Crane supporting structures;
- ENV 1993-7 Marine and maritime structures;
- ENV 1993-8 Agricultural structures.

(17) Work on this Part 1.3 of Eurocode 3 was initiated by the Commission of the European Communities. The work was carried out in collaboration with a working group of the European Convention for Constructional Steelwork (ECCS) and a draft was issued in 1990 as a "Draft Eurocode 3 : Annex A".

(18) With the transfer of work on Structural Eurocodes to CEN, the responsibility for completing this document passed to CEN Technical Committee CEN/TC 250, sub-committee CEN/TC 250/SC 3.

(19) In this Part 1.3 of Eurocode 3, a distinction is made between three construction classes using cold formed thin gauge members and sheeting. The boxed values of the partial factors given in Part 1.3 are recommended values for Construction Class I and Construction Class II.

1 General

1.1 Scope

(1)P This Part 1.3 of ENV 1993 deals with the design of steel structures comprising cold formed thin gauge members and sheeting. It gives supplementary provisions for structural applications using cold formed steel products made from coated or uncoated thin gauge hot or cold rolled sheet or strip. It is intended to be used for the design of buildings and civil engineering works in conjunction with ENV 1993-1-1.

NOTE: The execution of steel structures comprised of cold formed thin gauge members and sheeting is covered in ENV 1090-2.

(2)P Methods are given for determining the load bearing capacity and serviceability of elements and connections under predominantly static loads. These design methods apply to steel members and profiled steel sheets that have been cold formed by such processes as cold-rolled forming or press-braking. They are also applicable for the design of profiled steel sheeting for composite steel and concrete slabs at the construction stage, see ENV 1994-1-1.

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

(4)P This Part 1.3 of ENV 1993 gives methods for design by calculation and for design assisted by testing.

NOTE: In the field of cold formed members and sheeting, many standard products are commonly used for which design by calculation might not lead to economical solutions, so it is frequently desirable to use design assisted by testing. Appropriate test methods are given in annex A.

(5) 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.

(6) This Part does not apply to cold formed structural hollow sections, for which reference should be made to ENV 1993-1-1.

1.2 Distinction between principles and application rules

(1)P Depending on the character of the individual paragraphs, a distinction is made in this Part between principles and application rules.

(2)P The principles comprise:

- general or definitive statements for which there is no alternative;
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3) The principles are identified by the letter P following the paragraph number.

(4)P The application rules are generally recognized rules that follow the principles and satisfy their requirements. Alternative design rules different from the application rules given in the Eurocode may be used, provided that it is shown that the alternative rule accords with the relevant principles and has at least the same reliability.

(5) In this Part the application rules are identified by a number in brackets, as in this paragraph.

1.3 Normative references

This European Prestandard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

- EN 10002 *Metallic materials - Tensile testing:*
 - Part 1: *Method of test (at ambient temperature);*
- EN 10025 *Hot rolled products of non-alloy structural steels - Technical delivery conditions;*
- EN 10113 *Hot rolled products in weldable fine grain structural steels:*
 - Part 2: *Delivery conditions for normalized/normalized rolled steels;*
 - Part 3: *Delivery conditions for thermomechanical rolled steels;*
- EN 10143 *Continuously hot-dip metal coated steel sheet and strip - Tolerances on dimensions and shape;*
- EN 10147 *Specification for continuously hot-dip zinc coated structural steel sheet - Technical delivery conditions;*
- prEN 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 10155 *Structural steels with improved atmospheric corrosion resistance - Technical delivery conditions;*
- ENV 1090 *Execution of steel structures:*
 - Part 2: *Rules for cold formed thin gauge members and sheeting;*
- ENV 1991 *Eurocode 1: Basis of design and actions on structures:*
 - Part 1: *Basis of design;*
- ENV 1993 *Eurocode 3: Design of steel structures:*
 - Part 1.1: *General rules : General rules and rules for buildings;*
- ENV 1994 *Eurocode 4: Design of composite steel and concrete structures:*
 - Part 1.1: *General rules : General rules and rules for buildings;*
- ISO 1000 *SI units;*
- ISO 4997 *Cold reduced steel sheet of structural quality.*



1.4 Definitions

Supplementary to ENV 1993-1-1, for the purposes of this Part 1.3 of ENV 1993, the following definitions apply:

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

1.4.2 basic yield strength: The tensile yield strength of the basic material.

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

1.4.4 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.

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

1.4.6 relative slenderness: A normalized slenderness ratio.

NOTE: In ENV 1993-1-1 relative slenderness is termed “non-dimensional slenderness”.

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

1.4.8 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.

1.4.9 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.

1.5 Symbols

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

C	Rotational spring stiffness;
K	Linear spring stiffness;
θ	Rotation.

(2) In addition to those given in ENV 1993-1-1, the following subscripts are used:

d	Developed;
red	Reduced;
spn	Span;
sup	Support;
TF	Torsional-flexural.

(3) In addition to those used in ENV 1993-1-1, the following major symbols are used:

b_p	Notional flat width of plane element;
h_w	Web height, measured between system lines of flanges;
s_w	Slant height of a web, measured between midpoints of corners.

(4) Further symbols are defined where they first occur.

