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BRITISH STANDARD

BS EN 1993-1-1:2005

Incorporating Corrigendum No. 1

Eurocode 3: Design of steel structures —

Part 1-1: General rules and rules for buildings

The European Standard EN 1993-1-1:2005 has the status of a British Standard

ICS 91.010.30; 91.080.10

British Standards

National foreword

This British Standard is the official English language version of EN 1993-1-1:2005, including Corrigendum February 2006. It supersedes DD ENV 1993-1-1:1992, which is withdrawn.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags [AC⟩⟨AC]. Tags indicating changes to CEN text carry the number of the CEN corrigendum. For example, text altered by June 2006 corrigendum is indicated by [AC1⟩⟨AC1].

The structural Eurocodes are divided into packages by grouping Eurocodes for each of the main materials, concrete, steel, composite concrete and steel, timber, masonry and aluminium, this is to enable a common date of withdrawal (DOW) for all the relevant parts that are needed for a particular design. The conflicting national standards will be withdrawn at the end of the coexistence period, after all the EN Eurocodes of a package are available.

Following publication of the EN, there is a period of allowed for the national calibration during which the national annex is issued, followed by a coexistence period of a maximum 3 years. During the coexistence period Member States are encouraged to adapt their national provisions. Conflicting national standards will be withdrawn by March 2010 at the latest.

BS EN 1993-1-1 will partially supersede BS 449-2, 5400-3 and 5950-1, which will be withdrawn by March 2010.

The UK participating in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/31, Structural use of steel, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Where a normative part of this EN allows for a choice to be made at the national level, the range and possible choice will be given in the normative text, and a note will qualify it as a Nationally Determined Parameter (NDP). NDPs can be a specific value for a factor, a specific level or class, a particular method or a particular application rule if several are proposed in the EN.

To enable EN 1993-1-1 to be used in the UK, the NDPs will be published in a National Annex, which will be made available by BSI in due course, after public consultation has taken place.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 18 May 2005

Amendments issued since publication

Amd. No.	Date	Comments
16568 Corrigendum No. 1	29 September 2006	See national foreword and revision to supersession details

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1993-1-1

May 2005

ICS 91.010.30; 91.080.10

Supersedes ENV 1993-1-1:1992
Incorporating Corrigendum February 2006

English version

Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings

Eurocode 3: Calcul des structures en acier - Partie 1-1: Règles générales et règles pour les bâtiments

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau

This European Standard was approved by CEN on 16 April 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Ref. No. EN 1993-1-1:2005: E

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Foreword

This European Standard EN 1993, Eurocode 3: Design of steel structures, 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 November 2005, and conflicting National Standards shall be withdrawn at latest by March 2010.

This Eurocode supersedes ENV 1993-1-1.

According to the CEN-CENELEC Internal Regulations, the National Standard Organizations of the following countries are bound to implement these 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, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Background of the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonization of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonized technical rules for the design of construction works which, in a first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980s.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement[1] between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to the CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links *de facto* the Eurocodes with the provisions of all the Council's Directives and/or Commission's Decisions dealing with European standards (e.g. the Council Directive 89/106/EEC on construction products – CPD – and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

The Structural Eurocode programme comprises the following standards generally consisting of a number of Parts:

EN 1990	Eurocode:	Basis of structural design
EN 1991	Eurocode 1:	Actions on structures
EN 1992	Eurocode 2:	Design of concrete structures
EN 1993	Eurocode 3:	Design of steel structures
EN 1994	Eurocode 4:	Design of composite steel and concrete structures
EN 1995	Eurocode 5:	Design of timber structures
EN 1996	Eurocode 6:	Design of masonry structures
EN 1997	Eurocode 7:	Geotechnical design
EN 1998	Eurocode 8:	Design of structures for earthquake resistance

[1] Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on EUROCODES for the design of building and civil engineering works (BC/CEN/03/89).

EN 1999 Eurocode 9: Design of aluminium structures

Eurocode standards recognize the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level where these continue to vary from State to State.

Status and field of application of Eurocodes

The Member States of the EU and EFTA recognize that Eurocodes serve as reference documents for the following purposes :

- as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 - Mechanical resistance and stability - and Essential Requirement N°2 - Safety in case of fire;
- as a basis for specifying contracts for construction works and related engineering services;
- as a framework for drawing up harmonized technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents[2] referred to in Article 12 of the CPD, although they are of a different nature from harmonized product standard[3]. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving a full compatibility of these technical specifications with the Eurocodes.

The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

National Standards implementing Eurocodes

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National annex (informative).

The National Annex (informative) may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, i.e. :

- values for partial factors and/or classes where alternatives are given in the Eurocode,
- values to be used where a symbol only is given in the Eurocode,
- geographical and climatic data specific to the Member State, e.g. snow map,
- the procedure to be used where alternative procedures are given in the Eurocode,
- references to non-contradictory complementary information to assist the user to apply the Eurocode.

Links between Eurocodes and product harmonized technical specifications (ENs

[2] According to Art. 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for hENs and ETAGs/ETAs.

[3] According to Art. 12 of the CPD the interpretative documents shall :
a) give concrete form to the essential requirements by harmonizing the terminology and the technical bases and indicating classes or levels for each requirement where necessary ;
b) indicate methods of correlating these classes or levels of requirement with the technical specifications, e.g. methods of calculation and of proof, technical rules for project design, etc. ;
c) serve as a reference for the establishment of harmonized standards and guidelines for European technical approvals.
The Eurocodes, *de facto*, play a similar role in the field of the ER 1 and a part of ER 2.

and ETAs)

There is a need for consistency between the harmonized technical specifications for construction products and the technical rules for works[4]. Furthermore, all the information accompanying the CE Marking of the construction products which refer to Eurocodes should clearly mention which Nationally Determined Parameters have been taken into account.

Additional information specific to EN 1993-1

EN 1993 is intended to be used with Eurocodes EN 1990 – Basis of Structural Design, EN 1991 – Actions on structures and EN 1992 to EN 1999, when steel structures or steel components are referred to.

EN 1993-1 is the first of six parts of EN 1993 – Design of Steel Structures. It gives generic design rules intended to be used with the other parts EN 1993-2 to EN 1993-6. It also gives supplementary rules applicable only to buildings.

EN 1993-1 comprises twelve subparts EN 1993-1-1 to EN 1993-1-12 each addressing specific steel components, limit states or materials.

It may also be used for design cases not covered by the Eurocodes (other structures, other actions, other materials) serving as a reference document for other CEN TC´s concerning structural matters.

EN 1993-1 is intended for use by

- committees drafting design related product, testing and execution standards,
- clients (e.g. for the formulation of their specific requirements)
- designers and constructors
- relevant authorities

Numerical values for partial factors and other reliability parameters are recommended as basic values that provide an acceptable level of reliability. They have been selected assuming that an appropriate level of workmanship and quality management applies.

[4] See Art.3.3 and Art.12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

National annex for EN 1993-1-1

This standard gives values with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1993-1 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 1993-1-1 through the following clauses:

- 2.3.1(1)
- 3.1(2)
- 3.2.1(1)
- 3.2.2(1)
- 3.2.3(1)
- 3.2.3(3)B
- 3.2.4(1)B
- 5.2.1(3)
- 5.2.2(8)
- 5.3.2(3)
- 5.3.2(11)
- 5.3.4(3)
- 6.1(1)
- 6.1(1)B
- 6.3.2.2(2)
- 6.3.2.3(1)
- 6.3.2.3(2)
- 6.3.2.4(1)B
- 6.3.2.4(2)B
- 6.3.3(5)
- 6.3.4(1)
- 7.2.1(1)B
- 7.2.2(1)B
- 7.2.3(1)B
- BB.1.3(3)B

1 General

1.1 Scope

1.1.1 Scope of Eurocode 3

(1) Eurocode 3 applies to the design of buildings and civil engineering works in steel. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design and verification that are given in EN 1990 – Basis of structural design.

(2) Eurocode 3 is concerned only with requirements for resistance, serviceability, durability and fire resistance of steel structures. Other requirements, e.g. concerning thermal or sound insulation, are not covered.

(3) Eurocode 3 is intended to be used in conjunction with:

- EN 1990 "Basis of structural design"
- EN 1991 "Actions on structures"
- ENs, ETAGs and ETAs for construction products relevant for steel structures
- EN 1090 "Execution of Steel Structures – Technical requirements"
- EN 1992 to EN 1999 when steel structures or steel components are referred to

(4) Eurocode 3 is subdivided in various parts:

EN 1993-1 Design of Steel Structures : General rules and rules for buildings.

EN 1993-2 Design of Steel Structures : Steel bridges.

EN 1993-3 Design of Steel Structures : Towers, masts and chimneys.

EN 1993-4 Design of Steel Structures : Silos, tanks and pipelines.

EN 1993-5 Design of Steel Structures : Piling.

EN 1993-6 Design of Steel Structures : Crane supporting structures.

(5) EN 1993-2 to EN 1993-6 refer to the generic rules in EN 1993-1. The rules in parts EN 1993-2 to EN 1993-6 supplement the generic rules in EN 1993-1.

(6) EN 1993-1 "General rules and rules for buildings" comprises:

EN 1993-1-1 Design of Steel Structures : General rules and rules for buildings.

EN 1993-1-2 Design of Steel Structures : Structural fire design.

EN 1993-1-3 Design of Steel Structures : Cold-formed thin gauge members and sheeting.

EN 1993-1-4 Design of Steel Structures : Stainless steels.

EN 1993-1-5 Design of Steel Structures : Plated structural elements.

EN 1993-1-6 Design of Steel Structures : Strength and stability of shell structures.

EN 1993-1-7 Design of Steel Structures : Strength and stability of planar plated structures transversely loaded.

EN 1993-1-8 Design of Steel Structures : Design of joints.

EN 1993-1-9 Design of Steel Structures : Fatigue strength of steel structures.

EN 1993-1-10 Design of Steel Structures : Selection of steel for fracture toughness and through-thickness properties.

EN 1993-1-11 Design of Steel Structures : Design of structures with tension components made of steel.

EN 1993-1-12 Design of Steel Structures : Supplementary rules for high strength steel.

1.1.2 Scope of Part 1.1 of Eurocode 3

(1) EN 1993-1-1 gives basic design rules for steel structures with material thicknesses t ≥ 3 mm. It also gives supplementary provisions for the structural design of steel buildings. These supplementary provisions are indicated by the letter "B" after the paragraph number, thus ( )B.

NOTE For cold formed thin gauge members and plate thicknesses t < 3 mm see EN 1993-1-3.

(2) The following subjects are dealt with in EN 1993-1-1:

Section 1: General

Section 2: Basis of design

Section 3: Materials

Section 4: Durability

Section 5: Structural analysis

Section 6: Ultimate limit states

Section 7: Serviceability limit states

(3) Sections 1 to 2 provide additional clauses to those given in EN 1990 "Basis of structural design".

(4) Section 3 deals with material properties of products made of low alloy structural steels.

(5) Section 4 gives general rules for durability.

(6) Section 5 refers to the structural analysis of structures, in which the members can be modelled with sufficient accuracy as line elements for global analysis.

(7) Section 6 gives detailed rules for the design of cross sections and members.

(8) Section 7 gives rules for serviceability.

1.2 Normative references

This European Standard 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 Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

1.2.1 General reference standards

EN 1090	Execution of steel structures – Technical requirements
EN ISO 12944	Paints and varnishes – Corrosion protection of steel structures by protective paint systems
EN 1461	Hot dip galvanized coatings on fabricated iron and steel articles – specifications and test methods

1.2.2 Weldable structural steel reference standards

EN 10025-1:2004	Hot-rolled products of structural steels - Part 1: General delivery conditions.
EN 10025-2:2004	Hot-rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels.
EN 10025-3:2004	Hot-rolled products of structural steels - Part 3: Technical delivery conditions for normalized / normalized rolled weldable fine grain structural steels.

EN 10025-4:2004 Hot-rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels.

EN 10025-5:2004 Hot-rolled products of structural steels - Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance.

EN 10025-6:2004 Hot-rolled products of structural steels - Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition.

EN 10164:1993 Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions.

EN 10210-1:1994 Hot finished structural hollow sections of non-alloy and fine grain structural steels – Part 1: Technical delivery requirements.

EN 10219-1:1997 Cold formed hollow sections of structural steel - Part 1: Technical delivery requirements.

1.3 Assumptions

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

– fabrication and erection complies with EN 1090

1.4 Distinction between principles and application rules

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

1.5 Terms and definitions

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

(2) The following terms and definitions are used in EN 1993-1-1 with the following meanings:

1.5.1
frame
the whole or a portion of a structure, comprising an assembly of directly connected structural elements, designed to act together to resist load; this term refers to both moment-resisting frames and triangulated frames; it covers both plane frames and three-dimensional frames

1.5.2
sub-frame
a frame that forms part of a larger frame, but is be treated as an isolated frame in a structural analysis

1.5.3
type of framing
terms used to distinguish between frames that are either:

– **semi-continuous**, in which the structural properties of the members and joints need explicit consideration in the global analysis

– **continuous**, in which only the structural properties of the members need be considered in the global analysis

– **simple**, in which the joints are not required to resist moments

1.5.4
global analysis
the determination of a consistent set of internal forces and moments in a structure, which are in equilibrium with a particular set of actions on the structure

1.5.5
system length
distance in a given plane between two adjacent points at which a member is braced against lateral displacement in this plane, or between one such point and the end of the member

1.5.6
buckling length
system length of an otherwise similar member with pinned ends, which has the same buckling resistance as a given member or segment of member

1.5.7
shear lag effect
non-uniform stress distribution in wide flanges due to shear deformation; it is taken into account by using a reduced "effective" flange width in safety assessments

1.5.8
capacity design
design method for achieving the plastic deformation capacity of a member by providing additional strength in its connections and in other parts connected to it

1.5.9
uniform member
member with a constant cross-section along its whole length

1.6 Symbols

(1) For the purpose of this standard the following symbols apply.

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

NOTE Symbols are ordered by appearance in EN 1993-1-1. Symbols may have various meanings.

Section 1

x-x axis along a member

y-y axis of a cross-section

z-z axis of a cross-section

u-u major principal axis (where this does not coincide with the y-y axis)

v-v minor principal axis (where this does not coincide with the z-z axis)

b width of a cross section

h depth of a cross section

d depth of straight portion of a web

t_w web thickness

t_f flange thickness

r radius of root fillet

r_1 radius of root fillet

r_2 toe radius

t thickness

Section 2

P_k nominal value of the effect of prestressing imposed during erection

G_k nominal value of the effect of permanent actions

X_K characteristic values of material property

X_n nominal values of material property

R_d design value of resistance

R_k characteristic value of resistance

γ_M general partial factor

γ_{Mi} particular partial factor

γ_{Mf} partial factor for fatigue

η conversion factor

a_d design value of geometrical data

Section 3

f_y yield strength

f_u ultimate strength

R_{eh} yield strength to product standards

R_m ultimate strength to product standards

A_0 original cross-section area

ε_y yield strain

ε_u ultimate strain

Z_{Ed} required design Z-value resulting from the magnitude of strains from restrained metal shrinkage under the weld beads.

Z_{Rd} available design Z-value

E modulus of elasticity

G shear modulus

ν Poisson's ratio in elastic stage

α coefficient of linear thermal expansion

Section 5

α_{cr} factor by which the design loads would have to be increased to cause elastic instability in a global mode

F_{Ed} design loading on the structure

F_{cr} elastic critical buckling load for global instability mode based on initial elastic stiffnesses

H_{Ed} design value of the horizontal reaction at the bottom of the storey to the horizontal loads and fictitious horizontal loads

V_{Ed} total design vertical load on the structure on the bottom of the storey

$\delta_{H,Ed}$ horizontal displacement at the top of the storey, relative to the bottom of the storey

h storey height

$\bar{\lambda}$ non dimensional slenderness

N_{Ed} design value of the axial force

ϕ global initial sway imperfection

ϕ_0 basic value for global initial sway imperfection

α_h reduction factor for height h applicable to columns

h height of the structure

α_m reduction factor for the number of columns in a row

m number of columns in a row

e_0 maximum amplitude of a member imperfection

L member length

η_{init} amplitude of elastic critical buckling mode

η_{cr} shape of elastic critical buckling mode

$e_{0,d}$ design value of maximum amplitude of an imperfection

M_{Rk} characteristic moment resistance of the critical cross section

N_{Rk} characteristic resistance to normal force of the critical cross section

α imperfection factor

$EI\,\eta''_{cr}$ bending moment due to η_{cr} at the critical cross section

χ reduction factor for the relevant buckling curve

$\alpha_{ult,k}$ minimum force amplifier to reach the characteristic resistance without taking buckling into account

α_{cr} minimum force amplifier to reach the elastic critical buckling

q equivalent force per unit length

δ_q in-plane deflection of a bracing system

q_d equivalent design force per unit length

M_{Ed} design bending moment

k factor for $e_{0,d}$

ε strain

σ stress

$\sigma_{com,Ed}$ maximum design compressive stress in an element

ℓ length

ε coefficient depending on f_y

c width or depth of a part of a cross section

α portion of a part of a cross section in compression

ψ stress or strain ratio

k_σ plate buckling coefficient

d outer diameter of circular tubular sections

Section 6

γ_{M0} partial factor for resistance of cross-sections whatever the class is

γ_{M1} partial factor for resistance of members to instability assessed by member checks

γ_{M2} partial factor for resistance of cross-sections in tension to fracture

$\sigma_{x,Ed}$ design value of the local longitudinal stress

$\sigma_{z,Ed}$ design value of the local transverse stress

τ_{Ed} design value of the local shear stress

N_{Ed} design normal force

$M_{y,Ed}$ design bending moment, y-y axis

$M_{z,Ed}$ design bending moment, z-z axis

N_{Rd} design values of the resistance to normal forces

$M_{y,Rd}$ design values of the resistance to bending moments, y-y axis

$M_{z,Rd}$ design values of the resistance to bending moments, z-z axis

s staggered pitch, the spacing of the centres of two consecutive holes in the chain measured parallel to the member axis

p spacing of the centres of the same two holes measured perpendicular to the member axis

n number of holes extending in any diagonal or zig-zag line progressively across the member or part of the member

d_0 diameter of hole

e_N shift of the centroid of the effective area A_{eff} relative to the centre of gravity of the gross cross section

ΔM_{Ed} additional moment from shift of the centroid of the effective area A_{eff} relative to the centre of gravity of the gross cross section

A_{eff} effective area of a cross section

$N_{t,Rd}$ design values of the resistance to tension forces

$N_{pl,Rd}$ design plastic resistance to normal forces of the gross cross-section

$N_{u,Rd}$ design ultimate resistance to normal forces of the net cross-section at holes for fasteners

A_{net} net area of a cross section

$N_{net,Rd}$ design plastic resistance to normal forces of the net cross-section

$N_{c,Rd}$ design resistance to normal forces of the cross-section for uniform compression

$M_{c,Rd}$ design resistance for bending about one principal axis of a cross-section