1.6 Units

- (1)P S.I. units shall be used in accordance with ISO 1000.
- (2) The following units are recommended for use in calculations:
- forces and loads: kN, kN/m, kN/m²;
 - unit mass: kg/m³;
 - unit weight: kN/m³;
 - stresses and strengths: N/mm² ($\equiv$ MN/m² or MPa);
 - bending moments: kNm;
 - torsional moments: kNm.

1.7 Terminology

1.7.1 Form of sections

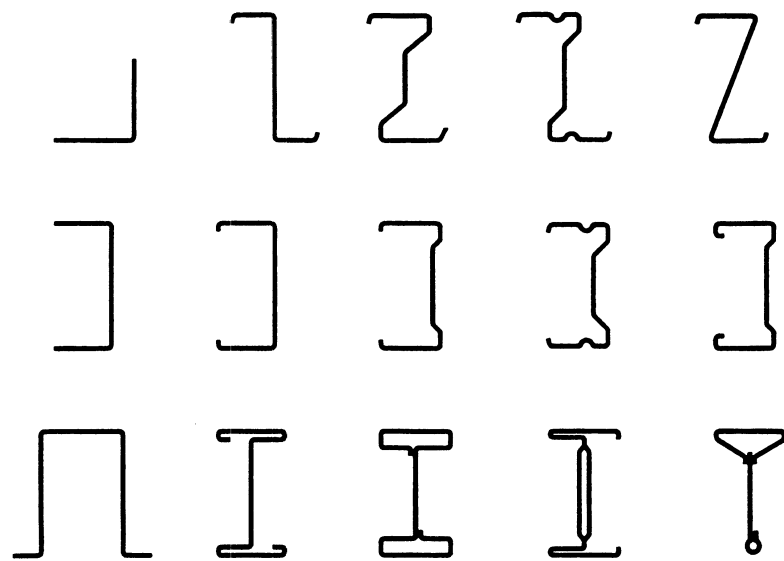
- (1) Cold formed members and profiled sheets are steel products made from coated or uncoated hot rolled or cold rolled flat products. Within the permitted tolerances, they have a constant thickness over their entire length and may have either a constant or a variable cross-section.

NOTE: These products are obtained solely by cold forming, for example profiled by a rolling machine or formed by a press or press brake.

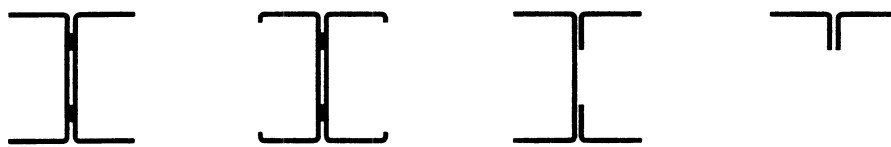
- (2) The cross-sections of cold formed members and profiled sheets essentially comprise a number of curved elements joined by plane elements.
- (3) Typical forms of sections for cold formed members include:
- single open sections as shown in figure 1.1(a);
 - open built-up sections as shown in figure 1.1(b);
 - closed built-up sections as shown in figure 1.1(c).
- (4) Examples of cross-sections for cold formed members and sheets are illustrated as follows:
- compression members and tension members, in figure 1.2(a);
 - beams and other members subject to bending, in figure 1.2(b);
 - profiled sheets and liner trays, in figure 1.2(c).
- (5) Cross-sections of cold formed members and sheets can either be unstiffened or incorporate longitudinal stiffeners in their webs or flanges, or in both.

1.7.2 Form of stiffeners

- (1) Typical forms of stiffeners for cold formed members and sheets include:
- folds and bends, see figure 1.3(a);
 - folded or curved grooves, see figure 1.3(b);
 - other sections, bolted, rivetted or welded on, see figure 1.3(c).
- (2) Longitudinal flange stiffeners can be either edge stiffeners or intermediate stiffeners.



a) Single open sections



b) Open built-up sections



c) Closed built-up sections

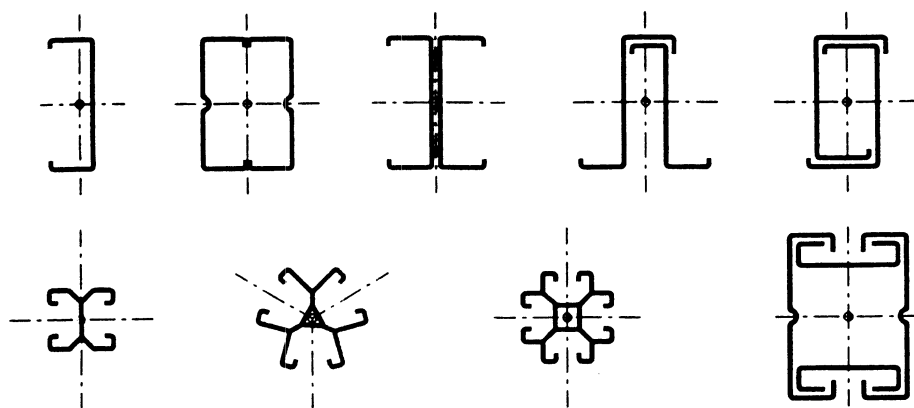
Figure 1.1: Typical forms of sections for cold formed members

(3) Typical edge stiffeners include:

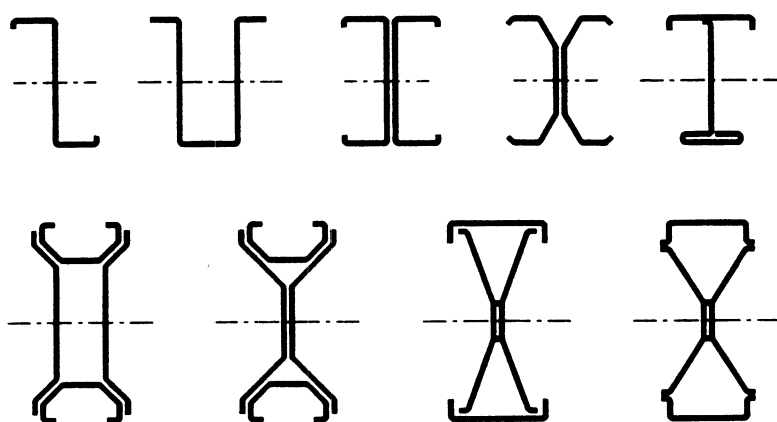
- single edge fold stiffeners or lips, see figure 1.4(a);
- double edge fold stiffeners, see figure 1.4(b).

(4) Typical intermediate longitudinal stiffeners are illustrated as follows:

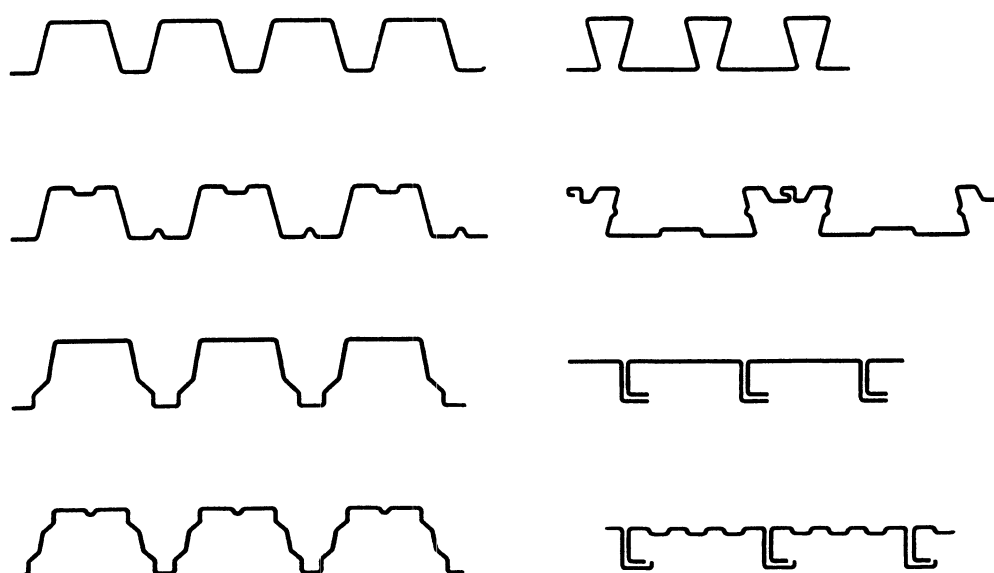
- for flanges, in figure 1.5(a);
- for webs in figure 1.5(b).



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

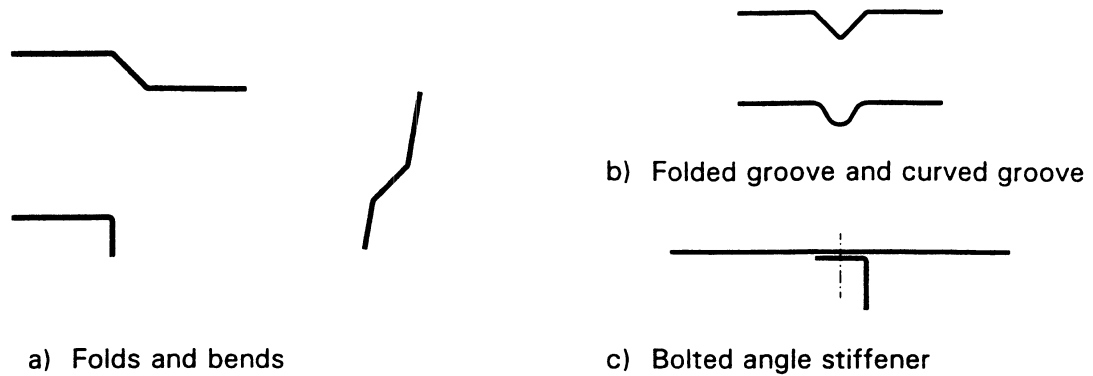


Figure 1.3: Typical forms of stiffeners for cold formed members and sheeting



Figure 1.4: Typical edge stiffeners

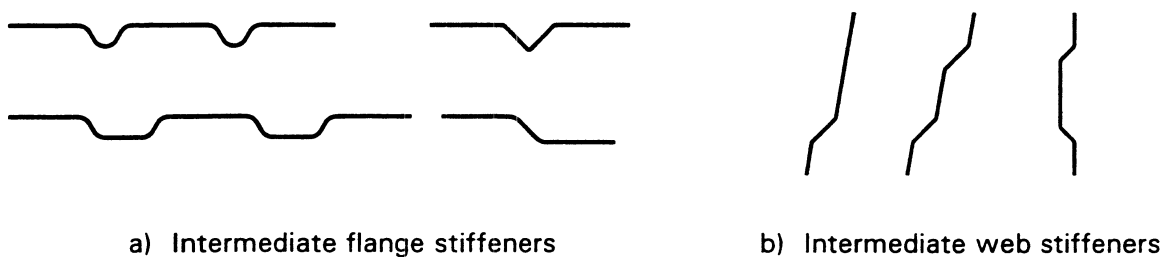


Figure 1.5: Typical intermediate longitudinal stiffeners

1.7.3 Cross-section dimensions

- (1) Overall dimensions of cold formed thin gauge 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.
- (2) Unless stated otherwise, the other cross-sectional dimensions of cold formed thin gauge 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, the system line of the element 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.
- (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.