W_{pl} plastic section modulus

$W_{el,min}$ minimum elastic section modulus

$W_{eff,min}$ minimum effective section modulus

A_f area of the tension flange

$A_{f,net}$ net area of the tension flange

V_{Ed} design shear force

$V_{c,Rd}$ design shear resistance

$V_{pl,Rd}$ plastic design shear resistance

A_v shear area

η factor for shear area

S first moment of area

I second moment of area

A_w area of a web

A_f area of one flange

T_{Ed} design value of total torsional moments

T_{Rd} design resistance to torsional moments

$T_{t,Ed}$ design value of internal St. Venant torsion

$T_{w,Ed}$ design value of internal warping torsion

$\tau_{t,Ed}$ design shear stresses due to St. Venant torsion

$\tau_{w,Ed}$ design shear stresses due to warping torsion

$\sigma_{w,Ed}$ design direct stresses due to the bimoment B_{Ed}

B_{Ed} bimoment

$V_{pl,T,Rd}$ reduced design plastic shear resistance making allowance for the presence of a torsional moment

ρ reduction factor to determine reduced design values of the resistance to bending moments making allowance for the presence of shear forces

$M_{V,,Rd}$ reduced design values of the resistance to bending moments making allowance for the presence of shear forces

$M_{N,,Rd}$ reduced design values of the resistance to bending moments making allowance for the presence of normal forces

n ratio of design normal force to design plastic resistance to normal forces of the gross cross-section

a ratio of web area to gross area

α parameter introducing the effect of biaxial bending

β parameter introducing the effect of biaxial bending

$e_{N,y}$ shift of the centroid of the effective area A_{eff} relative to the centre of gravity of the gross cross section (y-y axis)

$e_{N,z}$ shift of the centroid of the effective area A_{eff} relative to the centre of gravity of the gross cross section (z-z axis)

$W_{eff,min}$ minimum effective section modulus

$N_{b,Rd}$ design buckling resistance of a compression member

χ reduction factor for relevant buckling mode

Φ value to determine the reduction factor χ

a_0, a, b, c, d class indexes for buckling curves

N_{cr} elastic critical force for the relevant buckling mode based on the gross cross sectional properties

i radius of gyration about the relevant axis, determined using the properties of the gross cross-section

λ_1 slenderness value to determine the relative slenderness

$\bar{\lambda}_T$ relative slenderness for torsional or torsional-flexural buckling

$N_{cr,TF}$ elastic torsional-flexural buckling force

$N_{cr,T}$ elastic torsional buckling force

$M_{b,Rd}$ design buckling resistance moment

χ_{LT} reduction factor for lateral-torsional buckling

Φ_{LT} value to determine the reduction factor χ_{LT}

α_{LT} imperfection factor

$\bar{\lambda}_{LT}$ non dimensional slenderness for lateral torsional buckling

M_{cr} elastic critical moment for lateral-torsional buckling

$\bar{\lambda}_{LT,0}$ plateau length of the lateral torsional buckling curves for rolled sections

β correction factor for the lateral torsional buckling curves for rolled sections

$\chi_{LT,mod}$ modified reduction factor for lateral-torsional buckling

f modification factor for χ_{LT}

k_c correction factor for moment distribution

ψ ratio of moments in segment

L_c length between lateral restraints

$\bar{\lambda}_f$ equivalent compression flange slenderness

i_{fz} radius of gyration of compression flange about the minor axis of the section

$I_{eff,f}$ effective second moment of area of compression flange about the minor axis of the section

$A_{eff,f}$ effective area of compression flange

$A_{eff,w,c}$ effective area of compressed part of web

$\bar{\lambda}_{c0}$ slenderness parameter

$k_{f\ell}$ modification factor

ΔM_y moments due to the shift of the centroidal y-y axis

ΔM_z moments due to the shift of the centroidal z-z axis

χ_y reduction factor due to flexural buckling (y-y axis)

χ_z reduction factor due to flexural buckling (z-z axis)

k_{yy} interaction factor

k_{yz} interaction factor

k_{zy} interaction factor

k_{zz} interaction factor

$\bar{\lambda}_{op}$ global non dimensional slenderness of a structural component for out-of-plane buckling

χ_{op} reduction factor for the non-dimensional slenderness $\bar{\lambda}_{op}$

$\alpha_{ult,k}$ minimum load amplifier of the design loads to reach the characteristic resistance of the most critical cross section

$\alpha_{cr,op}$ minimum amplifier for the in plane design loads to reach the elastic critical resistance with regard to lateral or lateral torsional buckling

N_{Rk} characteristic value of resistance to compression

$M_{y,Rk}$ characteristic value of resistance to bending moments about y-y axis

$M_{z,Rk}$ characteristic value of resistance to bending moments about z-z axis

Q_m local force applied at each stabilized member at the plastic hinge locations

L_{stable} stable length of segment

L_{ch} buckling length of chord

h_0 distance of centrelines of chords of a built-up column

a distance between restraints of chords

α angle between axes of chord and lacings

i_{min} minimum radius of gyration of single angles

A_{ch} area of one chord of a built-up column

$N_{ch,Ed}$ design chord force in the middle of a built-up member

M^{I}_{Ed} design value of the maximum moment in the middle of the built-up member

I_{eff} effective second moment of area of the built-up member

S_v shear stiffness of built-up member from the lacings or battened panel

n number of planes of lacings

A_d area of one diagonal of a built-up column

d length of a diagonal of a built-up column

A_V area of one post (or transverse element) of a built-up column

I_{ch} in plane second moment of area of a chord

I_b in plane second moment of area of a batten

μ efficiency factor

i_y radius of gyration (y-y axis)

Annex A

C_{my} equivalent uniform moment factor

C_{mz} equivalent uniform moment factor

C_{mLT} equivalent uniform moment factor

μ_y factor

μ_z factor

$N_{cr,y}$ elastic flexural buckling force about the y-y axis

$N_{cr,z}$ elastic flexural buckling force about the z-z axis

C_{yy} factor

C_{yz} factor

C_{zy} factor

C_{zz} factor

w_y factor

w_z factor

n_{pl} factor

$\bar{\lambda}_{max}$ maximum of $\bar{\lambda}_y$ and $\bar{\lambda}_z$

b_{LT} factor

c_{LT} factor

d_{LT} factor

e_{LT} factor

ψ_y ratio of end moments (y-y axis)

$C_{my,0}$ factor

$C_{mz,0}$ factor

a_{LT} factor

I_T St. Venant torsional constant

I_y second moment of area about y-y axis

$M_{i,Ed}(x)$ maximum first order moment

$|\delta_x|$ maximum member displacement along the member

Annex B

α_s factor

α_h factor

C_m equivalent uniform moment factor

Annex AB

γ_G partial factor for permanent loads

G_k characteristic value of permanent loads

γ_Q partial factor for variable loads

Q_k characteristic value of variable loads

Annex BB

$\bar{\lambda}_{eff,v}$ effective slenderness ratio for buckling about v-v axis

$\bar{\lambda}_{eff,y}$ effective slenderness ratio for buckling about y-y axis

$\bar{\lambda}_{eff,z}$ effective slenderness ratio for buckling about z-z axis

L system length

L_{cr} buckling length

S shear stiffness provided by sheeting

I_w warping constant

$C_{\vartheta,k}$ rotational stiffness provided by stabilizing continuum and connections

K_υ factor for considering the type of analysis

K_ϑ factor for considering the moment distribution and the type of restraint

$C_{\vartheta R,k}$ rotational stiffness provided by the stabilizing continuum to the beam assuming a stiff connection to the member

$C_{\vartheta C,k}$ rotational stiffness of the connection between the beam and the stabilizing continuum

$C_{\vartheta D,k}$ rotational stiffness deduced from an analysis of the distorsional deformations of the beam cross sections

L_m stable length between adjacent lateral restraints

L_k stable length between adjacent torsional restraints

L_s stable length between a plastic hinge location and an adjacent torsional restraint

C_1 modification factor for moment distribution

C_m modification factor for linear moment gradient

C_n modification factor for non-linear moment gradient

a distance between the centroid of the member with the plastic hinge and the centroid of the restraint members

B_0 factor

B_1 factor

B_2 factor

η ratio of critical values of axial forces

i_s radius of gyration related to centroid of restraining member

β_t ratio of the algebraically smaller end moment to the larger end moment

R_1 moment at a specific location of a member

R_2 moment at a specific location of a member

R_3 moment at a specific location of a member

R_4 moment at a specific location of a member

R_5 moment at a specific location of a member

R_E maximum of R_1 or R_5

R_s maximum value of bending moment anywhere in the length L_y

c taper factor

h_h additional depth of the haunch or taper

h_{max} maximum depth of cross-section within the length L_y

h_{min} minimum depth of cross-section within the length L_y

h_s vertical depth of the un-haunched section

L_h length of haunch within the length L_y

L_y length between restraints

1.7 Conventions for member axes

(1) The 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 steel members, the conventions used for cross-section axes are:

– generally:

  y-y - cross-section axis parallel to the flanges

  z-z - cross-section axis perpendicular to the flanges

– for angle sections:

  y-y - axis parallel to the smaller leg

  z-z - axis perpendicular to the smaller leg

– where necessary:

  u-u - major principal axis (where this does not coincide with the yy axis)

  v-v - minor principal axis (where this does not coincide with the zz axis)

(3) The symbols used for dimensions and axes of rolled steel sections are indicated in Figure 1.1.

(4) The convention used for subscripts that indicate axes for moments is: "Use the axis about which the moment acts."

NOTE All rules in this Eurocode relate to principal axis properties, which are generally defined by the axes y-y and z-z but for sections such as angles are defined by the axes u-u and v-v.

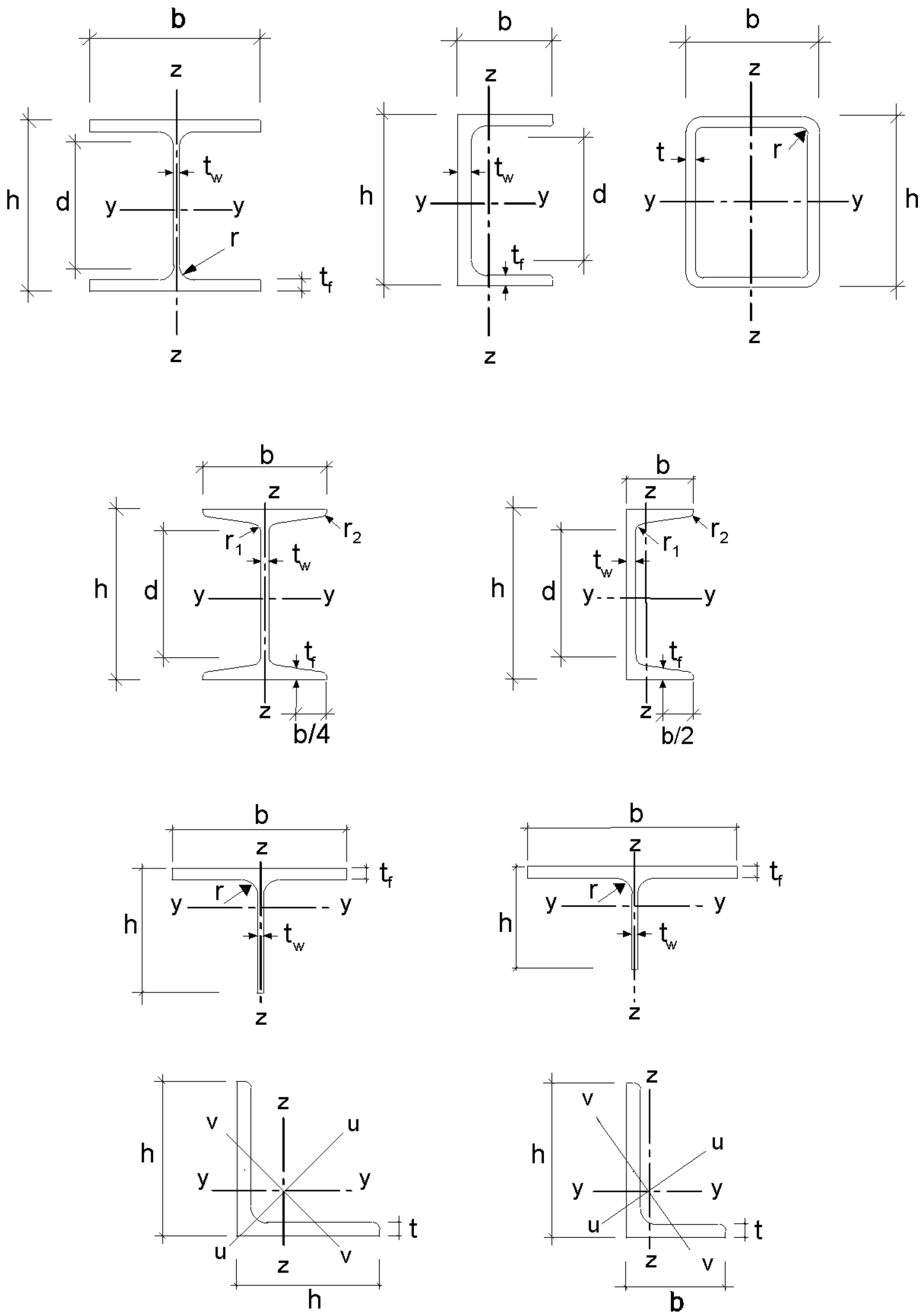


Figure 1.1: Dimensions and axes of sections

2 Basis of design

2.1 Requirements

2.1.1 Basic requirements

AC1 (1)P The design of steel structures shall be in accordance with the general rules given in EN 1990. AC1

(2) The supplementary provisions for steel structures given in this section should also be applied.

(3) The basic requirements of EN 1990 section 2 should be deemed be satisfied where limit state design is used in conjunction with the partial factor method and the load combinations given in EN 1990 together with the actions given in EN 1991.

(4) The rules for resistances, serviceability and durability given in the various parts of EN 1993 should be applied.

2.1.2 Reliability management

(1) Where different levels of reliability are required, these levels should preferably be achieved by an appropriate choice of quality management in design and execution, according to EN 1990 Annex C and EN 1090.

2.1.3 Design working life, durability and robustness

2.1.3.1 General

AC1 (1)P Depending upon the type of action affecting durability and the design working life (see EN 1990) steel structures shall be AC1

- designed against corrosion by means of
  - suitable surface protection (see EN ISO 12944)
  - the use of weathering steel
  - the use of stainless steel (see EN 1993-1-4)
- detailed for sufficient fatigue life (see EN 1993-1-9)
- designed for wearing
- designed for accidental actions (see EN 1991-1-7)
- inspected and maintained.

2.1.3.2 Design working life for buildings

AC1 (1)P,B The design working life shall be taken as the period for which a building structure is expected to be used for its intended purpose. AC1

(2)B For the specification of the intended design working life of a permanent building see Table 2.1 of EN 1990.

(3)B For structural elements that cannot be designed for the total design life of the building, see 2.1.3.3(3)B.

2.1.3.3 Durability for buildings

AC1 (1)P,B To ensure durability, buildings and their components shall either be designed for environmental actions and fatigue if relevant or else protected from them. AC1

[AC1) (2)P,B The effects of deterioration of material, corrosion or fatigue where relevant shall be taken into account by appropriate choice of material, see EN 1993-1-4 and EN 1993-1-10, and details, see EN 1993-1-9, or by structural redundancy and by the choice of an appropriate corrosion protection system. (AC1]

(3)B If a building includes components that need to be replaceable (e.g. bearings in zones of soil settlement), the possibility of their safe replacement should be verified as a transient design situation.

2.2 Principles of limit state design

(1) The resistance of cross-sections and members specified in this Eurocode 3 for the ultimate limit states as defined in EN 1990, 3.3 are based on tests in which the material exhibited sufficient ductility to apply simplified design models.

(2) The resistances specified in this Eurocode Part may therefore be used where the conditions for materials in section 3 are met.

2.3 Basic variables

2.3.1 Actions and environmental influences

(1) Actions for the design of steel structures should be taken from EN 1991. For the combination of actions and partial factors of actions see Annex A to EN 1990.

NOTE 1 The National Annex may define actions for particular regional or climatic or accidental situations.

NOTE 2B For proportional loading for incremental approach, see Annex AB.1.

NOTE 3B For simplified load arrangement, see Annex AB.2.

(2) The actions to be considered in the erection stage should be obtained from EN 1991-1-6.

(3) Where the effects of predicted absolute and differential settlements need to be considered, best estimates of imposed deformations should be used.

(4) The effects of uneven settlements or imposed deformations or other forms of prestressing imposed during erection should be taken into account by their nominal value P_k as permanent actions and grouped with other permanent actions G_k from a single action ($G_k + P_k$).

(5) Fatigue actions not defined in EN 1991 should be determined according to Annex A of EN 1993-1-9.

2.3.2 Material and product properties

(1) Material properties for steels and other construction products and the geometrical data to be used for design should be those specified in the relevant ENs, ETAGs or ETAs unless otherwise indicated in this standard.

2.4 Verification by the partial factor method

2.4.1 Design values of material properties

[AC1) (1)P For the design of steel structures characteristic values X_K or nominal values X_n of material properties shall be used as indicated in this Eurocode. (AC1]

2.4.2 Design values of geometrical data

(1) Geometrical data for cross-sections and systems may be taken from product standards hEN or drawings for the execution to EN 1090 and treated as nominal values.

(2) Design values of geometrical imperfections specified in this standard are equivalent geometric imperfections that take into account the effects of:

– geometrical imperfections of members as governed by geometrical tolerances in product standards or the execution standard;
– structural imperfections due to fabrication and erection;
– residual stresses;
– variation of the yield strength.

2.4.3 Design resistances

(1) For steel structures equation (6.6c) or equation (6.6d) of EN 1990 applies:

$$R_d = \frac{R_k}{\gamma_M} = \frac{1}{\gamma_M} R_k \left(\eta_1 X_{k1}; \eta_i X_{ki}; a_d\right) \qquad (2.1)$$

where R_k is the characteristic value of the particular resistance determined with characteristic or nominal values for the material properties and dimensions

γ_M is the global partial factor for the particular resistance

NOTE For the definitions of η_1, η_i, X_{k1}, X_{ki} and a_d see EN 1990.

2.4.4 Verification of static equilibrium (EQU)

(1) The reliability format for the verification of static equilibrium in Table 1.2 (A) in Annex A of EN 1990 also applies to design situations equivalent to (EQU), e.g. for the design of holding down anchors or the verification of uplift of bearings of continuous beams.

2.5 Design assisted by testing

(1) The resistances R_k in this standard have been determined using Annex D of EN 1990.

(2) In recommending classes of constant partial factors γ_{Mi} the characteristic values R_k were obtained from

$$R_k = R_d \gamma_{Mi} \qquad (2.2)$$

where R_d are design values according to Annex D of EN 1990

γ_{Mi} are recommended partial factors.

NOTE 1 The numerical values of the recommended partial factors γ_{Mi} have been determined such that R_k represents approximately the 5 %-fractile for an infinite number of tests.

NOTE 2 For characteristic values of fatigue strength and partial factors γ_{Mf} for fatigue see EN 1993-1-9.

NOTE 3 For characteristic values of toughness resistance and safety elements for the toughness verification see EN 1993-1-10.

(3) Where resistances R_k for prefabricated products should be determined from tests, the procedure in (2) should be followed.

3 Materials

3.1 General

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

(2) This Part of EN 1993 covers the design of steel structures fabricated from steel material conforming to the steel grades listed in Table 3.1.

NOTE For other steel material and products see National Annex.

3.2 Structural steel

3.2.1 Material properties

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

a) either by adopting the values $f_y = R_{eh}$ and $f_u = R_m$ direct from the product standard

b) or by using the simplification given in Table 3.1

NOTE The National Annex may give the choice.

3.2.2 Ductility requirements

(1) For steels a minimum ductility is required that should be expressed in terms of limits for:

- the ratio f_u / f_y of the specified minimum ultimate tensile strength f_u to the specified minimum yield strength f_y;
- the elongation at failure on a gauge length of $5,65\sqrt{A_o}$ (where A_0 is the original cross-sectional area);
- the ultimate strain ε_u, where ε_u corresponds to the ultimate strength f_u .

NOTE The limiting values of the ratio f_u / f_y , the elongation at failure and the ultimate strain ε_u may be defined in the National Annex. The following values are recommended:

- $f_u / f_y \geq 1,10$;
- elongation at failure not less than 15%;
- $\varepsilon_u \geq 15\varepsilon_y$, where ε_y is the yield strain ($\varepsilon_y = f_y / E$).

(2) Steel conforming with one of the steel grades listed in Table 3.1 should be accepted as satisfying these requirements.

3.2.3 Fracture toughness

AC1 (1)P The material shall have sufficient fracture toughness to avoid brittle fracture of tension elements at the lowest service temperature expected to occur within the intended design life of the structure. AC1

NOTE The lowest service temperature to be adopted in design may be given in the National Annex.

(2) No further check against brittle fracture need to be made if the conditions given in EN 1993-1-10 are satisfied for the lowest temperature.

(3)B For building components under compression a minimum toughness property should be selected.

NOTE B The National Annex may give information on the selection of toughness properties for members in compression. The use of Table 2.1 of EN 1993-1-10 for $\sigma_{Ed} = 0,25\ f_y(t)$ is recommended.

(4) For selecting steels for members with hot dip galvanized coatings see EN 1461.

Table 3.1: Nominal values of yield strength f_y and ultimate tensile strength f_u for hot rolled structural steel

Standard and steel grade	Nominal thickness of the element t [mm]			
	$t \leq 40$ mm		40 mm $< t \leq 80$ mm	
	f_y [N/mm^2]	f_u [N/mm^2]	f_y [N/mm^2]	f_u [N/mm^2]
EN 10025-2				
S 235	235	360	215	360
S 275	275	430	255	410
S 355	355	510	335	470
S 450	440	550	410	550
EN 10025-3				
S 275 N/NL	275	390	255	370
S 355 N/NL	355	490	335	470
S 420 N/NL	420	520	390	520
S 460 N/NL	460	540	430	540
EN 10025-4				
S 275 M/ML	275	370	255	360
S 355 M/ML	355	470	335	450
S 420 M/ML	420	520	390	500
S 460 M/ML	460	540	430	530
EN 10025-5				
S 235 W	235	360	215	340
S 355 W	355	510	335	490
EN 10025-6				
S 460 Q/QL/QL1	460	570	440	550

Table 3.1 (continued): Nominal values of yield strength f_y and ultimate tensile strength f_u for structural hollow sections

Standard and steel grade	Nominal thickness of the element t [mm]			
	$t \leq 40$ mm		$40 \text{ mm} < t \leq 80$ mm	
	f_y [N/mm^2]	f_u [N/mm^2]	f_y [N/mm^2]	f_u [N/mm^2]
EN 10210-1				
S 235 H	235	360	215	340
S 275 H	275	430	255	410
S 355 H	355	510	335	490
S 275 NH/NLH	275	390	255	370
S 355 NH/NLH	355	490	335	470
S 420 NH/NHL	420	540	390	520
S 460 NH/NLH	460	560	430	550
EN 10219-1				
S 235 H	235	360		
S 275 H	275	430		
S 355 H	355	510		
S 275 NH/NLH	275	370		
S 355 NH/NLH	355	470		
S 460 NH/NLH	460	550		
S 275 MH/MLH	275	360		
S 355 MH/MLH	355	470		
S 420 MH/MLH	420	500		
S 460 MH/MLH	460	530		

3.2.4 Through-thickness properties

(1) Where steel with improved through-thickness properties is necessary according to EN 1993-1-10, steel according to the required quality class in EN 10164 should be used.

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

NOTE 2B Particular care should be given to welded beam to column connections and welded end plates with tension in the through-thickness direction.

NOTE 3B The National Annex may give the relevant allocation of target values Z_{Ed} according to 3.2(2) of EN 1993-1-10 to the quality class in EN 10164. The allocation in Table 3.2 is recommended for buildings:

Table 3.2: Choice of quality class according to EN 10164

Target value of Z_{Ed} according to EN 1993-1-10	Required value of Z_{Rd} expressed in terms of design Z-values according to EN 10164
$Z_{Ed} \leq 10$	—
$10 < Z_{Ed} \leq 20$	Z 15
$20 < Z_{Ed} \leq 30$	Z 25
$Z_{Ed} > 30$	Z 35

3.2.5 Tolerances

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

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

(3) For structural analysis and design the nominal values of dimensions should be used.

3.2.6 Design values of material coefficients

(1) The material coefficients to be adopted in calculations for the structural steels covered by this Eurocode Part should be taken as follows:

- modulus of elasticity $E = 210\,000\ \mathrm{N/mm^2}$
- shear modulus $G = \dfrac{E}{2(1+\nu)} \approx 81\,000\ \mathrm{N/mm^2}$
- Poisson's ratio in elastic stage $\nu = 0{,}3$
- coefficient of linear thermal expansion $\alpha = 12 \times 10^{-6}\ per K$ (for $T \leq 100\ °C$)

NOTE For calculating the structural effects of unequal temperatures in composite concrete-steel structures to EN 1994 the coefficient of linear thermal expansion is taken as $\alpha = 10 \times 10^{-6}\ per\ K$.

3.3 Connecting devices

3.3.1 Fasteners

(1) Requirements for fasteners are given in EN 1993-1-8.

3.3.2 Welding consumables

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

3.4 Other prefabricated products in buildings

(1)B Any semi-finished or finished structural product used in the structural design of buildings should comply with the relevant EN Product Standard or ETAG or ETA.

4 Durability

(1) The basic requirements for durability are set out in EN 1990.

AC1 (2)P The means of executing the protective treatment undertaken off-site and on-site shall be in accordance with EN 1090. AC1

NOTE EN 1090 lists the factors affecting execution that need to be specified during design.

(3) Parts susceptible to corrosion, mechanical wear or fatigue should be designed such that inspection, maintenance and reconstruction can be carried out satisfactorily and access is available for in-service inspection and maintenance.

(4)B For building structures no fatigue assessment is normally required except as follows:

a) Members supporting lifting appliances or rolling loads

b) Members subject to repeated stress cycles from vibrating machinery

c) Members subject to wind-induced vibrations

d) Members subject to crowd-induced oscillations

AC1 (5)P For elements that cannot be inspected an appropriate corrosion allowance shall be included. AC1

(6)B Corrosion protection does not need to be applied to internal building structures, if the internal relative humidity does not exceed 80%.

5 Structural analysis

5.1 Structural modelling for analysis

5.1.1 Structural modelling and basic assumptions

AC1 (1)P Analysis shall be based upon calculation models of the structure that are appropriate for the limit state under consideration. AC1

(2) The calculation model and basic assumptions for the calculations should reflect the structural behaviour at the relevant limit state with appropriate accuracy and reflect the anticipated type of behaviour of the cross sections, members, joints and bearings.

AC1 (3)P The method used for the analysis shall be consistent with the design assumptions. AC1

(4)B For the structural modelling and basic assumptions for components of buildings see also EN 1993-1-5 and EN 1993-1-11.

5.1.2 Joint modelling

(1) The effects of the behaviour of the joints on the distribution of internal forces and moments within a structure, and on the overall deformations of the structure, may generally be neglected, but where such effects are significant (such as in the case of semi-continuous joints) they should be taken into account, see EN 1993-1-8.

(2) To identify whether the effects of joint behaviour on the analysis need be taken into account, a distinction may be made between three joint models as follows, see EN 1993-1-8, 5.1.1:

- simple, in which the joint may be assumed not to transmit bending moments;
- continuous, in which the behaviour of the joint may be assumed to have no effect on the analysis;
- semi-continuous, in which the behaviour of the joint needs to be taken into account in the analysis

(3) The requirements of the various types of joints are given in EN 1993-1-8.

5.1.3 Ground-structure interaction

(1) Account should be taken of the deformation characteristics of the supports where significant.

NOTE EN 1997 gives guidance for calculation of soil-structure interaction.

5.2 Global analysis

5.2.1 Effects of deformed geometry of the structure

(1) The internal forces and moments may generally be determined using either:

- first-order analysis, using the initial geometry of the structure or
- second-order analysis, taking into account the influence of the deformation of the structure.

(2) The effects of the deformed geometry (second-order effects) should be considered if they increase the action effects significantly or modify significantly the structural behaviour.

(3) First order analysis may be used for the structure, if the increase of the relevant internal forces or moments or any other change of structural behaviour caused by deformations can be neglected. This condition may be assumed to be fulfilled, if the following criterion is satisfied:

$$\alpha_{cr} = \frac{F_{cr}}{F_{Ed}} \geq 10 \quad \text{for elastic analysis}$$
$$\alpha_{cr} = \frac{F_{cr}}{F_{Ed}} \geq 15 \quad \text{for plastic analysis} \qquad (5.1)$$

where α_{cr} is the factor by which the design loading would have to be increased to cause elastic instability in a global mode

F_{Ed} is the design loading on the structure

F_{cr} is the elastic critical buckling load for global instability mode based on initial elastic stiffnesses

NOTE A greater limit for α_{cr} for plastic analysis is given in equation (5.1) because structural behaviour may be significantly influenced by non linear material properties in the ultimate limit state (e.g. where a frame forms plastic hinges with moment redistributions or where significant non linear deformations from semi-rigid joints occur). Where substantiated by more accurate approaches the National Annex may give a lower limit for α_{cr} for certain types of frames.

(4)B Portal frames with shallow roof slopes and beam-and-column type plane frames in buildings may be checked for sway mode failure with first order analysis if the criterion (5.1) is satisfied for each storey. In these structures α_{cr} may be calculated using the following approximative formula, provided that the axial compression in the beams or rafters is not significant:

$$\alpha_{cr} = \left(\frac{H_{Ed}}{V_{Ed}}\right)\left(\frac{h}{\delta_{H,Ed}}\right) \qquad (5.2)$$

where H_{Ed} is the design value of the horizontal reaction at the bottom of the storey to the horizontal loads and fictitious horizontal loads, see 5.3.2(7)

V_{Ed} is the total design vertical load on the structure on the bottom of the storey

$\delta_{H,Ed}$ is the horizontal displacement at the top of the storey, relative to the bottom of the storey, when the frame is loaded with horizontal loads (e.g. wind) and fictitious horizontal loads which are applied at each floor level

h is the storey height

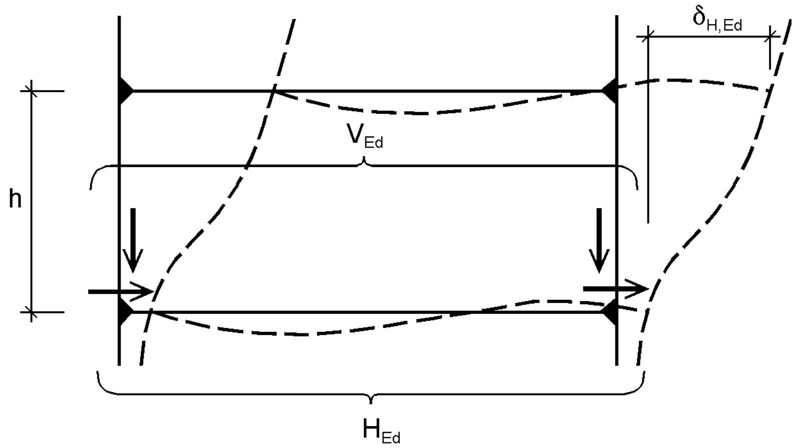


Figure 5.1: Notations for 5.2.1(2)

NOTE 1B For the application of (4)B in the absence of more detailed information a roof slope may be taken to be shallow if it is not steeper that 1:2 (26°).

NOTE 2B For the application of (4)B in the absence of more detailed information the axial compression in the beams or rafters may be assumed to be significant if

$$\bar{\lambda} \geq 0{,}3\sqrt{\frac{A\,f_y}{N_{Ed}}} \tag{5.3}$$

where N_{Ed} is the design value of the compression force,

$\bar{\lambda}$ is the inplane non dimensional slenderness calculated for the beam or rafters considered as hinged at its ends of the system length measured along the beams of rafters.

(5) The effects of shear lag and of local buckling on the stiffness should be taken into account if this significantly influences the global analysis, see EN 1993-1-5.

NOTE For rolled sections and welded sections with similar dimensions shear lag effects may be neglected.

(6) The effects on the global analysis of the slip in bolt holes and similar deformations of connection devices like studs and anchor bolts on action effects should be taken into account, where relevant and significant.

5.2.2 Structural stability of frames

(1) If according to 5.2.1 the influence of the deformation of the structure has to be taken into account (2) to (6) should be applied to consider these effects and to verify the structural stability.

(2) The verification of the stability of frames or their parts should be carried out considering imperfections and second order effects.

(3) According to the type of frame and the global analysis, second order effects and imperfections may be accounted for by one of the following methods:

a) both totally by the global analysis,

b) partially by the global analysis and partially through individual stability checks of members according to 6.3,

c) for basic cases by individual stability checks of equivalent members according to 6.3 using appropriate buckling lengths according to the global buckling mode of the structure.

(4) Second order effects may be calculated by using an analysis appropriate to the structure (including step-by-step or other iterative procedures). For frames where the first sway buckling mode is predominant first order elastic analysis should be carried out with subsequent amplification of relevant action effects (e.g. bending moments) by appropriate factors.

(5)B For single storey frames designed on the basis of elastic global analysis second order sway effects due to vertical loads may be calculated by increasing the horizontal loads H_{Ed} (e.g. wind) and equivalent loads $V_{Ed}\,\phi$ due to imperfections (see 5.3.2(7)) and other possible sway effects according to first order theory by the factor:

$$\frac{1}{1-\dfrac{1}{\alpha_{cr}}} \tag{5.4}$$

provided that $\alpha_{cr} \geq 3{,}0$,

where α_{cr} may be calculated according to (5.2) in 5.2.1(4)B, provided that the roof slope is shallow and that the axial compression in the beams or rafters is not significant as defined in 5.2.1(4)B.

NOTE B For $\alpha_{cr} < 3{,}0$ a more accurate second order analysis applies.

(6)B For multi-storey frames second order sway effects may be calculated by means of the method given in (5)B provided that all storeys have a similar

- distribution of vertical loads and
- distribution of horizontal loads and
- distribution of frame stiffness with respect to the applied storey shear forces.

NOTE B For the limitation of the method see also 5.2.1(4)B.

(7) In accordance with (3) the stability of individual members should be checked according to the following:

a) If second order effects in individual members and relevant member imperfections (see 5.3.4) are totally accounted for in the global analysis of the structure, no individual stability check for the members according to 6.3 is necessary.

b) If second order effects in individual members or certain individual member imperfections (e.g. member imperfections for flexural and/or lateral torsional buckling, see 5.3.4) are not totally accounted for in the global analysis, the individual stability of members should be checked according to the relevant criteria in 6.3 for the effects not included in the global analysis. This verification should take account of end moments and forces from the global analysis of the structure, including global second order effects and global imperfections (see 5.3.2) when relevant and may be based on a buckling length equal to the system length

(8) Where the stability of a frame is assessed by a check with the equivalent column method according to 6.3 the buckling length values should be based on a global buckling mode of the frame accounting for the stiffness behaviour of members and joints, the presence of plastic hinges and the distribution of compressive forces under the design loads. In this case internal forces to be used in resistance checks are calculated according to first order theory without considering imperfections.

NOTE The National Annex may give information on the scope of application.

5.3 Imperfections

5.3.1 Basis

(1) Appropriate allowances should be incorporated in the structural analysis to cover the effects of imperfections, including residual stresses and geometrical imperfections such as lack of verticality, lack of

straightness, lack of flatness, lack of fit and any minor eccentricities present in joints of the unloaded structure.

(2) Equivalent geometric imperfections, see 5.3.2 and 5.3.3, should be used, with values which reflect the possible effects of all type of imperfections unless these effects are included in the resistance formulae for member design, see section 5.3.4.

(3) The following imperfections should be taken into account:

a) global imperfections for frames and bracing systems

b) local imperfections for individual members

5.3.2 Imperfections for global analysis of frames

(1) The assumed shape of global imperfections and local imperfections may be derived from the elastic buckling mode of a structure in the plane of buckling considered.

(2) Both in and out of plane buckling including torsional buckling with symmetric and asymmetric buckling shapes should be taken into account in the most unfavourable direction and form.

(3) For frames sensitive to buckling in a sway mode the effect of imperfections should be allowed for in frame analysis by means of an equivalent imperfection in the form of an initial sway imperfection and individual bow imperfections of members. The imperfections may be determined from:

a) global initial sway imperfections, see Figure 5.2:

$$\phi = \phi_0 \, \alpha_h \, \alpha_m \tag{5.5}$$

where ϕ_0 is the basic value: $\phi_0 = 1/200$

α_h is the reduction factor for height h applicable to columns:

$$\alpha_h = \frac{2}{\sqrt{h}} \text{ but } \frac{2}{3} \leq \alpha_h \leq 1{,}0$$

h is the height of the structure in meters

α_m is the reduction factor for the number of columns in a row: $\alpha_m = \sqrt{0{,}5\left(1 + \frac{1}{m}\right)}$

m is the number of columns in a row including only those columns which carry a vertical load N_{Ed} not less than 50% of the average value of the column in the vertical plane considered

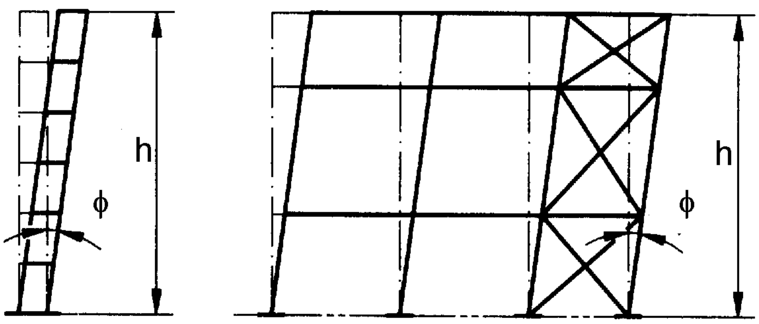


Figure 5.2: Equivalent sway imperfections

b) relative initial local bow imperfections of members for flexural buckling

$$e_0 / L \tag{5.6}$$

where L is the member length

NOTE The values e_0 / L may be chosen in the National Annex. Recommended values are given in Table 5.1.