1.7.4 Convention for member axes

(1) In the Structural Eurocodes the general convention for member axes is:

- $x - x$ along the member;
- $y - y$ axis of the cross-section;
- $z - z$ axis of the cross-section.

(2) For cold formed steel members the following axis convention is used in this Part 1.3 of ENV 1993:

- for monosymmetric cross-sections:
 - $y - y$ the axis of symmetry of the cross-section;
 - $z - z$ the other principal axis of the cross-section;
- otherwise:
 - $y - y$ major axis;
 - $z - z$ minor axis.
- where necessary:
 - $u - u$ axis perpendicular to the height (if this does not coincide with $y - y$ or $z - z$);
 - $v - v$ axis parallel to the height (if this does not coincide with $y - y$ or $z - z$).

NOTE: This differs from the axis convention used in ENV 1993-1-1 in order to give rules for torsional-flexural buckling that can be applied consistently to all cross-sections.

(3) The use of $u - u$ and $v - v$ axes is illustrated in figure 1.6.

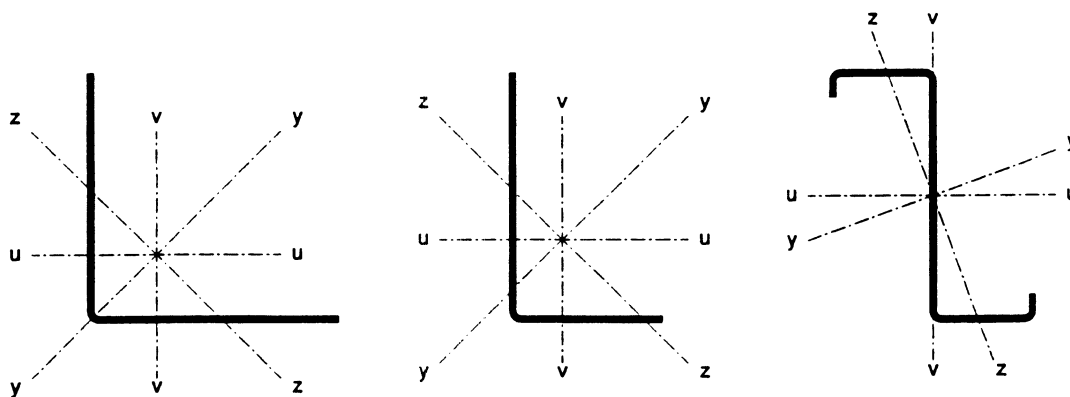


Figure 1.6: Axis convention

(4) For profiled sheets and liner trays the following axis convention is used in this Part 1.3 of ENV 1993:

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

2 Basis of design

2.1 General

(1)P For the purpose of differentiating levels of reliability, a distinction may be made between three “construction classes” defined as follows:

- **Construction Class I:** Construction where cold formed thin gauge members and sheeting are designed to contribute to the overall strength and stability of a structure;
- **Construction Class II:** Construction where cold formed thin gauge members and sheeting are designed to contribute to the strength and stability of individual structural elements;
- **Construction Class III:** Construction where cold formed sheeting is used as an element that only transfers loads to the structure.

(2)P The methods for design by calculation and for design assisted by testing given in this Part 1.3 of ENV 1993 may be adopted for all construction classes.

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

(4)P The values of the partial factors given in this Part 1.3 of ENV 1993 shall be adopted for Construction Class I and Construction Class II.

2.2 Ultimate limit states

(1)P The principles for ultimate limit states given in Sections 2 and 5 in Part 1.1 of ENV 1993 shall also be applied to cold formed thin gauge members and sheeting.

(2) The application rules for ultimate limit states given in Sections 2 and 4 of Part 1.1 of ENV 1993 should also be applied, except where different application rules are given in this Part 1.3.

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

- resistance of cross-sections where failure is caused by yielding:

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

- resistance of members and sheeting where failure is caused by buckling:

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

- resistance of net sections at bolt holes:

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

(4)P For values of γ_M for resistances of connections, see Section 8 of this Part 1.3.

2.3 Serviceability limit states

(1)P The principles for serviceability limit states given in Sections 2 and 4 of Part 1.1 of ENV 1993 shall also be applied to cold formed thin gauge members and sheeting, see 7.1(1)P in this Part 1.3.

(2) The application rules for serviceability limit states given in Sections 2 and 4 of Part 1.1 of ENV 1993 should also be applied, except where different application rules are given in Section 7 of this Part 1.3.

(3)P For verifications at serviceability limit states the partial factor $\gamma_{M,ser}$ shall be taken as follows:

$$\gamma_{M,ser} = 1,0$$

2.4 Design assisted by testing

(1)P Verifications for ultimate limit states or serviceability limit states that rely on the results of testing shall be in accordance with Section 9.