Table 5.1: Design values of initial local bow imperfection e_0 / L

Buckling curve acc. to Table 6.1	elastic analysis	plastic analysis
	e_0 / L	e_0 / L
a_0	1 / 350	1 / 300
a	1 / 300	1 / 250
b	1 / 250	1 / 200
c	1 / 200	1 / 150
d	1 / 150	1 / 100

(4)B For building frames sway imperfections may be disregarded where

$$H_{Ed} \geq 0{,}15\ V_{Ed} \tag{5.7}$$

(5)B For the determination of horizontal forces to floor diaphragms the configuration of imperfections as given in Figure 5.3 should be applied, where ϕ is a sway imperfection obtained from (5.5) assuming a single storey with height h, see (3) a).

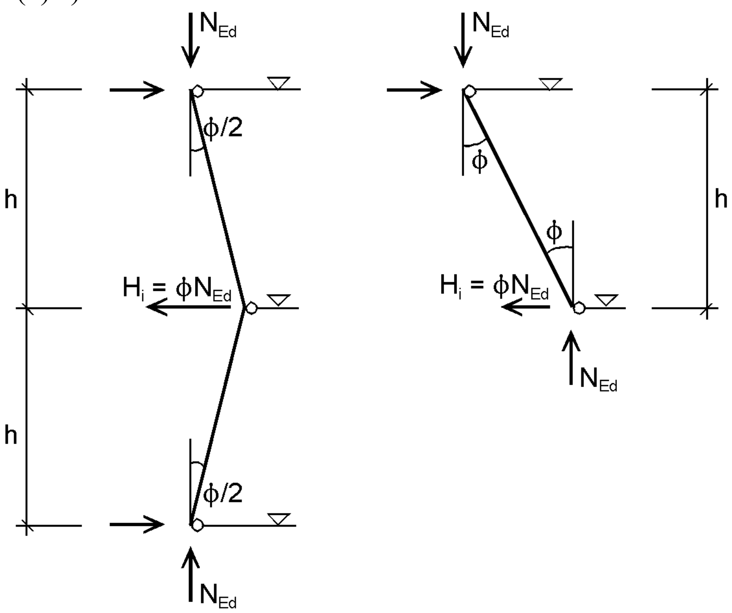


Figure 5.3: Configuration of sway imperfections ϕ for horizontal forces on floor diaphragms

(6) When performing the global analysis for determining end forces and end moments to be used in member checks according to 6.3 local bow imperfections may be neglected. However for frames sensitive to second order effects local bow imperfections of members additionally to global sway imperfections (see 5.2.1(3)) should be introduced in the structural analysis of the frame for each compressed member where the following conditions are met:

- at least one moment resistant joint at one member end
- $$\bar{\lambda} > 0{,}5\sqrt{\frac{A\ f_y}{N_{Ed}}} \tag{5.8}$$

where N_{Ed} is the design value of the compression force

and $\bar{\lambda}$ is the in-plane non-dimensional slenderness calculated for the member considered as hinged at its ends

NOTE Local bow imperfections are taken into account in member checks, see 5.2.2 (3) and 5.3.4.

(7) The effects of initial sway imperfection and local bow imperfections may be replaced by systems of equivalent horizontal forces, introduced for each column, see Figure 5.3 and Figure 5.4.

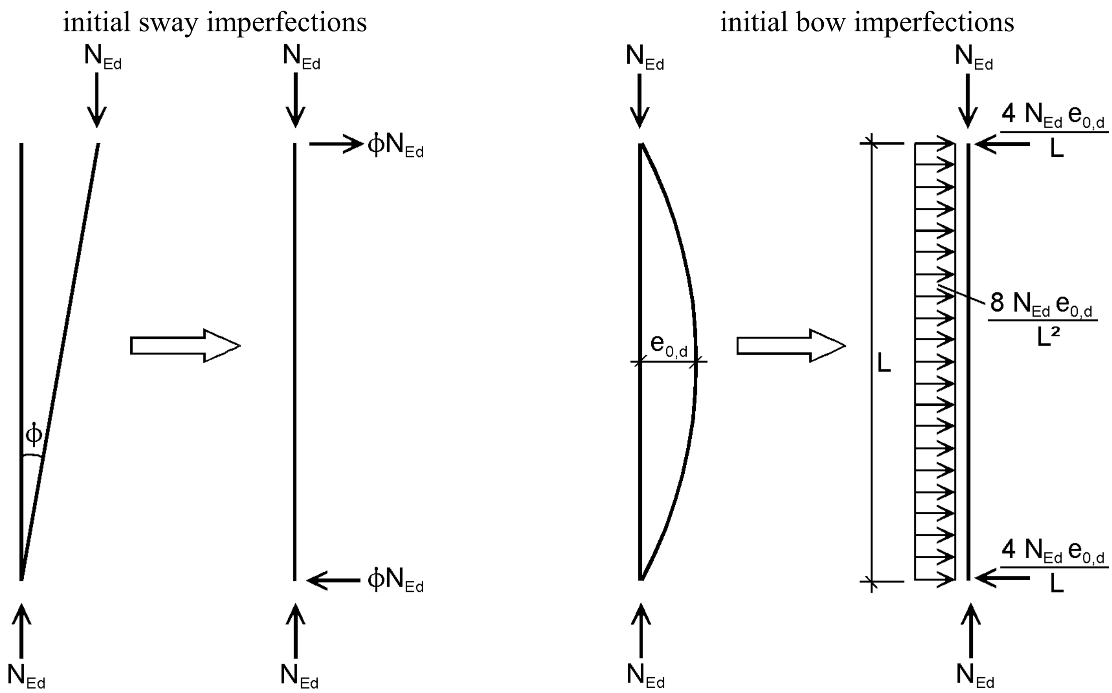
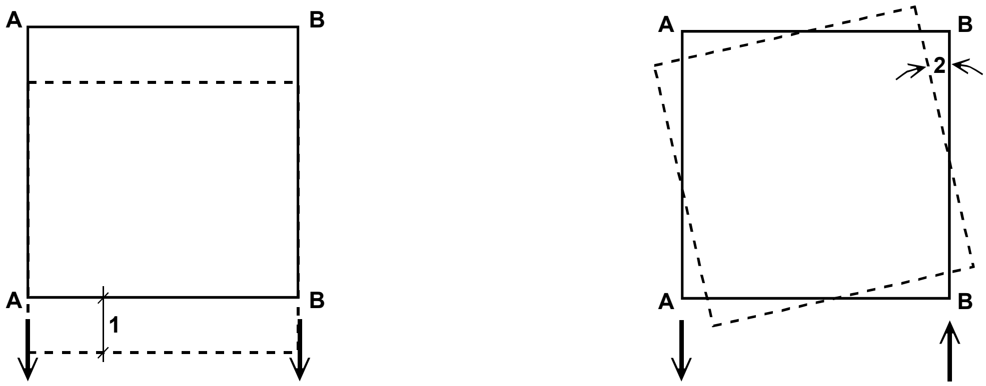


Figure 5.4: Replacement of initial imperfections by equivalent horizontal forces

(8) These initial sway imperfections should apply in all relevant horizontal directions, but need only be considered in one direction at a time.

(9)B Where, in multi-storey beam-and-column building frames, equivalent forces are used they should be applied at each floor and roof level.

(10) The possible torsional effects on a structure caused by anti-symmetric sways at the two opposite faces, should also be considered, see Figure 5.5.



(a) Faces A-A and B-B sway in same direction

(b) Faces A-A and B-B sway in opposite direction

1 translational sway
2 rotational sway

Figure 5.5: Translational and torsional effects (plan view)

(11) As an alternative to (3) and (6) the shape of the elastic critical buckling mode η_{cr} of the structure may be applied as a unique global and local imperfection. The amplitude of this imperfection may be determined from:

$$\eta_{init} = e_0 \frac{N_{cr}}{EI\,\eta''_{cr,\max}} \eta_{cr} = \frac{e_0}{\bar{\lambda}^2} \frac{N_{Rk}}{EI\,\eta''_{cr,\max}} \eta_{cr} \tag{5.9}$$

where:

$$e_0 = \alpha\left(\bar{\lambda} - 0{,}2\right) \frac{M_{Rk}}{N_{Rk}} \frac{1 - \dfrac{\chi\bar{\lambda}^2}{\gamma_{M1}}}{1 - \chi\bar{\lambda}^2} \quad \text{for } \bar{\lambda} > 0{,}2 \tag{5.10}$$

and $\bar{\lambda} = \sqrt{\dfrac{\alpha_{ult,k}}{\alpha_{cr}}}$ is the relative slenderness of the structure (5.11)

α is the imperfection factor for the relevant buckling curve, see Table 6.1 and Table 6.2;

χ is the reduction factor for the relevant buckling curve depending on the relevant cross-section, see 6.3.1;

$\alpha_{ult,k}$ is the minimum force amplifier for the axial force configuration N_{Ed} in members to reach the characteristic resistance N_{Rk} of the most axially stressed cross section without taking buckling into account

α_{cr} is the minimum force amplifier for the axial force configuration N_{Ed} in members to reach the elastic critical buckling

M_{Rk} is the characteristic moments resistance of the critical cross section, e.g. $M_{el,Rk}$ or $M_{pl,Rk}$ as relevant

N_{Rk} is the characteristic resistance to normal force of the critical cross section, i.e. $N_{pl,Rk}$

$EI\,\eta''_{cr,\max}$ is the bending moment due to η_{cr} at the critical cross section

η_{cr} is the shape of elastic critical buckling mode

NOTE 1 For calculating the amplifiers $\alpha_{ult,k}$ and α_{cr} the members of the structure may be considered to be loaded by axial forces N_{Ed} only that result from the first order elastic analysis of the structure for the design loads.

NOTE 2 The National Annex may give information for the scope of application of (11).

5.3.3 Imperfection for analysis of bracing systems

(1) In the analysis of bracing systems which are required to provide lateral stability within the length of beams or compression members the effects of imperfections should be included by means of an equivalent geometric imperfection of the members to be restrained, in the form of an initial bow imperfection:

$$e_0 = \alpha_m L / 500 \tag{5.12}$$

where L is the span of the bracing system

and $\alpha_m = \sqrt{0{,}5\left(1 + \dfrac{1}{m}\right)}$

in which m is the number of members to be restrained.

(2) For convenience, the effects of the initial bow imperfections of the members to be restrained by a bracing system, may be replaced by the equivalent stabilizing force as shown in Figure 5.6:

$$q_d = \sum N_{Ed}\, 8 \frac{e_0 + \delta_q}{L^2} \tag{5.13}$$

where δ_q is the inplane deflection of the bracing system due to q plus any external loads calculated from first order analysis

NOTE δ_q may be taken as 0 if second order theory is used.

(3) Where the bracing system is required to stabilize the compression flange of a beam of constant height, the force N_{Ed} in Figure 5.6 may be obtained from:

$$N_{Ed} = M_{Ed} / h \tag{5.14}$$

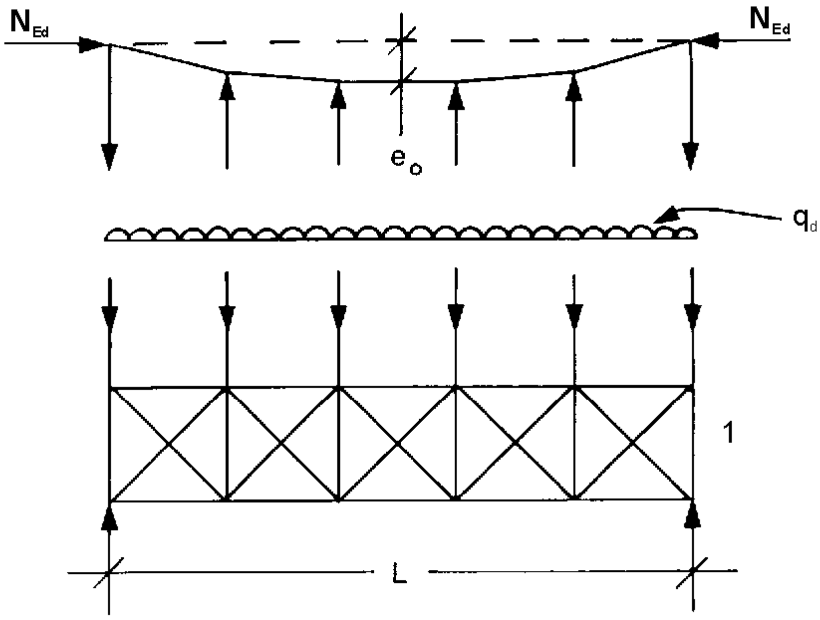
where M_{Ed} is the maximum moment in the beam

and h is the overall depth of the beam.

NOTE Where a beam is subjected to external compression N_{Ed} should include a part of the compression force.

(4) At points where beams or compression members are spliced, it should also be verified that the bracing system is able to resist a local force equal to $\alpha_m N_{Ed}$ / 100 applied to it by each beam or compression member which is spliced at that point, and to transmit this force to the adjacent points at which that beam or compression member is restrained, see Figure 5.7.

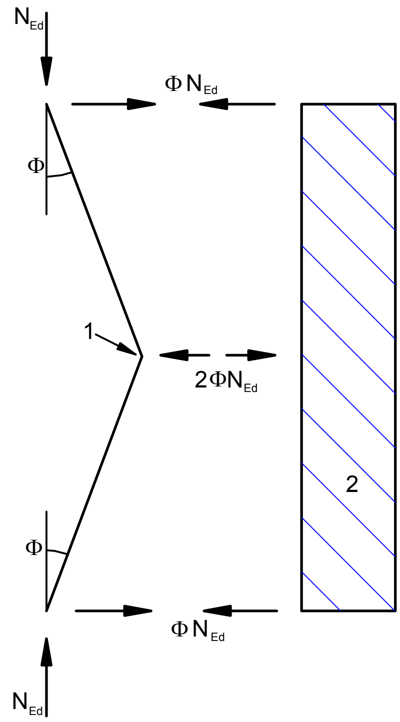
(5) For checking for the local force according to clause (4), any external loads acting on bracing systems should also be included, but the forces arising from the imperfection given in (1) may be omitted.



e_0 *imperfection*
q_d *equivalent force per unit length*
1 bracing system

The force N_{Ed} is assumed uniform within the span L of the bracing system. For non-uniform forces this is slightly conservative.

Figure 5.6: Equivalent stabilizing force



$\Phi = \alpha_m \Phi_0 \quad : \Phi_0 = 1 / 200$

$2\Phi N_{Ed} = \alpha_m N_{Ed} / 100$

1 splice
2 bracing system

Figure 5.7: Bracing forces at splices in compression elements

5.3.4 Member imperfections

(1) The effects of local bow imperfections of members are incorporated within the formulas given for buckling resistance for members, see section 6.3.

(2) Where the stability of members is accounted for by second order analysis according to 5.2.2(7)a) for compression members imperfections e_0 according to 5.3.2(3)b), 5.3.2(5) or 5.3.2(6) should be considered.

(3) For a second order analysis taking account of lateral torsional buckling of a member in bending the imperfections may be adopted as $ke_{0,d}$, where $e_{0,d}$ is the equivalent initial bow imperfection of the weak axis of the profile considered. In general an additional torsional imperfection need not to be allowed for.

NOTE The National Annex may choose the value of k. The value k = 0,5 is recommended.

5.4 Methods of analysis considering material non-linearities

5.4.1 General

(1) The internal forces and moments may be determined using either

a) elastic global analysis

b) plastic global analysis.

NOTE For finite element model (FEM) analysis see EN 1993-1-5.

(2) Elastic global analysis may be used in all cases.

(3) Plastic global analysis may be used only where the structure has sufficient rotation capacity at the actual locations of the plastic hinges, whether this is in the members or in the joints. Where a plastic hinge occurs in a member, the member cross sections should be double symmetric or single symmetric with a plane of symmetry in the same plane as the rotation of the plastic hinge and it should satisfy the requirements specified in 5.6. Where a plastic hinge occurs in a joint the joint should either have sufficient strength to ensure the hinge remains in the member or should be able to sustain the plastic resistance for a sufficient rotation, see EN 1993-1-8.

(4)B As a simplified method for a limited plastic redistribution of moments in continuous beams where following an elastic analysis some peak moments exceed the plastic bending resistance of 15 % maximum, the parts in excess of these peak moments may be redistributed in any member, provided, that:

a) the internal forces and moments in the frame remain in equilibrium with the applied loads, and

b) all the members in which the moments are reduced have Class 1 or Class 2 cross-sections (see 5.5), and

c) lateral torsional buckling of the members is prevented.

5.4.2 Elastic global analysis

(1) Elastic global analysis should be based on the assumption that the stress-strain behaviour of the material is linear, whatever the stress level is.

NOTE For the choice of a semi-continuous joint model see 5.1.2(2) to (4).

(2) Internal forces and moments may be calculated according to elastic global analysis even if the resistance of a cross section is based on its plastic resistance, see 6.2.

(3) Elastic global analysis may also be used for cross sections the resistances of which are limited by local buckling, see 6.2.

5.4.3 Plastic global analysis

(1) Plastic global analysis allows for the effects of material non-linearity in calculating the action effects of a structural system. The behaviour should be modelled by one of the following methods:

- by elastic-plastic analysis with plastified sections and/or joints as plastic hinges,
- by non-linear plastic analysis considering the partial plastification of members in plastic zones,
- by rigid plastic analysis neglecting the elastic behaviour between hinges.

(2) Plastic global analysis may be used where the members are capable of sufficient rotation capacity to enable the required redistributions of bending moments to develop, see 5.5 and 5.6.

(3) Plastic global analysis should only be used where the stability of members at plastic hinges can be assured, see 6.3.5.

(4) The bi-linear stress-strain relationship indicated in Figure 5.8 may be used for the grades of structural steel specified in section 3. Alternatively, a more precise relationship may be adopted, see EN 1993-1-5.

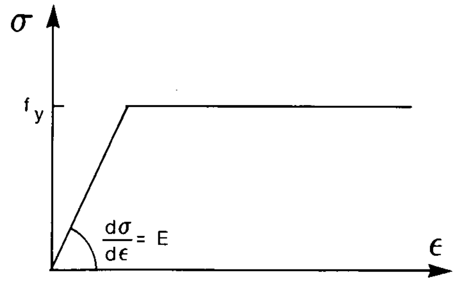


Figure 5.8: Bi-linear stress-strain relationship

(5) Rigid plastic analysis may be applied if no effects of the deformed geometry (e.g. second-order effects) have to be considered. In this case joints are classified only by strength, see EN 1993-1-8.

(6) The effects of deformed geometry of the structure and the structural stability of the frame should be verified according to the principles in 5.2.

NOTE The maximum resistance of a frame with significantly deformed geometry may occur before all hinges of the first order collapse mechanism have formed.

5.5 Classification of cross sections

5.5.1 Basis

(1) The role of cross section classification is to identify the extent to which the resistance and rotation capacity of cross sections is limited by its local buckling resistance.

5.5.2 Classification

(1) Four classes of cross-sections are defined, as follows:

- Class 1 cross-sections are those which can form a plastic hinge with the rotation capacity required from plastic analysis without reduction of the resistance.
- Class 2 cross-sections are those which can develop their plastic moment resistance, but have limited rotation capacity because of local buckling.
- Class 3 cross-sections are those in which the stress in the extreme compression fibre of the steel member assuming an elastic distribution of stresses can reach the yield strength, but local buckling is liable to prevent development of the plastic moment resistance.
- Class 4 cross-sections are those in which local buckling will occur before the attainment of yield stress in one or more parts of the cross-section.

(2) In Class 4 cross sections effective widths may be used to make the necessary allowances for reductions in resistance due to the effects of local buckling, see EN 1993-1-5, 5.2.2.

(3) The classification of a cross-section depends on the width to thickness ratio of the parts subject to compression.

(4) Compression parts include every part of a cross-section which is either totally or partially in compression under the load combination considered.

(5) The various compression parts in a cross-section (such as a web or flange) can, in general, be in different classes.

(6) A cross-section is classified according to the highest (least favourable) class of its compression parts. Exceptions are specified in 6.2.1(10) and 6.2.2.4(1).

(7) Alternatively the classification of a cross-section may be defined by quoting both the flange classification and the web classification.

(8) The limiting proportions for Class 1, 2, and 3 compression parts should be obtained from Table 5.2. A part which fails to satisfy the limits for Class 3 should be taken as Class 4.

(9) Except as given in (10) Class 4 sections may be treated as Class 3 sections if the width to thickness ratios are less than the limiting proportions for Class 3 obtained from Table 5.2 when ε is increased by $\sqrt{\frac{f_y / \gamma_{M0}}{\sigma_{com,Ed}}}$, where $\sigma_{com,Ed}$ is the maximum design compressive stress in the part taken from first order or where necessary second order analysis.

(10) However, when verifying the design buckling resistance of a member using section 6.3, the limiting proportions for Class 3 should always be obtained from Table 5.2.

(11) Cross-sections with a Class 3 web and Class 1 or 2 flanges may be classified as class 2 cross sections with an effective web in accordance with 6.2.2.4.

(12) Where the web is considered to resist shear forces only and is assumed not to contribute to the bending and normal force resistance of the cross section, the cross section may be designed as Class 2, 3 or 4 sections, depending only on the flange class.

NOTE For flange induced web buckling see EN 1993-1-5.

5.6 Cross-section requirements for plastic global analysis

(1) At plastic hinge locations, the cross-section of the member which contains the plastic hinge should have a rotation capacity of not less than the required at the plastic hinge location.

(2) In a uniform member sufficient rotation capacity may be assumed at a plastic hinge if both the following requirements are satisfied:

a) the member has Class 1 cross-sections at the plastic hinge location;

b) where a transverse force that exceeds 10 % of the shear resistance of the cross section, see 6.2.6, is applied to the web at the plastic hinge location, web stiffeners should be provided within a distance along the member of h/2 from the plastic hinge location, where h is the height of the cross section at this location.

(3) Where the cross-section of the member vary along their length, the following additional criteria should be satisfied:

a) Adjacent to plastic hinge locations, the thickness of the web should not be reduced for a distance each way along the member from the plastic hinge location of at least 2d, where d is the clear depth of the web at the plastic hinge location.

b) Adjacent to plastic hinge locations, the compression flange should be Class 1 for a distance each way along the member from the plastic hinge location of not less than the greater of:

- 2d, where d is as defined in (3)a)
- the distance to the adjacent point at which the moment in the member has fallen to 0,8 times the plastic moment resistance at the point concerned.

c) Elsewhere in the member the compression flange should be class 1 or class 2 and the web should be class 1, class 2 or class 3.

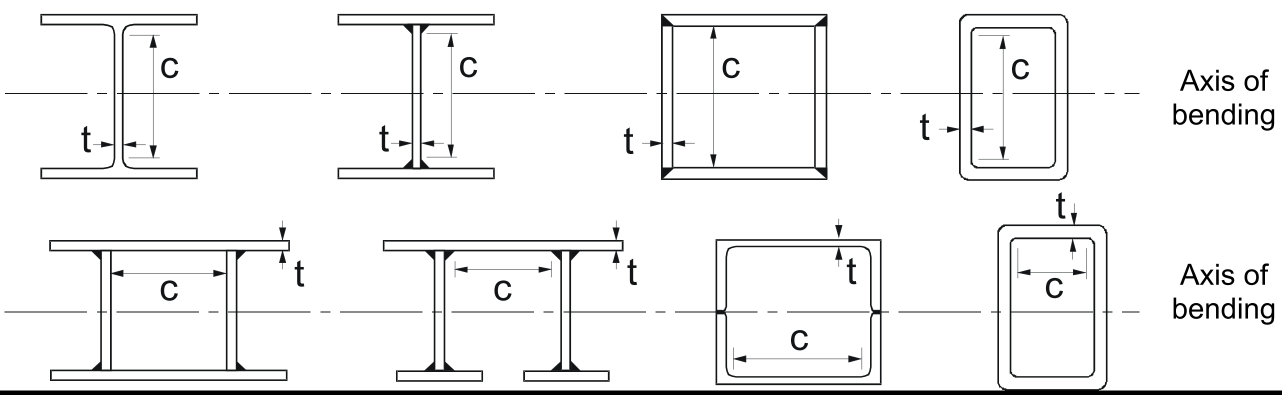
(4) Adjacent to plastic hinge locations, any fastener holes in tension should satisfy 6.2.5(4) for a distance such as defined in (3)b) each way along the member from the plastic hinge location.

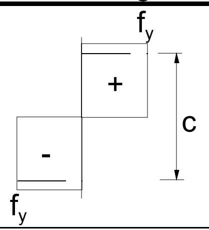
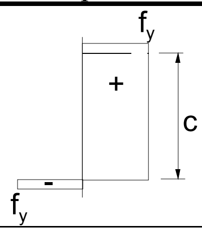
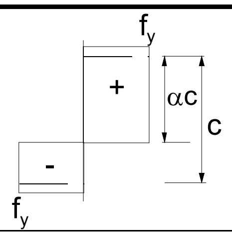
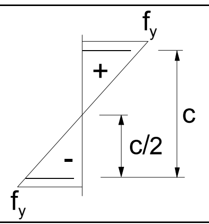
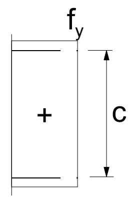
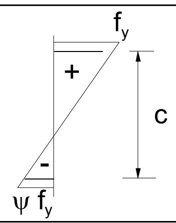
(5) For plastic design of a frame, regarding cross section requirements, the capacity of plastic redistribution of moments may be assumed sufficient if the requirements in (2) to (4) are satisfied for all members where plastic hinges exist, may occur or have occurred under design loads.

(6) In cases where methods of plastic global analysis are used which consider the real stress and strain behaviour along the member including the combined effect of local, member and global buckling the requirements (2) to (5) need not be applied.

Table 5.2 (sheet 1 of 3): Maximum width-to-thickness ratios for compression parts

Internal compression parts



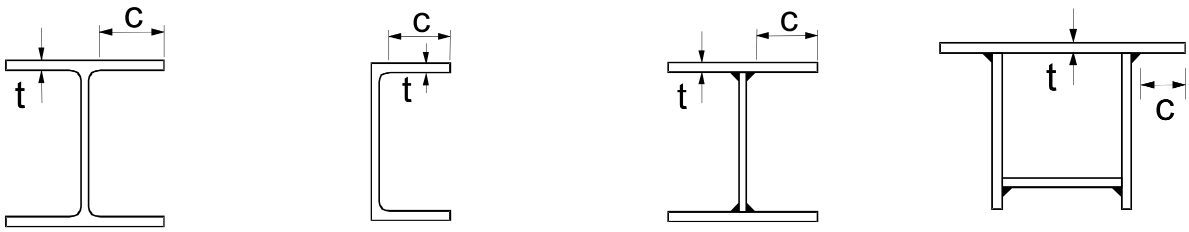
Class	Part subject to bending	Part subject to compression	Part subject to bending and compression
Stress distribution in parts (compression positive)			
1	$c/t \le 72\varepsilon$	$c/t \le 33\varepsilon$	when $\alpha > 0{,}5$: $c/t \le \dfrac{396\varepsilon}{13\alpha - 1}$ when $\alpha \le 0{,}5$: $c/t \le \dfrac{36\varepsilon}{\alpha}$
2	$c/t \le 83\varepsilon$	$c/t \le 38\varepsilon$	when $\alpha > 0{,}5$: $c/t \le \dfrac{456\varepsilon}{13\alpha - 1}$ when $\alpha \le 0{,}5$: $c/t \le \dfrac{41{,}5\varepsilon}{\alpha}$
Stress distribution in parts (compression positive)			
3	$c/t \le 124\varepsilon$	$c/t \le 42\varepsilon$	when $\psi > -1$: $c/t \le \dfrac{42\varepsilon}{0{,}67 + 0{,}33\psi}$ when $\psi \le -1^{*)}$: $c/t \le 62\varepsilon(1-\psi)\sqrt{(-\psi)}$

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

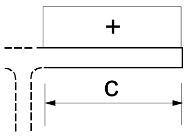
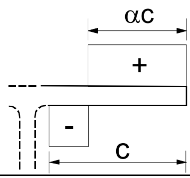
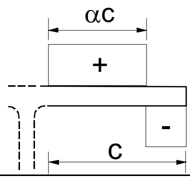
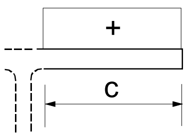
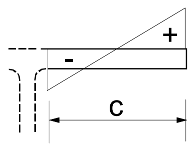
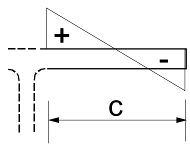
*) $\psi \le -1$ applies where either the compression stress $\sigma \le f_y$ or the tensile strain $\varepsilon_y > f_y/E$

Table 5.2 (sheet 2 of 3): Maximum width-to-thickness ratios for compression parts

Outstand flanges



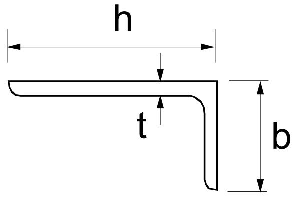
Rolled sections   Welded sections

Class	Part subject to compression	Part subject to bending and compression: Tip in compression	Part subject to bending and compression: Tip in tension
Stress distribution in parts (compression positive)			
1	$c/t \le 9\varepsilon$	$c/t \le \dfrac{9\varepsilon}{\alpha}$	$c/t \le \dfrac{9\varepsilon}{\alpha\sqrt{\alpha}}$
2	$c/t \le 10\varepsilon$	$c/t \le \dfrac{10\varepsilon}{\alpha}$	$c/t \le \dfrac{10\varepsilon}{\alpha\sqrt{\alpha}}$
Stress distribution in parts (compression positive)			
3	$c/t \le 14\varepsilon$	$c/t \le 21\varepsilon\sqrt{k_\sigma}$ For k_σ see EN 1993-1-5	

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

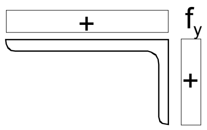
Table 5.2 (sheet 3 of 3): Maximum width-to-thickness ratios for compression parts

Angles

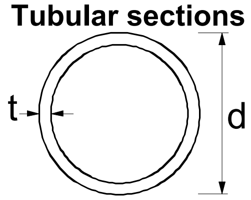


Refer also to “Outstand flanges” (see sheet 2 of 3)

Does not apply to angles in continuous contact with other components

Class	Section in compression
Stress distribution across section (compression positive)	
3	$h/t \le 15\varepsilon : \frac{b+h}{2t} \le 11,5\varepsilon$

Tubular sections



Class	Section in bending and/or compression
1	$d/t \le 50\varepsilon^2$
2	$d/t \le 70\varepsilon^2$
3	$d/t \le 90\varepsilon^2$ **NOTE** For $d/t > 90\varepsilon^2$ see EN 1993-1-6.

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71
	ε^2	1,00	0,85	0,66	0,56	0,51

6 Ultimate limit states

6.1 General

(1) The partial factors γ_M as defined in 2.4.3 should be applied to the various characteristic values of resistance in this section as follows:

- resistance of cross-sections whatever the class is: γ_{M0}
- resistance of members to instability assessed by member checks: γ_{M1}
- resistance of cross-sections in tension to fracture: γ_{M2}
- resistance of joints: see EN 1993-1-8

NOTE 1 For other recommended numerical values see EN 1993 Part 2 to Part 6. For structures not covered by EN 1993 Part 2 to Part 6 the National Annex may define the partial factors γ_{Mi}; it is recommended to take the partial factors γ_{Mi} from EN 1993-2.

NOTE 2B Partial factors γ_{Mi} for buildings may be defined in the National Annex. The following numerical values are recommended for buildings:

$\gamma_{M0} = 1,00$

$\gamma_{M1} = 1,00$

$\gamma_{M2} = 1,25$

6.2 Resistance of cross-sections

6.2.1 General

AC1 (1)P The design value of an action effect in each cross section shall not exceed the corresponding design resistance and if several action effects act simultaneously the combined effect shall not exceed the resistance for that combination. AC1

(2) Shear lag effects and local buckling effects should be included by an effective width according to EN 1993-1-5. Shear buckling effects should also be considered according to EN 1993-1-5.

(3) The design values of resistance should depend on the classification of the cross-section.

(4) Elastic verification according to the elastic resistance may be carried out for all cross sectional classes provided the effective cross sectional properties are used for the verification of class 4 cross sections.

(5) For the elastic verification the following yield criterion for a critical point of the cross section may be used unless other interaction formulae apply, see 6.2.8 to 6.2.10.

$$\left(\frac{\sigma_{x,Ed}}{f_y/\gamma_{M0}}\right)^2+\left(\frac{\sigma_{z,Ed}}{f_y/\gamma_{M0}}\right)^2-\left(\frac{\sigma_{x,Ed}}{f_y/\gamma_{M0}}\right)\left(\frac{\sigma_{z,Ed}}{f_y/\gamma_{M0}}\right)+3\left(\frac{\tau_{Ed}}{f_y/\gamma_{M0}}\right)^2\leq 1 \qquad (6.1)$$

where $\sigma_{x,Ed}$ is the design value of the local longitudinal stress at the point of consideration

$\sigma_{z,Ed}$ is the design value of the local transverse stress at the point of consideration

τ_{Ed} is the design value of the local shear stress at the point of consideration

NOTE The verification according to (5) can be conservative as it excludes partial plastic stress distribution, which is permitted in elastic design. Therefore it should only be performed where the interaction of on the basis of resistances N_{Rd} , M_{Rd} , V_{Rd} cannot be performed.

(6) The plastic resistance of cross sections should be verified by finding a stress distribution which is in equilibrium with the internal forces and moments without exceeding the yield strength. This stress distribution should be compatible with the associated plastic deformations.

(7) As a conservative approximation for all cross section classes a linear summation of the utilization ratios for each stress resultant may be used. For class 1, class 2 or class 3 cross sections subjected to the combination of N_{Ed} , $M_{y,Ed}$ and $M_{z,Ed}$ this method may be applied by using the following criteria:

$$\frac{N_{Ed}}{N_{Rd}} + \frac{M_{y,Ed}}{M_{y,Rd}} + \frac{M_{z,Ed}}{M_{z,Rd}} \leq 1 \qquad (6.2)$$

where N_{Rd} , $M_{y,Rd}$ and $M_{z,Rd}$ are the design values of the resistance depending on the cross sectional classification and including any reduction that may be caused by shear effects, see 6.2.8.

NOTE For class 4 cross sections see 6.2.9.3(2).

(8) Where all the compression parts of a cross-section are at least Class 2, the cross-section may be taken as capable of developing its full plastic resistance in bending.

(9) Where all the compression parts of a cross-section are Class 3, its resistance should be based on an elastic distribution of strains across the cross-section. Compressive stresses should be limited to the yield strength at the extreme fibres.

NOTE The extreme fibres may be assumed at the midplane of the flanges for ULS checks. For fatigue see EN 1993-1-9.

(10) Where yielding first occurs on the tension side of the cross section, the plastic reserves of the tension zone may be utilized by accounting for partial plastification when determining the resistance of a Class 3 cross-section.

6.2.2 Section properties

6.2.2.1 Gross cross-section

(1) The properties of the gross cross-section should be determined using the nominal dimensions. Holes for fasteners need not be deducted, but allowance should be made for larger openings. Splice materials should not be included.

6.2.2.2 Net area

(1) The net area of a cross-section should be taken as its gross area less appropriate deductions for all holes and other openings.

(2) For calculating net section properties, the deduction for a single fastener hole should be the gross cross-sectional area of the hole in the plane of its axis. For countersunk holes, appropriate allowance should be made for the countersunk portion.

(3) Provided that the fastener holes are not staggered, the total area to be deducted for fastener holes should be the maximum sum of the sectional areas of the holes in any cross-section perpendicular to the member axis (see failure plane ② in Figure 6.1).

NOTE The maximum sum denotes the position of the critical fracture line.

(4) Where the fastener holes are staggered, the total area to be deducted for fasteners should be the greater of:

a) the deduction for non-staggered holes given in (3)

b) $$t\left(nd_0 - \sum \frac{s^2}{4p}\right) \tag{6.3}$$

where s is the staggered pitch, the spacing of the centres of two consecutive holes in the chain measured parallel to the member axis;

p is the spacing of the centres of the same two holes measured perpendicular to the member axis;

t is the thickness;

n is the number of holes extending in any diagonal or zig-zag line progressively across the member or part of the member, see Figure 6.1.

d_0 is the diameter of hole

(5) In an angle or other member with holes in more then one plane, the spacing p should be measured along the centre of thickness of the material (see Figure 6.2).