(2) Test specimens for sheet profiles should normally comprise at least two complete corrugations, but a test specimen may comprise just one complete corrugation, provided that the stiffness of the corrugations is sufficient.

2.5 Durability

(1)P To ensure adequate durability of cold formed components under conditions relevant to both their intended use and their intended life, the following inter-related factors shall be taken into account at the design stage:

- the intended use of the structure;
- the required performance criteria;
- the expected environmental conditions;
- the composition, properties and performance of the materials;
- the effects of connecting different materials together;
- the shape of the members and the structural detailing;
- the quality of the workmanship and the level of control;
- the particular protective measures;
- the likely maintenance during the intended life.

(2)P The internal and external environmental conditions shall be estimated at the design stage in order to assess their significance in relation to durability and enable adequate provisions to be made for the protection of the materials.

(3) Special attention should be given to cases in which different materials are intended to act compositely, if these materials are such that electrochemical phenomena might produce conditions leading to corrosion.

(4) The environmental conditions prevailing from the time of manufacture, including those during transport and storage on site, should be taken into account.



3 Properties of materials and cross-sections

3.1 Structural steel

3.1.1 General

(1)P All steels used for cold formed members and profiled sheets shall be suitable for cold forming and welding. Steels used for members and sheets to be galvanized shall also be suitable for galvanizing.

(2)P The methods for design by calculation given in this Part 1.3 of ENV 1993 may be used for structural steels conforming with the European Standards and International Standards listed in table 3.1.

Table 3.1: 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 steel sheet of structural quality	EN 10025	S 235 S 275 S 355	235 275 355	360 430 510
Hot rolled steel sheet of high yield strength of structural quality	EN 10113: Part 2	S 275 N S 355 N S 420 N S 460 N	275 355 420 460	370 470 520 550
	EN 10113: Part 3	S 275 M S 355 M S 420 M S 460 M	275 355 420 460	360 450 500 530
Cold reduced steel sheet of structural quality	ISO 4997	CR 220 CR 250 CR 320	220 250 320	300 330 400
Continuous hot dip zinc coated carbon steel sheet of structural quality	EN 10147	Fe E 220 G Fe E 250 G Fe E 280 G Fe E 320 G Fe E 350 G	220 250 280 320 350	300 330 360 390 420
High yield strength steels for cold forming	prEN 10149: Part 2	S 315 MC S 355 MC S 420 MC S 460 MC S 500 MC S 550 MC	315 355 420 460 500 550	390 430 480 520 550 600
	prEN 10149: Part 3	S 260 NC S 315 NC S 355 NC S 420 NC	260 315 355 420	370 430 470 530

(3)P These design methods may also be applied to other structural steels with similar strength and toughness properties, provided that all of the following conditions are satisfied:

- a) the steel satisfies the requirements for chemical analysis, mechanical tests and other control procedures to the extent and in the manner prescribed in the standards that are listed in table 3.1;
- b) the ratio of the specified minimum ultimate tensile strength f_u to the specified minimum basic yield strength f_{yb} is not less than 1,2;
- c) the steel is supplied either:
 - to another recognized standard for structural steel sheet;
 - with mechanical properties and chemical composition at least equivalent to one of the steel grades that are listed in table 3.1.

(4)P The nominal values of the basic yield strength f_{yb} and ultimate tensile strength f_u given in table 3.1 shall be adopted as characteristic values in design calculations. For other steels the characteristic values shall be based on the results of tensile tests carried out in accordance with EN 10002-1.

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

(6)P Where the yield strength is specified using the symbol f_y the average yield strength f_{ya} may be used, if the conditions given in 3.1.2 are satisfied, otherwise the basic yield strength f_{yb} shall be used. Where the yield strength is specified using the symbol f_{yb} the basic yield strength f_{yb} shall be used.

(7)P For the steels covered by this Part 1.3 of ENV 1993, the other material properties to be used in design shall be taken as follows:

- modulus of elasticity: $E = 210\,000\text{ N/mm}^2$;
- shear modulus: $G = E/2(1 + \nu)\text{ N/mm}^2$;
- Poisson's ratio: $\nu = 0,3$;
- coefficient of linear thermal elongation: $\alpha = 12 \times 10^{-6}\text{ 1/K}$;
- unit mass $\rho = 7850\text{ kg/m}^3$.

3.1.2 Average yield strength

(1)P The average yield strength f_{ya} of a cross-section due to cold working may be determined from the results of full size tests in accordance with Section 9.

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

$$f_{ya} = f_{yb} + (f_u - f_{yb})knt^2/A_g \quad \text{but} \quad f_{ya} \leq (f_u + f_{yb})/2 \quad \dots (3.1)$$

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 cold rolling;
 - $k = 5$ for other methods of forming;
- n is the number of 90° bends in the cross-section with an internal radius $r \leq 5t$ (fractions of 90° bends should be counted as fractions of n);
- t is the nominal core thickness t_{cor} of the steel material before cold forming, exclusive of zinc or organic coatings, see 3.1.3.

(3)P The increased yield strength due to cold forming shall be taken into account only as follows:

- in axially loaded members in which the effective cross-sectional area A_{eff} equals the gross area A_g ;
- in other cases in which it can be shown that the effects of cold forming lead to an increase in the load carrying capacity.