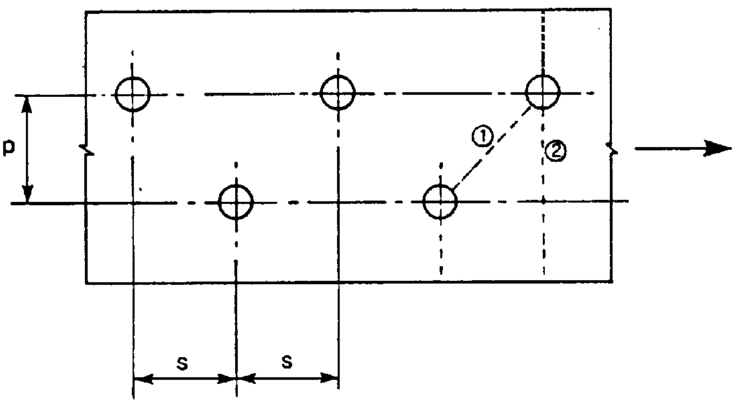


Figure 6.1: Staggered holes and critical fracture lines 1 and 2

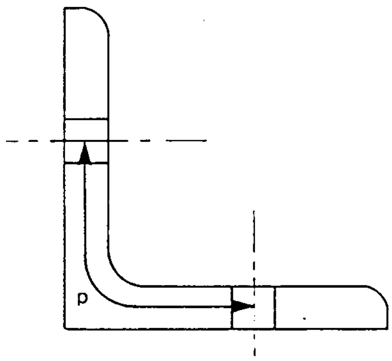


Figure 6.2: Angles with holes in both legs

6.2.2.3 Shear lag effects

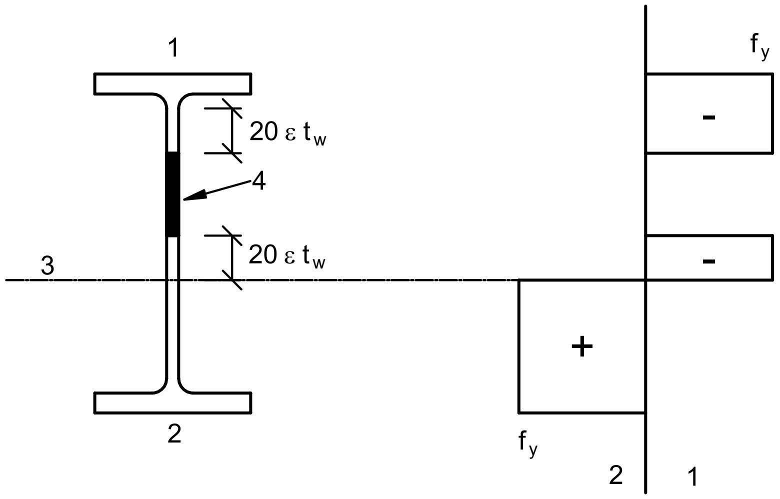
(1) The calculation of the effective widths is covered in EN 1993-1-5.

(2) In class 4 sections the interaction between shear lag and local buckling should be considered according to EN 1993-1-5.

NOTE For cold formed thin gauge members see EN 1993-1-3.

6.2.2.4 Effective properties of cross sections with class 3 webs and class 1 or 2 flanges

(1) Where cross-sections with a class 3 web and class 1 or 2 flanges are classified as effective Class 2 cross-sections, see 5.5.2(11), the proportion of the web in compression should be replaced by a part of $20\varepsilon t_w$ adjacent to the compression flange, with another part of $20\varepsilon t_w$ adjacent to the plastic neutral axis of the effective cross-section in accordance with Figure 6.3.



1 compression
2 tension
3 plastic neutral axis
4 neglect

Figure 6.3: Effective class 2 web

6.2.2.5 Effective cross-section properties of Class 4 cross-sections

(1) The effective cross-section properties of Class 4 cross-sections should be based on the effective widths of the compression parts.

(2) For cold formed thin walled sections see 1.1.2(1) and EN 1993-1-3.

(3) The effective widths of planar compression parts should be obtained from EN 1993-1-5.

(4) Where a class 4 cross section is subjected to an axial compression force, the method given in EN 1993-1-5 should be used to determine the possible shift e_N of the centroid of the effective area A_{eff} relative to the centre of gravity of the gross cross section and the resulting additional moment:

$$\Delta M_{Ed} = N_{Ed} e_N \tag{6.4}$$

NOTE The sign of the additional moment depends on the effect in the combination of internal forces and moments, see 6.2.9.3(2).

(5) For circular hollow sections with class 4 cross sections see EN 1993-1-6.

6.2.3 Tension

AC1 (1)P The design value of the tension force N_{Ed} at each cross section shall satisfy: AC1

$$\frac{N_{Ed}}{N_{t,Rd}} \leq 1{,}0 \quad (6.5)$$

(2) For sections with holes the design tension resistance $N_{t,Rd}$ should be taken as the smaller of:

a) the design plastic resistance of the gross cross-section

$$N_{pl,Rd} = \frac{A\,f_y}{\gamma_{M0}} \quad (6.6)$$

b) the design ultimate resistance of the net cross-section at holes for fasteners

$$N_{u,Rd} = \frac{0{,}9 A_{net}\, f_u}{\gamma_{M2}} \quad (6.7)$$

(3) Where capacity design is requested, see EN 1998, the design plastic resistance $N_{pl,Rd}$ (as given in 6.2.3(2) a)) should be less than the design ultimate resistance of the net section at fasteners holes $N_{u,Rd}$ (as given in 6.2.3(2) b)).

(4) In category C connections (see EN 1993-1-8, 3.4.2(1), the design tension resistance $N_{t,Rd}$ in 6.2.3(1) of the net section at holes for fasteners should be taken as $N_{net,Rd}$, where:

$$N_{net,Rd} = \frac{A_{net}\, f_y}{\gamma_{M0}} \quad (6.8)$$

(5) For angles connected through one leg, see also EN 1993-1-8, 3.6.3. Similar consideration should also be given to other type of sections connected through outstands.

6.2.4 Compression

AC1 (1)P The design value of the compression force N_{Ed} at each cross-section shall satisfy: AC1

$$\frac{N_{Ed}}{N_{c,Rd}} \leq 1{,}0 \quad (6.9)$$

(2) The design resistance of the cross-section for uniform compression $N_{c,Rd}$ should be determined as follows:

$$N_{c,Rd} = \frac{A\,f_y}{\gamma_{M0}} \quad \text{for class 1, 2 or 3 cross-sections} \quad (6.10)$$

$$N_{c,Rd} = \frac{A_{eff}\, f_y}{\gamma_{M0}} \quad \text{for class 4 cross-sections} \quad (6.11)$$

(3) Fastener holes except for oversize and slotted holes as defined in EN 1090 need not be allowed for in compression members, provided that they are filled by fasteners.

(4) In the case of unsymmetrical Class 4 sections, the method given in 6.2.9.3 should be used to allow for the additional moment ΔM_{Ed} due to the eccentricity of the centroidal axis of the effective section, see 6.2.2.5(4).

6.2.5 Bending moment

AC1 (1)P The design value of the bending moment M_{Ed} at each cross-section shall satisfy: AC1

$$\frac{M_{Ed}}{M_{c,Rd}} \leq 1{,}0 \qquad (6.12)$$

where $M_{c,Rd}$ is determined considering fastener holes, see (4) to (6).

(2) The design resistance for bending about one principal axis of a cross-section is determined as follows:

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl}\ f_y}{\gamma_{M0}} \quad \text{for class 1 or 2 cross sections} \qquad (6.13)$$

$$M_{c,Rd} = M_{el,Rd} = \frac{W_{el,min}\ f_y}{\gamma_{M0}} \quad \text{for class 3 cross sections} \qquad (6.14)$$

$$M_{c,Rd} = \frac{W_{eff,min}\ f_y}{\gamma_{M0}} \quad \text{for class 4 cross sections} \qquad (6.15)$$

where $W_{el,min}$ and $W_{eff,min}$ corresponds to the fibre with the maximum elastic stress.

(3) For bending about both axes, the methods given in 6.2.9 should be used.

(4) Fastener holes in the tension flange may be ignored provided that for the tension flange:

$$\frac{A_{f,net}\, 0{,}9\ f_u}{\gamma_{M2}} \geq \frac{A_f\ f_y}{\gamma_{M0}} \qquad (6.16)$$

where A_f is the area of the tension flange.

NOTE The criterion in (4) provides capacity design (see 1.5.8) in the region of plastic hinges.

(5) Fastener holes in tension zone of the web need not be allowed for, provided that the limit given in (4) is satisfied for the complete tension zone comprising the tension flange plus the tension zone of the web.

(6) Fastener holes except for oversize and slotted holes in compression zone of the cross-section need not be allowed for, provided that they are filled by fasteners.

6.2.6 Shear

AC1 (1)P The design value of the shear force V_{Ed} at each cross section shall satisfy: AC1

$$\frac{V_{Ed}}{V_{c,Rd}} \leq 1{,}0 \qquad (6.17)$$

where $V_{c,Rd}$ is the design shear resistance. For plastic design $V_{c,Rd}$ is the design plastic shear resistance $V_{pl,Rd}$ as given in (2). For elastic design $V_{c,Rd}$ is the design elastic shear resistance calculated using (4) and (5).

(2) In the absence of torsion the design plastic shear resistance is given by:

$$V_{pl,Rd} = \frac{A_v\left(f_y / \sqrt{3}\right)}{\gamma_{M0}} \qquad (6.18)$$

where A_v is the shear area.

(3) The shear area A_v may be taken as follows:

a) rolled I and H sections, load parallel to web $A - 2bt_f + (t_w + 2r)\, t_f$ but not less than $\eta h_w t_w$

b) rolled channel sections, load parallel to web $A - 2bt_f + (t_w + r)\, t_f$

c) rolled T-section, load parallel to web $0{,}9\,(A - bt_f)$

d) welded I, H and box sections, load parallel to web $\eta \sum (h_w t_w)$

e) welded I, H, channel and box sections, load parallel to flanges $A - \sum (h_w t_w)$

f) rolled rectangular hollow sections of uniform thickness:

load parallel to depth $Ah/(b+h)$

load parallel to width $Ab/(b+h)$

g) circular hollow sections and tubes of uniform thickness $2A/\pi$

where A is the crosssectional area;

b is the overall breadth;

h is the overall depth;

h_w is the depth of the web;

r is the root radius;

t_f is the flange thickness;

t_w is the web thickness (If the web thickness in not constant, t_w should be taken as the minimum thickness.).

η see EN 1993-1-5.

NOTE η may be conservatively taken equal 1,0.

(4) For verifying the design elastic shear resistance $V_{c,Rd}$ the following criterion for a critical point of the cross section may be used unless the buckling verification in section 5 of EN 1993-1-5 applies:

$$\frac{\tau_{Ed}}{f_y / \left(\sqrt{3}\,\gamma_{M0}\right)} \leq 1{,}0 \tag{6.19}$$

where τ_{Ed} may be obtained from: $\tau_{Ed} = \dfrac{V_{Ed}\, S}{I\, t}$ (6.20)

where V_{Ed} is the design value of the shear force

S is the first moment of area about the centroidal axis of that portion of the cross-section between the point at which the shear is required and the boundary of the cross-section

I is second moment of area of the whole cross section

t is the thickness at the examined point

NOTE The verification according to (4) is conservative as it excludes partial plastic shear distribution, which is permitted in elastic design, see (5). Therefore it should only be carried out where the verification on the basis of $V_{c,Rd}$ according to equation (6.17) cannot be performed.

(5) For I- or H-sections the shear stress in the web may be taken as:

$$\tau_{Ed} = \frac{V_{Ed}}{A_w} \quad \text{if } A_f / A_w \geq 0{,}6 \tag{6.21}$$

where A_f is the area of one flange;

A_w is the area of the web: $A_w = h_w t_w$.

(6) In addition the shear buckling resistance for webs without intermediate stiffeners should be according to section 5 of EN 1993-1-5, if

$$\frac{h_w}{t_w} > 72 \frac{\varepsilon}{\eta} \tag{6.22}$$

For η see section 5 of EN 1993-1-5.

NOTE η may be conservatively taken equal to 1,0.

(7) Fastener holes need not be allowed for in the shear verification except in verifying the design shear resistance at connection zones as given in EN 1993-1-8.

(8) Where the shear force is combined with a torsional moment, the plastic shear resistance $V_{pl,Rd}$ should be reduced as specified in 6.2.7(9).

6.2.7 Torsion

(1) For members subject to torsion for which distortional deformations may be disregarded the design value of the torsional moment T_{Ed} at each cross-section should satisfy:

$$\frac{T_{Ed}}{T_{Rd}} \leq 1{,}0 \tag{6.23}$$

where T_{Rd} is the design torsional resistance of the cross section.

(2) The total torsional moment T_{Ed} at any cross- section should be considered as the sum of two internal effects:

$$T_{Ed} = T_{t,Ed} + T_{w,Ed} \tag{6.24}$$

where $T_{t,Ed}$ is the internal St. Venant torsion;

$T_{w,Ed}$ is the internal warping torsion.

(3) The values of $T_{t,Ed}$ and $T_{w,Ed}$ at any cross-section may be determined from T_{Ed} by elastic analysis, taking account of the section properties of the member, the conditions of restraint at the supports and the distribution of the actions along the member.

(4) The following stresses due to torsion should be taken into account:

- the shear stresses $\tau_{t,Ed}$ due to St. Venant torsion $T_{t,Ed}$
- the direct stresses $\sigma_{w,Ed}$ due to the bimoment B_{Ed} and shear stresses $\tau_{w,Ed}$ due to warping torsion $T_{w,Ed}$

(5) For the elastic verification the yield criterion in 6.2.1(5) may be applied.

(6) For determining the plastic moment resistance of a cross section due to bending and torsion only torsion effects B_{Ed} should be derived from elastic analysis, see (3).

(7) As a simplification, in the case of a member with a closed hollow cross-section, such as a structural hollow section, it may be assumed that the effects of torsional warping can be neglected. Also as a simplification, in the case of a member with open cross section, such as I or H, it may be assumed that the effects of St. Venant torsion can be neglected.

(8) For the calculation of the resistance T_{Rd} of closed hollow sections the design shear strength of the individual parts of the cross section according to EN 1993-1-5 should be taken into account.

(9) For combined shear force and torsional moment the plastic shear resistance accounting for torsional effects should be reduced from $V_{pl,Rd}$ to $V_{pl,T,Rd}$ and the design shear force should satisfy:

$$\frac{V_{Ed}}{V_{pl,T,Rd}} \leq 1,0 \qquad (6.25)$$

in which $V_{pl,T,Rd}$ may be derived as follows:

– for an I or H section:

$$V_{pl,T,Rd} = \sqrt{1 - \frac{\tau_{t,Ed}}{1,25\left(f_y/\sqrt{3}\right)/\gamma_{M0}}}\; V_{pl,Rd} \qquad (6.26)$$

– for a channel section:

$$V_{pl,T,Rd} = \left[\sqrt{1 - \frac{\tau_{t,Ed}}{1,25\left(f_y/\sqrt{3}\right)/\gamma_{M0}}} - \frac{\tau_{w,Ed}}{\left(f_y/\sqrt{3}\right)/\gamma_{M0}}\right] V_{pl,Rd} \qquad (6.27)$$

– for a structural hollow section:

$$V_{pl,T,Rd} = \left[1 - \frac{\tau_{t,Ed}}{\left(f_y/\sqrt{3}\right)/\gamma_{M0}}\right] V_{pl,Rd} \qquad (6.28)$$

where $V_{pl,Rd}$ is given in 6.2.6.

6.2.8 Bending and shear

(1) Where the shear force is present allowance should be made for its effect on the moment resistance.

(2) Where the shear force is less than half the plastic shear resistance its effect on the moment resistance may be neglected except where shear buckling reduces the section resistance, see EN 1993-1-5.

(3) Otherwise the reduced moment resistance should be taken as the design resistance of the cross-section, calculated using a reduced yield strength

$$(1 - \rho)\, f_y \qquad (6.29)$$

for the shear area,

where $\rho = \left(\frac{2\,V_{Ed}}{V_{pl,Rd}} - 1\right)^2$ and $V_{pl,Rd}$ is obtained from 6.2.6(2).

NOTE See also 6.2.10(3).

(4) When torsion is present ρ should be obtained from $\rho = \left(\frac{2\,V_{Ed}}{V_{pl,T,Rd}} - 1\right)^2$, see 6.2.7, but should be taken as 0 for $V_{Ed} \leq 0,5V_{pl,T,Rd}$.

(5) The reduced design plastic resistance moment allowing for the shear force may alternatively be obtained for I-cross-sections with equal flanges and bending about the major axis as follows:

$$M_{y,V,Rd} = \frac{\left[W_{pl,y} - \frac{\rho A_w^{\ 2}}{4 t_w}\right] f_y}{\gamma_{M0}} \quad \text{but } M_{y,V,Rd} \leq M_{y,c,Rd} \tag{6.30}$$

where $M_{y,c,Rd}$ is obtained from 6.2.5(2)

and $A_w = h_w\, t_w$

(6) For the interaction of bending, shear and transverse loads see section 7 of EN 1993-1-5.

6.2.9 Bending and axial force

6.2.9.1 Class 1 and 2 cross-sections

(1) Where an axial force is present, allowance should be made for its effect on the plastic moment resistance.

AC1 (2)P For class 1 and 2 cross sections, the following criterion shall be satisfied: AC1

$$M_{Ed} \leq M_{N,Rd} \tag{6.31}$$

where $M_{N,Rd}$ is the design plastic moment resistance reduced due to the axial force N_{Ed}.

(3) For a rectangular solid section without fastener holes $M_{N,Rd}$ should be taken as:

$$M_{N,Rd} = M_{pl,Rd}\left[1 - \left(N_{Ed} / N_{pl,Rd}\right)^2\right] \tag{6.32}$$

(4) For doubly symmetrical I- and H-sections or other flanges sections, allowance need not be made for the effect of the axial force on the plastic resistance moment about the y-y axis when both the following criteria are satisfied:

$$N_{Ed} \leq 0{,}25\, N_{pl,Rd} \text{ and} \tag{6.33}$$

$$N_{Ed} \leq \frac{0{,}5\, h_w\, t_w\, f_y}{\gamma_{M0}} \tag{6.34}$$

For doubly symmetrical I- and H-sections, allowance need not be made for the effect of the axial force on the plastic resistance moment about the z-z axis when:

$$N_{Ed} \leq \frac{h_w\, t_w\, f_y}{\gamma_{M0}} \tag{6.35}$$

(5) For cross-sections where fastener holes are not to be accounted for, the following approximations may be used for standard rolled I or H sections and for welded I or H sections with equal flanges:

$$M_{N,y,Rd} = M_{pl,y,Rd}\,(1\text{-}n)/(1\text{-}0{,}5a) \quad \text{but } M_{N,y,Rd} \leq M_{pl,y,Rd} \tag{6.36}$$

$$\text{for } n \leq a: \quad M_{N,z,Rd} = M_{pl,z,Rd} \tag{6.37}$$

$$\text{for } n > a: \quad M_{N,z,Rd} = M_{pl,z,Rd}\left[1 - \left(\frac{n-a}{1-a}\right)^2\right] \tag{6.38}$$

where $n = N_{Ed} / N_{pl.Rd}$

$a = (A\text{-}2bt_f)/A$ but $a \leq 0{,}5$

For cross-sections where fastener holes are not to be accounted for, the following approximations may be used for rectangular structural hollow sections of uniform thickness and for welded box sections with equal flanges and equal webs:

$$M_{N,y,Rd} = M_{pl,y,Rd}\,(1 - n)/(1 - 0{,}5a_w) \quad \text{but } M_{N,y,Rd} \leq M_{pl,y.Rd} \tag{6.39}$$

$$M_{N,z,Rd} = M_{pl,z,Rd}\,(1 - n)/(1 - 0{,}5a_f) \quad \text{but } M_{N,z,Rd} \leq M_{pl,z,Rd} \tag{6.40}$$

where $a_w = (A - 2bt)/A$ but $a_w \leq 0{,}5$ for hollow sections

$a_w = (A-2bt_f)/A$ but $a_w \leq 0{,}5$ for welded box sections

$a_f = (A - 2ht)/A$ but $a_f \leq 0{,}5$ for hollow sections

$a_f = (A-2ht_w)/A$ but $a_f \leq 0{,}5$ for welded box sections

(6) For bi-axial bending the following criterion may be used:

$$\left[\frac{M_{y,Ed}}{M_{N,y,Rd}}\right]^{\alpha} + \left[\frac{M_{z,Ed}}{M_{N,z,Rd}}\right]^{\beta} \leq 1 \tag{6.41}$$

in which α and β are constants, which may conservatively be taken as unity, otherwise as follows:

– I and H sections:

$$\alpha = 2\ ;\ \beta = 5n \quad \text{but } \beta \geq 1$$

– circular hollow sections:

$$\alpha = 2\ ;\ \beta = 2$$

– rectangular hollow sections:

$$\alpha = \beta = \frac{1{,}66}{1 - 1{,}13\,n^2} \qquad \text{but } \alpha = \beta \leq 6$$

where $n = N_{Ed} / N_{pl,Rd}$.

6.2.9.2 Class 3 cross-sections

AC1 (1)P In the absence of shear force, for Class 3 cross-sections the maximum longitudinal stress shall satisfy the criterion: AC1

$$\sigma_{x,Ed} \leq \frac{f_y}{\gamma_{M0}} \tag{6.42}$$

where $\sigma_{x,Ed}$ is the design value of the local longitudinal stress due to moment and axial force taking account of fastener holes where relevant, see 6.2.3, 6.2.4 and 6.2.5

6.2.9.3 Class 4 cross-sections

AC1 (1)P In the absence of shear force, for Class 4 cross-sections the maximum longitudinal stress $\sigma_{x,Ed}$ calculated using the effective cross sections (see 5.5.2(2)) shall satisfy the criterion: AC1

$$\sigma_{x,Ed} \leq \frac{f_y}{\gamma_{M0}} \tag{6.43}$$

where $\sigma_{x,Ed}$ is the design value of the local longitudinal stress due to moment and axial force taking account of fastener holes where relevant, see 6.2.3, 6.2.4 and 6.2.5

(2) The following criterion should be met:

$$\frac{N_{Ed}}{A_{eff}\, f_y / \gamma_{M0}} + \frac{M_{y,Ed} + N_{Ed}\, e_{Ny}}{W_{eff,y,min}\, f_y / \gamma_{M0}} + \frac{M_{z,Ed} + N_{Ed}\, e_{Nz}}{W_{eff,z,min}\, f_y / \gamma_{M0}} \le 1 \qquad (6.44)$$

where A_{eff} is the effective area of the cross-section when subjected to uniform compression

$W_{eff,min}$ is the effective section modulus (corresponding to the fibre with the maximum elastic stress) of the cross-section when subjected only to moment about the relevant axis

e_N is the shift of the relevant centroidal axis when the cross-section is subjected to compression only, see 6.2.2.5(4)

NOTE The signs of N_{Ed} , $M_{y,Ed}$, $M_{z,Ed}$ and $\Delta M_i = N_{Ed}\, e_{Ni}$ depend on the combination of the respective direct stresses.

6.2.10 Bending, shear and axial force

(1) Where shear and axial force are present, allowance should be made for the effect of both shear force and axial force on the resistance moment.

(2) Provided that the design value of the shear force V_{Ed} does not exceed 50% of the design plastic shear resistance $V_{pl.Rd}$ no reduction of the resistances defined for bending and axial force in 6.2.9 need be made, except where shear buckling reduces the section resistance, see EN 1993-1-5.

(3) Where V_{Ed} exceeds 50% of $V_{pl.Rd}$ the design resistance of the cross-section to combinations of moment and axial force should be calculated using a reduced yield strength

$$(1-\rho)f_y \qquad (6.45)$$

for the shear area

where $\rho = (2V_{Ed} / V_{pl.Rd} - 1)^2$ and $V_{pl,Rd}$ is obtained from 6.2.6(2).

NOTE Instead of reducing the yield strength also the plate thickness of the relevant part of the cross section may be reduced.

6.3 Buckling resistance of members

6.3.1 Uniform members in compression

6.3.1.1 Buckling resistance

(1) A compression member should be verified against buckling as follows:

$$\frac{N_{Ed}}{N_{b,Rd}} \le 1{,}0 \qquad (6.46)$$

where N_{Ed} is the design value of the compression force;

$N_{b,Rd}$ is the design buckling resistance of the compression member.

(2) For members with non-symmetric Class 4 sections allowance should be made for the additional moment ΔM_{Ed} due to the eccentricity of the centroidal axis of the effective section, see also 6.2.2.5(4), and the interaction should be carried out to 6.3.4 or 6.3.3.

(3) The design buckling resistance of a compression member should be taken as:

$$N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}} \quad \text{for Class 1, 2 and 3 cross-sections} \tag{6.47}$$

$$N_{b,Rd} = \frac{\chi A_{eff} f_y}{\gamma_{M1}} \quad \text{for Class 4 cross-sections} \tag{6.48}$$

where χ is the reduction factor for the relevant buckling mode.

NOTE For determining the buckling resistance of members with tapered sections along the member or for non-uniform distribution of the compression force second order analysis according to 5.3.4(2) may be performed. For out-of-plane buckling see also 6.3.4.

(4) In determining A and A_{eff} holes for fasteners at the column ends need not to be taken into account.

6.3.1.2 Buckling curves

(1) For axial compression in members the value of χ for the appropriate non-dimensional slenderness $\bar{\lambda}$ should be determined from the relevant buckling curve according to:

$$\chi = \frac{1}{\Phi + \sqrt{\Phi^2 - \bar{\lambda}^2}} \quad \text{but } \chi \leq 1{,}0 \tag{6.49}$$

where $\Phi = 0{,}5\left[1 + \alpha\left(\bar{\lambda} - 0{,}2\right) + \bar{\lambda}^2\right]$

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} \quad \text{for Class 1, 2 and 3 cross-sections}$$

$$\bar{\lambda} = \sqrt{\frac{A_{eff} f_y}{N_{cr}}} \quad \text{for Class 4 cross-sections}$$

α is an imperfection factor

N_{cr} is the elastic critical force for the relevant buckling mode based on the gross cross sectional properties.

(2) The imperfection factor α corresponding to the appropriate buckling curve should be obtained from Table 6.1 and Table 6.2.

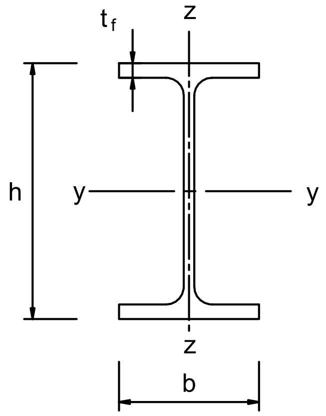
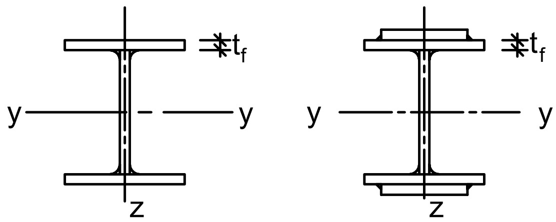
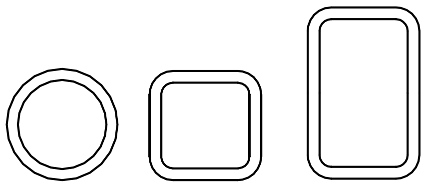
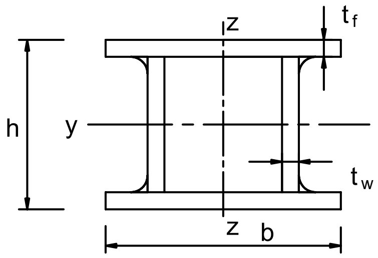
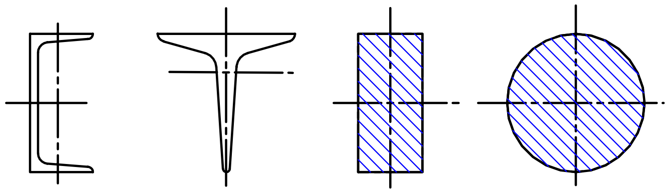
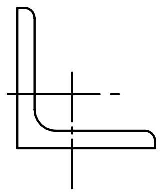
Table 6.1: Imperfection factors for buckling curves

Buckling curve	a_0	a	b	c	d
Imperfection factor α	0,13	0,21	0,34	0,49	0,76

(3) Values of the reduction factor χ for the appropriate non-dimensional slenderness $\bar{\lambda}$ may be obtained from Figure 6.4.

(4) For slenderness $\bar{\lambda} \leq 0{,}2$ or for $\frac{N_{Ed}}{N_{cr}} \leq 0{,}04$ the buckling effects may be ignored and only cross sectional checks apply.

Table 6.2: Selection of buckling curve for a cross-section

Cross section		Limits		Buckling about axis	Buckling curve: S 235, S 275, S 355, S 420	Buckling curve: S 460
Rolled sections		$h/b > 1,2$	$t_f \leq 40$ mm	y – y z – z	a b	a_0 a_0
			40 mm $< t_f \leq 100$	y – y z – z	b c	a a
		$h/b \leq 1,2$	$t_f \leq 100$ mm	y – y z – z	b c	a a
			$t_f > 100$ mm	y – y z – z	d d	c c
Welded I-sections		$t_f \leq 40$ mm		y – y z – z	b c	b c
		$t_f > 40$ mm		y – y z – z	c d	c d
Hollow sections		hot finished		any	a	a_0
		cold formed		any	c	c
Welded box sections		generally (except as below)		any	b	b
		thick welds: $a > 0,5t_f$ $b/t_f < 30$ $h/t_w < 30$		any	c	c
U-, T- and solid sections				any	c	c
L-sections				any	b	b

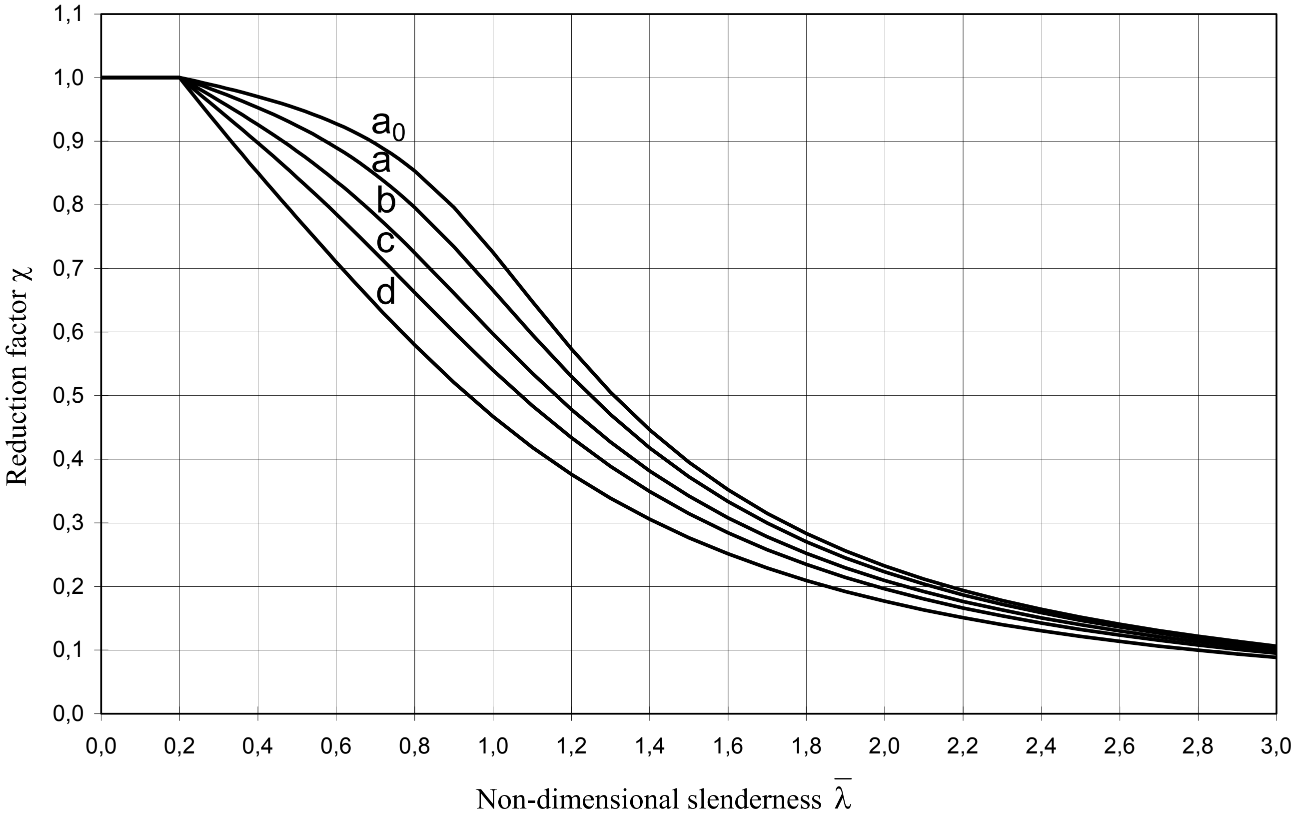


Figure 6.4: Buckling curves

6.3.1.3 Slenderness for flexural buckling

(1) The non-dimensional slenderness $\bar{\lambda}$ is given by:

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{cr}}{i} \frac{1}{\lambda_1} \qquad \text{for Class 1, 2 and 3 cross-sections} \qquad (6.50)$$

$$\bar{\lambda} = \sqrt{\frac{A_{eff} f_y}{N_{cr}}} = \frac{L_{cr}}{i} \frac{\sqrt{\frac{A_{eff}}{A}}}{\lambda_1} \qquad \text{for Class 4 cross-sections} \qquad (6.51)$$

where L_{cr} is the buckling length in the buckling plane considered

i is the radius of gyration about the relevant axis, determined using the properties of the gross cross-section

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = 93{,}9\varepsilon$$

$$\varepsilon = \sqrt{\frac{235}{f_y}} \qquad (f_y \text{ in N/mm}^2)$$

NOTE B For elastic buckling of components of building structures see Annex BB.

(2) For flexural buckling the appropriate buckling curve should be determined from Table 6.2.

6.3.1.4 Slenderness for torsional and torsional-flexural buckling

(1) For members with open cross-sections account should be taken of the possibility that the resistance of the member to either torsional or torsional-flexural buckling could be less than its resistance to flexural buckling.

(2) The non-dimensional slenderness $\bar{\lambda}_T$ for torsional or torsional-flexural buckling should be taken as:

$$\bar{\lambda}_T = \sqrt{\frac{Af_y}{N_{cr}}} \quad \text{for Class 1, 2 and 3 cross-sections} \qquad (6.52)$$

$$\bar{\lambda}_T = \sqrt{\frac{A_{eff}f_y}{N_{cr}}} \quad \text{for Class 4 cross-sections} \qquad (6.53)$$

where $N_{cr} = N_{cr,TF}$ but $N_{cr} < N_{cr,T}$

$N_{cr,TF}$ is the elastic torsional-flexural buckling force;

$N_{cr,T}$ is the elastic torsional buckling force.

(3) For torsional or torsional-flexural buckling the appropriate buckling curve may be determined from Table 6.2 considering the one related to the z-axis.

6.3.2 Uniform members in bending

6.3.2.1 Buckling resistance

(1) A laterally unrestrained member subject to major axis bending should be verified against lateral-torsional buckling as follows:

$$\frac{M_{Ed}}{M_{b,Rd}} \leq 1{,}0 \qquad (6.54)$$

where M_{Ed} is the design value of the moment

$M_{b,Rd}$ is the design buckling resistance moment.

(2) Beams with sufficient restraint to the compression flange are not susceptible to lateral-torsional buckling. In addition, beams with certain types of cross-sections, such as square or circular hollow sections, fabricated circular tubes or square box sections are not susceptible to lateral-torsional buckling.

(3) The design buckling resistance moment of a laterally unrestrained beam should be taken as:

$$M_{b,Rd} = \chi_{LT} W_y \frac{f_y}{\gamma_{M1}} \qquad (6.55)$$

where W_y is the appropriate section modulus as follows:

- $W_y = W_{pl,y}$ for Class 1 or 2 cross-sections
- $W_y = W_{el,y}$ for Class 3 cross-sections
- $W_y = W_{eff,y}$ for Class 4 cross-sections

χ_{LT} is the reduction factor for lateral-torsional buckling.

NOTE 1 For determining the buckling resistance of beams with tapered sections second order analysis according to 5.3.4(3) may be performed. For out-of-plane buckling see also 6.3.4.

NOTE 2B For buckling of components of building structures see also Annex BB.

(4) In determining W_y holes for fasteners at the beam end need not to be taken into account.

6.3.2.2 Lateral torsional buckling curves – General case

(1) Unless otherwise specified, see 6.3.2.3, for bending members of constant cross-section, the value of χ_{LT} for the appropriate non-dimensional slenderness $\bar{\lambda}_{LT}$, should be determined from:

$$\chi_{LT} = \frac{1}{\Phi_{LT} + \sqrt{\Phi_{LT}^2 - \bar{\lambda}_{LT}^2}} \quad \text{but } \chi_{LT} \leq 1{,}0 \qquad (6.56)$$

where $\Phi_{LT} = 0{,}5\left[1 + \alpha_{LT}\left(\bar{\lambda}_{LT} - 0{,}2\right) + \bar{\lambda}_{LT}^2\right]$

α_{LT} is an imperfection factor

$$\bar{\lambda}_{LT} = \sqrt{\frac{W_y f_y}{M_{cr}}}$$

M_{cr} is the elastic critical moment for lateral-torsional buckling

(2) M_{cr} is based on gross cross sectional properties and takes into account the loading conditions, the real moment distribution and the lateral restraints.

NOTE The imperfection factor α_{LT} corresponding to the appropriate buckling curve may be obtained from the National Annex. The recommended values α_{LT} are given in Table 6.3.

Table 6.3: Recommended values for imperfection factors for lateral torsional buckling curves

Buckling curve	a	b	c	d
Imperfection factor α_{LT}	0,21	0,34	0,49	0,76

The recommendations for buckling curves are given in Table 6.4.

Table 6.4: Recommended values for lateral torsional buckling curves for cross-sections using equation (6.56)

Cross-section	Limits	Buckling curve
Rolled I-sections	$h/b \leq 2$ $h/b > 2$	**a** **b**
Welded I-sections	$h/b \leq 2$ $h/b > 2$	**c** **d**
Other cross-sections	-	**d**

(3) Values of the reduction factor χ_{LT} for the appropriate non-dimensional slenderness $\bar{\lambda}_{LT}$ may be obtained from Figure 6.4.