(4) In determining A_{eff} the yield strength f_y should be taken as f_{yb} .

(5) The average yield strength f_{ya} may be utilized in determining:

- the cross-section resistance of an axially loaded tension member;
- the cross-section resistance and the buckling resistance of an axially loaded compression member with a fully effective cross-section;
- the moment resistance of a cross-section with fully effective flanges.

(6) To determine the moment resistance of a cross-section with fully effective flanges, the cross-section may be subdivided into m nominal plane elements, such as flanges. Expression (3.1) may then be used to obtain values of increased yield strength $f_{y,i}$ separately for each nominal plane element i , provided that:

$$\sum_{i=1}^m A_{g,i} f_{y,i} / \sum_{i=1}^m A_{g,i} \leq f_{ya} \quad \dots (3.2)$$

where:

$A_{g,i}$ is the gross cross-sectional area of nominal plane element i .

(7)P The increase in yield strength due to cold forming shall not be utilized for members that are subjected to heat treatment after forming at more than 520°C for more than one hour.

(8) Special attention should be paid to the fact that some heat treatments (especially annealing) might induce a reduced yield strength lower than the basic yield strength f_{yb} .

3.1.3 Thickness

(1)P The provisions for design by calculation given in this Part 1.3 of ENV 1993 may be used only for steel within the following ranges of nominal core thickness t_{cor} exclusive of zinc or organic coatings:

- for sheeting: $0,5 \text{ mm} \leq t_{\text{cor}} \leq 4,0 \text{ mm}$;
- for members: $1,0 \text{ mm} \leq t_{\text{cor}} \leq 8,0 \text{ mm}$.

(2)P Thicker or thinner material may also be used, provided that the load bearing capacity is determined by design assisted by testing in accordance with Section 9.

(3)P Because the design provisions for cold formed members and sheeting given in this Part 1.3 have been developed on the basis of thickness tolerances that are approximately half the tolerance values specified as "normal tolerances" in EN 10143, if larger tolerances are used the nominal values of thickness t_{nom} shall be adjusted to maintain the equivalent reliability.

(4) For continuously hot-dip metal coated members and sheeting of nominal thickness $t_{\text{nom}} < 1,5 \text{ mm}$ supplied with negative tolerances equal to the "special tolerances (S)" given in EN 10143, the design thickness t may be taken as equal to the nominal core thickness t_{cor} .

(5) In the case of continuously hot-dip metal coated steel sheet and strip conforming with EN 10147, the nominal core thickness t_{cor} may be taken as $t_{\text{nom}} - t_{\text{zin}}$ where t_{nom} is the nominal sheet thickness and t_{zin} is the total thickness of zinc coating, including both surfaces.

NOTE: For the usual Z 275 zinc coating, $t_{\text{zin}} = 0,04 \text{ mm}$.

3.2 Connecting devices

3.2.1 Bolt assemblies

(1)P Bolts, nuts and washers shall conform to the requirements given in ENV 1993-1-1.

3.2.2 Other types of mechanical fastener

(1)P The following additional types of mechanical fasteners may be used:

- self-tapping screws;
- cartridge-fired pins;
- blind rivets.

(2)P Self tapping screws may be:

- thread-forming self-tapping screws;
- thread-cutting self-tapping screws;
- self-drilling self-tapping screws.

(3) For details concerning suitable self-tapping screws, cartridge-fired pins and blind rivets reference should be made to ENV 1090: Part 2.*)

3.2.3 Welding consumables

(1)P Welding consumables shall conform to the requirements given in ENV 1993-1-1.

3.3 Section properties

3.3.1 General

(1)P Section properties shall be calculated according to normal good practice, taking due account of the sensitivity of the properties of the overall cross-section to any approximations used, see 3.3.4, and their influence on the predicted resistance of the member.

(2)P The effects of local buckling shall be taken into account by using effective cross-sections as specified in Section 4.

3.3.2 Gross cross-section

(1)P The properties of the gross cross-section shall be determined using the specified nominal dimensions. In calculating gross cross-sectional properties, holes for fasteners need not be deducted but allowance shall be made for large openings. Plates that are used solely in splices or as battens shall not be included.

3.3.3 Net area

(1)P The net area of a member cross-section, or of an element of a cross-section, shall be taken as its gross area minus appropriate deductions for all fastener holes and other openings.

(2)P In deducting holes for fasteners, the nominal hole diameter shall be used, not the fastener diameter.

*) This document is in preparation.

(3) For countersunk holes, the area to be deducted should be the gross cross-sectional area of the hole, including the countersunk portion, in the plane of its axis.

(4)P Provided that the fastener holes are not staggered, the area to be deducted from the gross cross-sectional area shall be the maximum sum of the sectional areas of the fastener holes in any cross-section perpendicular to the direction of direct stress in the member.

(5)P Where the fastener holes are staggered, the area to be deducted shall be the greater of:

- a) The deduction for non-staggered holes given in (4)P;
- b) The sum of the sectional areas of all holes in any diagonal or zigzag line extending progressively across the member or element, see figure 3.1, minus an allowance for each gauge space p in the chain of holes. This allowance shall be taken as $0,25 s^2 t / p$ but not more than $0,6 s t$, where:

p is the gauge space, i.e. the distance measured perpendicular to the direction of load transfer, between the centres of two consecutive holes in the chain;

s is the staggered pitch, i.e. the distance, measured parallel to the direction of load transfer, between the centres of the same two holes;

t is the thickness of the holed material.

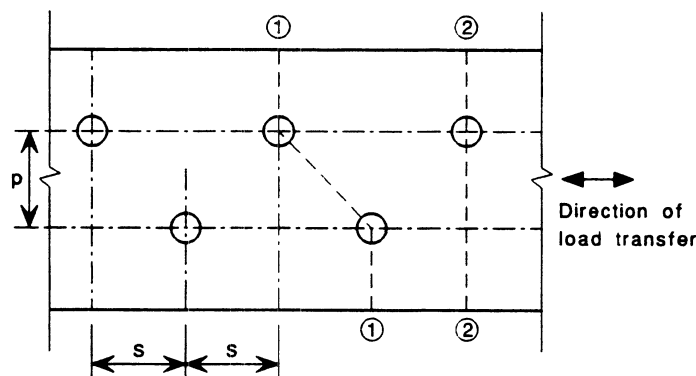


Figure 3.1: Staggered holes and appropriate sections

(6)P For cross-sections such as angles with holes in more than one plane, the spacing p shall be measured along the centre of thickness of the material, see figure 3.2.

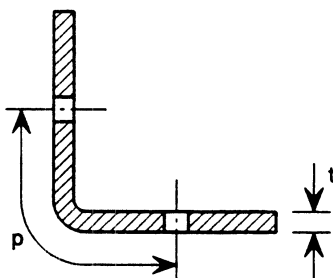


Figure 3.2: Angles with holes in both legs

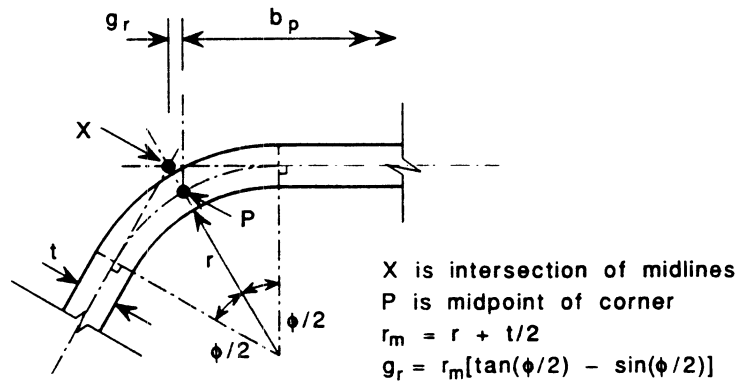
(7)P In a built-up member where the critical chains of holes in each component part do not correspond with the critical chain of holes for the member as a whole, the resistances of any fasteners joining the parts between such chains of holes shall be taken into account in determining the resistance of the member.

NOTE: No general rules can be given for continuously perforated members because the resistance is influenced by the form and pattern of the perforations.

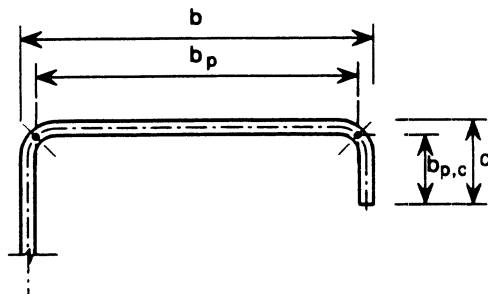
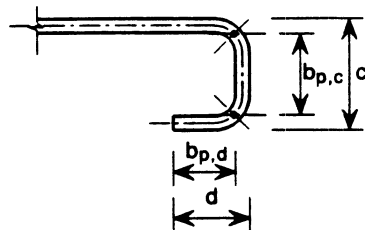
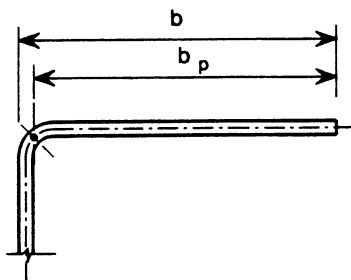
3.3.4 Influence of rounded corners

(1)P In cross-sections with rounded corners, the notional flat widths b_p of the plane elements shall be measured from the midpoints of the adjacent corner elements as indicated in figure 3.3.

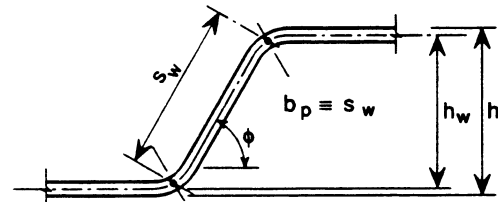
(2)P In cross-sections with rounded corners, the calculation of section properties shall be based upon the actual geometry of the cross-section.



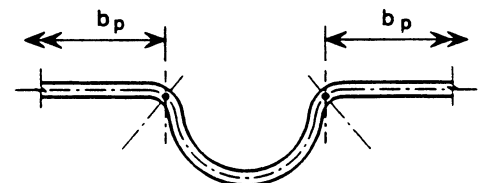
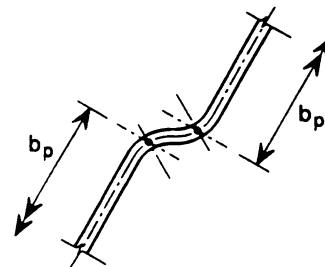
a) midpoint of corner or bend



b) notional flat width b_p of plane elements b, c and d



c) notional flat width b_p for a web ($b_p \equiv$ slant height s_w)



d) notional flat width b_p of plane elements adjacent to stiffeners

Figure 3.3: Notional widths of plane elements b_p allowing for corner radii

(3) The influence of rounded corners with internal radius $r \leq 5t$ and $r \leq 0,15b_p$ on section properties may be neglected, and the cross-section may be assumed to consist of plane elements with sharp corners.

(4) If the internal radius r exceeds the limits given in (3) the influence of rounded corners on section properties should be allowed for. This may be done with sufficient accuracy by reducing the properties calculated for an otherwise similar cross-section with sharp corners, see figure 3.4, using the following approximations:

$$A_g \approx A_{g,sh} (1 - \delta) \quad \dots (3.3a)$$

$$I_g \approx I_{g,sh} (1 - 2\delta) \quad \dots (3.3b)$$

$$I_w \approx I_{w,sh} (1 - 4\delta) \quad \dots (3.3c)$$

with:

$$\delta = 0,43 \frac{\sum_{j=1}^n r_j}{\sum_{i=1}^m b_{p,i}} \quad \dots (3.3d)$$

where:

- A_g is the area of the gross cross-section;
- $A_{g,sh}$ is the value of A_g for a cross-section with sharp corners;
- $b_{p,i}$ is the notional flat width of plane element i for a cross-section with sharp corners;
- I_g is the second moment of area of the gross cross-section;
- $I_{g,sh}$ is the value of I_g for a cross-section with sharp corners;
- I_w is the warping constant of the gross cross-section;
- $I_{w,sh}$ is the value of I_w for a cross-section with sharp corners;
- m is the number of plane elements;
- n is the number of curved elements;
- r_j is the internal radius of curved element j .

(5) The reductions given by expression (3.3) may also be applied in calculating the effective section properties A_{eff} , $I_{y,eff}$, $I_{z,eff}$ and $I_{w,eff}$, provided that the notional flat widths of the plane elements are measured to the points of intersection of their midlines.

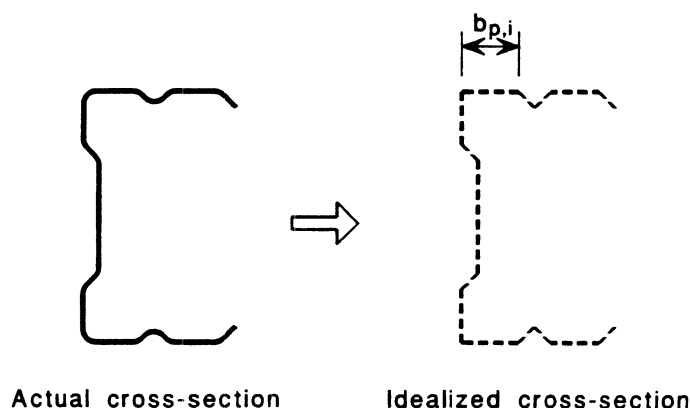
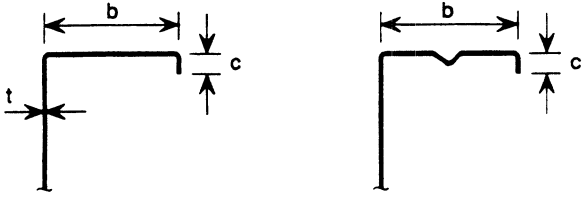
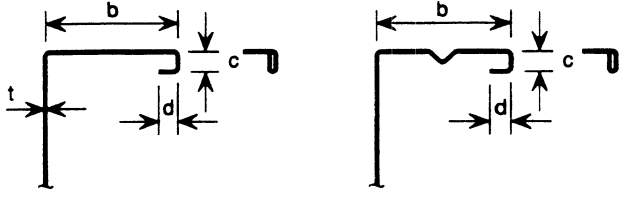
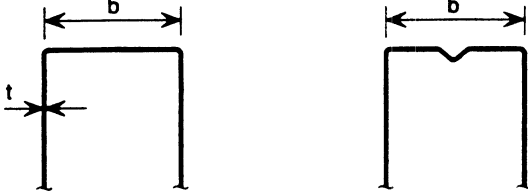


Figure 3.4: Approximate allowance for rounded corners

3.4 Geometrical proportions

- (1)P The provisions for design by calculation given in this Part 1.3 of ENV 1993 shall not be applied to cross-sections outside the range of width-to-thickness ratios for which sufficient experience and verification by testing is available.
- (2) The maximum width-to-thickness ratios b/t and h/t given in table 3.2 may be assumed to represent the field for which sufficient experience and verification by testing is already available.
- (3) Cross-sections with larger width-to-thickness ratios may also be used, provided that their resistance at ultimate limit states and their behaviour at serviceability limit states are verified by testing in accordance with Section 9.

Table 3.2: Maximum width-to-thickness ratios

Element of cross-section	Maximum value
	$b/t \leq 50$
	$b/t \leq 60$
	$b/t \leq 90$
	$b/t \leq 500$
	$45^\circ \leq \phi \leq 90^\circ$ $h/t \leq 500 \sin \phi$