(4) For slendernesses $\bar{\lambda}_{LT} \leq \bar{\lambda}_{LT,0}$ (see 6.3.2.3) or for $\frac{M_{Ed}}{M_{cr}} \leq \bar{\lambda}_{LT,0}{}^2$ (see 6.3.2.3) lateral torsional buckling effects may be ignored and only cross sectional checks apply.

6.3.2.3 Lateral torsional buckling curves for rolled sections or equivalent welded sections

(1) For rolled or equivalent welded sections in bending the values of χ_{LT} for the appropriate non-dimensional slenderness may be determined from

$$\chi_{LT} = \frac{1}{\Phi_{LT} + \sqrt{\Phi_{LT}^2 - \beta\bar{\lambda}_{LT}^2}} \quad \text{but} \quad \begin{cases} \chi_{LT} \le 1{,}0 \\ \chi_{LT} \le \dfrac{1}{\bar{\lambda}_{LT}^2} \end{cases} \tag{6.57}$$

$$\Phi_{LT} = 0{,}5\left[1 + \alpha_{LT}\left(\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}\right) + \beta\bar{\lambda}_{LT}^2\right]$$

NOTE The parameters $\bar{\lambda}_{LT,0}$ and β and any limitation of validity concerning the beam depth or h/b ratio may be given in the National Annex. The following values are recommended for rolled sections or equivalent welded sections:

$\bar{\lambda}_{LT,0} = 0{,}4$ (maximum value)

$\beta = 0{,}75$ (minimum value)

The recommendations for buckling curves are given in Table 6.5.

Table 6.5: Recommendation for the selection of lateral torsional buckling curve for cross sections using equation (6.57)

Cross-section	Limits	Buckling curve
Rolled I-sections	$h/b \le 2$	**b**
	$h/b > 2$	**c**
Welded I-sections	$h/b \le 2$	**c**
	$h/b > 2$	**d**

(2) For taking into account the moment distribution between the lateral restraints of members the reduction factor χ_{LT} may be modified as follows:

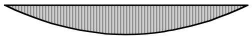
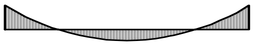
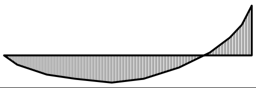
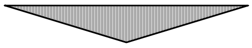
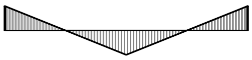
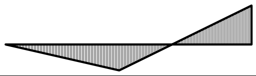
$$\chi_{LT,mod} = \frac{\chi_{LT}}{f} \quad \text{but } \chi_{LT,mod} \le 1 \tag{6.58}$$

NOTE The values f may be defined in the National Annex. The following minimum values are recommended:

$$f = 1 - 0{,}5(1 - k_c)[1 - 2{,}0(\bar{\lambda}_{LT} - 0{,}8)^2] \qquad \text{but } f \le 1{,}0$$

k_c is a correction factor according to Table 6.6

Table 6.6: Correction factors k_c

Moment distribution	k_c
 $\psi = 1$	1,0
 $-1 \le \psi \le 1$	$\dfrac{1}{1{,}33 - 0{,}33\psi}$
	0,94
	0,90
	0,91
	0,86
	0,77
	0,82

6.3.2.4 Simplified assessment methods for beams with restraints in buildings

(1)B Members with discrete lateral restraint to the compression flange are not susceptible to lateral-torsional buckling if the length L_c between restraints or the resulting slenderness $\bar{\lambda}_f$ of the equivalent compression flange satisfies:

$$\bar{\lambda}_f = \frac{k_c L_c}{i_{f,z}\lambda_1} \le \bar{\lambda}_{c0} \frac{M_{c,Rd}}{M_{y,Ed}} \tag{6.59}$$

where $M_{y,Ed}$ is the maximum design value of the bending moment within the restraint spacing

$$M_{c,Rd} = W_y \frac{f_y}{\gamma_{M1}}$$

W_y is the appropriate section modulus corresponding to the compression flange

k_c is a slenderness correction factor for moment distribution between restraints, see Table 6.6

$i_{f,z}$ is the radius of gyration of the equivalent compression flange composed of the compression flange plus 1/3 of the compressed part of the web area, about the minor axis of the section

$\bar{\lambda}_{c,0}$ is a slenderness limit of the equivalent compression flange defined above

$$\lambda_1 = \pi\sqrt{\frac{E}{f_y}} = 93{,}9\varepsilon$$

$$\varepsilon = \sqrt{\frac{235}{f_y}} \qquad (f_y \text{ in N/mm}^2)$$

NOTE 1B For Class 4 cross-sections $i_{f,z}$ may be taken as

$$i_{f,z} = \sqrt{\frac{I_{eff,f}}{A_{eff,f} + \frac{1}{3} A_{eff,w,c}}}$$

where $I_{eff,f}$ is the effective second moment of area of the compression flange about the minor axis of the section

$A_{eff,f}$ is the effective area of the compression flange

$A_{eff,w,c}$ is the effective areas of the compressed part of the web

NOTE 2B The slenderness limit $\bar{\lambda}_{c0}$ may be given in the National Annex. A limit value $\bar{\lambda}_{c0} = \bar{\lambda}_{LT,0} + 0{,}1$ is recommended, see 6.3.2.3.

(2)B If the slenderness of the compression flange $\bar{\lambda}_f$ exceeds the limit given in (1)B, the design buckling resistance moment may be taken as:

$$M_{b,Rd} = k_{f\ell} \chi \, M_{c,Rd} \quad \text{but} \quad M_{b.Rd} \leq M_{c.Rd} \tag{6.60}$$

where χ is the reduction factor of the equivalent compression flange determined with $\bar{\lambda}_f$

$k_{f\ell}$ is the modification factor accounting for the conservatism of the equivalent compression flange method

NOTE B The modification factor may be given in the National Annex. A value $k_{f\ell} = 1{,}10$ is recommended.

(3)B The buckling curves to be used in (2)B should be taken as follows:

curve d for welded sections provided that: $\frac{h}{t_f} \leq 44\varepsilon$

curve c for all other sections

where h is the overall depth of the cross-section

t_f is the thickness of the compression flange

NOTE B For lateral torsional buckling of components of building structures with restraints see also Annex BB.3.

6.3.3 Uniform members in bending and axial compression

(1) Unless second order analysis is carried out using the imperfections as given in 5.3.2, the stability of uniform members with double symmetric cross sections for sections not susceptible to distortional deformations should be checked as given in the following clauses, where a distinction is made for:

- members that are not susceptible to torsional deformations, e.g. circular hollow sections or sections restraint from torsion
- members that are susceptible to torsional deformations, e.g. members with open cross-sections and not restraint from torsion.

(2) In addition, the resistance of the cross-sections at each end of the member should satisfy the requirements given in 6.2.

NOTE 1 The interaction formulae are based on the modelling of simply supported single span members with end fork conditions and with or without continuous lateral restraints, which are subjected to compression forces, end moments and/or transverse loads.

NOTE 2 In case the conditions of application expressed in (1) and (2) are not fulfilled, see 6.3.4.

(3) For members of structural systems the resistance check may be carried out on the basis of the individual single span members regarded as cut out of the system. Second order effects of the sway system (P-Δ-effects) have to be taken into account, either by the end moments of the member or by means of appropriate buckling lengths respectively, see 5.2.2(3)c) and 5.2.2(8).

(4) Members which are subjected to combined bending and axial compression should satisfy:

$$\frac{N_{Ed}}{\dfrac{\chi_y N_{Rk}}{\gamma_{M1}}} + k_{yy}\frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{LT}\dfrac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz}\frac{M_{z,Ed} + \Delta M_{z,Ed}}{\dfrac{M_{z,Rk}}{\gamma_{M1}}} \le 1 \qquad (6.61)$$

$$\frac{N_{Ed}}{\dfrac{\chi_z N_{Rk}}{\gamma_{M1}}} + k_{zy}\frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{LT}\dfrac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz}\frac{M_{z,Ed} + \Delta M_{z,Ed}}{\dfrac{M_{z,Rk}}{\gamma_{M1}}} \le 1 \qquad (6.62)$$

where N_{Ed}, $M_{y,Ed}$ and $M_{z,Ed}$ are the design values of the compression force and the maximum moments about the y-y and z-z axis along the member, respectively

$\Delta M_{y,Ed}$, $\Delta M_{z,Ed}$ are the moments due to the shift of the centroidal axis according to 6.2.9.3 for class 4 sections, see Table 6.7,

χ_y and χ_z are the reduction factors due to flexural buckling from 6.3.1

χ_{LT} is the reduction factor due to lateral torsional buckling from 6.3.2

k_{yy}, k_{yz}, k_{zy}, k_{zz} are the interaction factors

Table 6.7: Values for $N_{Rk} = f_y A_i$, $M_{i,Rk} = f_y W_i$ and $\Delta M_{i,Ed}$

Class	1	2	3	4
A_i	A	A	A	A_{eff}
W_y	$W_{pl,y}$	$W_{pl,y}$	$W_{el,y}$	$W_{eff,y}$
W_z	$W_{pl,z}$	$W_{pl,z}$	$W_{el,z}$	$W_{eff,z}$
$\Delta M_{y,Ed}$	0	0	0	$e_{N,y} N_{Ed}$
$\Delta M_{z,Ed}$	0	0	0	$e_{N,z} N_{Ed}$

NOTE For members not susceptible to torsional deformation χ_{LT} would be $\chi_{LT} = 1,0$.

(5) The interaction factors k_{yy} , k_{yz} , k_{zy} , k_{zz} depend on the method which is chosen.

NOTE 1 The interaction factors k_{yy}, k_{yz}, k_{zy} and k_{zz} have been derived from two alternative approaches. Values of these factors may be obtained from Annex A (alternative method 1) or from Annex B (alternative method 2).

NOTE 2 The National Annex may give a choice from alternative method 1 or alternative method 2.

NOTE 3 For simplicity verifications may be performed in the elastic range only.

6.3.4 General method for lateral and lateral torsional buckling of structural components

(1) The following method may be used where the methods given in 6.3.1, 6.3.2 and 6.3.3 do not apply. It allows the verification of the resistance to lateral and lateral torsional buckling for structural components such as

- single members, built-up or not, uniform or not, with complex support conditions or not, or
- plane frames or subframes composed of such members,

which are subject to compression and/or mono-axial bending in the plane, but which do not contain rotative plastic hinges.

NOTE The National Annex may specify the field and limits of application of this method.

(2) Overall resistance to out-of-plane buckling for any structural component conforming to the scope in (1) can be verified by ensuring that:

$$\frac{\chi_{op}\alpha_{ult,k}}{\gamma_{M1}} \geq 1,0 \tag{6.63}$$

where $\alpha_{ult,k}$ is the minimum load amplifier of the design loads to reach the characteristic resistance of the most critical cross section of the structural component considering its in plane behaviour without taking lateral or lateral torsional buckling into account however accounting for all effects due to in plane geometrical deformation and imperfections, global and local, where relevant;

χ_{op} is the reduction factor for the non-dimensional slenderness $\bar{\lambda}_{op}$, see (3), to take account of lateral and lateral torsional buckling.

(3) The global non dimensional slenderness $\bar{\lambda}_{op}$ for the structural component should be determined from

$$\bar{\lambda}_{op} = \sqrt{\frac{\alpha_{ult,k}}{\alpha_{cr,op}}} \tag{6.64}$$

where $\alpha_{ult,k}$ is defined in (2)

$\alpha_{cr,op}$ is the minimum amplifier for the in plane design loads to reach the elastic critical resistance of the structural component with regards to lateral or lateral torsional buckling without accounting for in plane flexural buckling

NOTE In determining $\alpha_{cr,op}$ and $\alpha_{ult,k}$ Finite Element analysis may be used.

(4) The reduction factor χ_{op} may be determined from either of the following methods:

a) the minimum value of

χ for lateral buckling according to 6.3.1

χ_{LT} for lateral torsional buckling according to 6.3.2

each calculated for the global non dimensional slenderness $\bar{\lambda}_{op}$.

NOTE For example where $\alpha_{ult,k}$ is determined by the cross section check $\frac{1}{\alpha_{ult,k}} = \frac{N_{Ed}}{N_{Rk}} + \frac{M_{y,Ed}}{M_{y,Rk}}$ this method leads to:

$$\frac{N_{Ed}}{N_{Rk}/\gamma_{M1}} + \frac{M_{y,Ed}}{M_{y,Rk}/\gamma_{M1}} \leq \chi_{op} \tag{6.65}$$

b) a value interpolated between the values χ and χ_{LT} as determined in a) by using the formula for $\alpha_{ult,k}$ corresponding to the critical cross section

NOTE For example where $\alpha_{ult,k}$ is determined by the cross section check $\frac{1}{\alpha_{ult,k}} = \frac{N_{Ed}}{N_{Rk}} + \frac{M_{y,Ed}}{M_{y,Rk}}$ this method leads to:

$$\frac{N_{Ed}}{\chi N_{Rk}/\gamma_{M1}}+\frac{M_{y,Ed}}{\chi_{LT} M_{y,Rk}/\gamma_{M1}}\leq 1 \tag{6.66}$$

6.3.5 Lateral torsional buckling of members with plastic hinges

6.3.5.1 General

(1)B Structures may be designed with plastic analysis provided lateral torsional buckling in the frame is prevented by the following means:

a) restraints at locations of "rotated" plastic hinges, see 6.3.5.2, and

b) verification of stable length of segment between such restraints and other lateral restraints, see 6.3.5.3

(2)B Where under all ultimate limit state load combinations, the plastic hinge is "not-rotated" no restraints are necessary for such a plastic hinge.

6.3.5.2 Restraints at rotated plastic hinges

(1)B At each rotated plastic hinge location the cross section should have an effective lateral and torsional restraint with appropriate resistance to lateral forces and torsion induced by local plastic deformations of the member at this location.

(2)B Effective restraint should be provided

– for members carrying either moment or moment and axial force by lateral restraint to both flanges. This may be provided by lateral restraint to one flange and a stiff torsional restraint to the cross-section preventing the lateral displacement of the compression flange relative to the tension flange, see Figure 6.5.

– for members carrying either moment alone or moment and axial tension in which the compression flange is in contact with a floor slab, by lateral and torsional restraint to the compression flange (e.g. by connecting it to a slab, see Figure 6.6). For cross-sections that are more slender than rolled I and H sections the distorsion of the cross section should be prevented at the plastic hinge location (e.g. by means of a web stiffener also connected to the compression flange with a stiff joint from the compression flange into the slab).

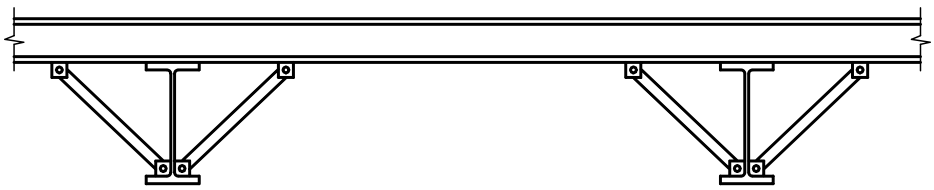
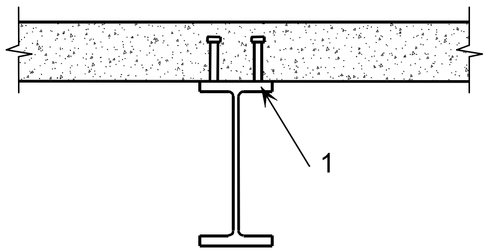


Figure 6.5: Typical stiff torsional restraint



1 compression flange

Figure 6.6: Typical lateral and torsional restraint by a slab to the compression flange

(3)B At each plastic hinge location, the connection (e.g. bolts) of the compression flange to the resisting element at that point (e.g. purlin), and any intermediate element (e.g. diagonal brace) should be designed to resist to a local force of at least 2,5% of $N_{f,Ed}$ (defined in 6.3.5.2(5)B) transmitted by the flange in its plane and perpendicular to the web plane, without any combination with other loads.

(4)B Where it is not practicable providing such a restraint directly at the hinge location, it should be provided within a distance of h/2 along the length of the member, where h is its overall depth at the plastic hinge location.

(5)B For the design of bracing systems, see 5.3.3, it should be verified by a check in addition to the check for imperfection according to 5.3.3 that the bracing system is able to resist the effects of local forces Q_m applied at each stabilized member at the plastic hinge locations, where;

$$Q_m = 1{,}5\,\alpha_m \frac{N_{f,Ed}}{100} \tag{6.67}$$

where $N_{f,Ed}$ is the axial force in the compressed flange of the stabilized member at the plastic hinge location;

α_m is according to 5.3.3(1).

NOTE For combination with external loads see also 5.3.3(5).

6.3.5.3 Verification of stable length of segment

(1)B The lateral torsional buckling verification of segments between restraints may be performed by checking that the length between restraints is not greater than the stable length.

For uniform beam segments with I or H cross sections with $\frac{h}{t_f} \le 40\varepsilon$ under linear moment and without significant axial compression the stable length may be taken from

$$\begin{aligned} L_{stable} &= 35\,\varepsilon\, i_z && \text{for } 0{,}625 \le \psi \le 1 \\ L_{stable} &= (60 - 40\psi)\,\varepsilon\, i_z && \text{for } -1 \le \psi \le 0{,}625 \end{aligned} \tag{6.68}$$

where $\varepsilon = \sqrt{\dfrac{235}{f_y\left[N/mm^2\right]}}$

$\psi = \dfrac{M_{Ed,min}}{M_{pl,Rd}}$ = ratio of end moments in the segment

NOTE B For the stable length of a segment see also Annex BB.3.

(2)B Where a rotated plastic hinge location occurs immediately adjacent to one end of a haunch, the tapered segment need not be treated as a segment adjacent to a plastic hinge location if the following criteria are satisfied:

a) the restraint at the plastic hinge location should be within a distance h/2 along the length of the tapered segment, not the uniform segment;

b) the compression flange of the haunch remains elastic throughout its length.

NOTE B For more information see Annex BB.3.

6.4 Uniform built-up compression members

6.4.1 General

(1) Uniform built-up compression members with hinged ends that are laterally supported should be designed with the following model, see Figure 6.7.

1. The member may be considered as a column with a bow imperfection $e_0 = \frac{L}{500}$
2. The elastic deformations of lacings or battenings, see Figure 6.7, may be considered by a continuous (smeared) shear stiffness S_V of the column.

NOTE For other end conditions appropriate modifications may be performed.

(2) The model of a uniform built-up compression member applies when

1. the lacings or battenings consist of equal modules with parallel chords
2. the minimum numbers of modules in a member is three.

NOTE This assumption allows the structure to be regular and smearing the discrete structure to a continuum.

(3) The design procedure is applicable to built-up members with lacings in two planes, see Figure 6.8.

(4) The chords may be solid members or may themselves be laced or battened in the perpendicular plane.

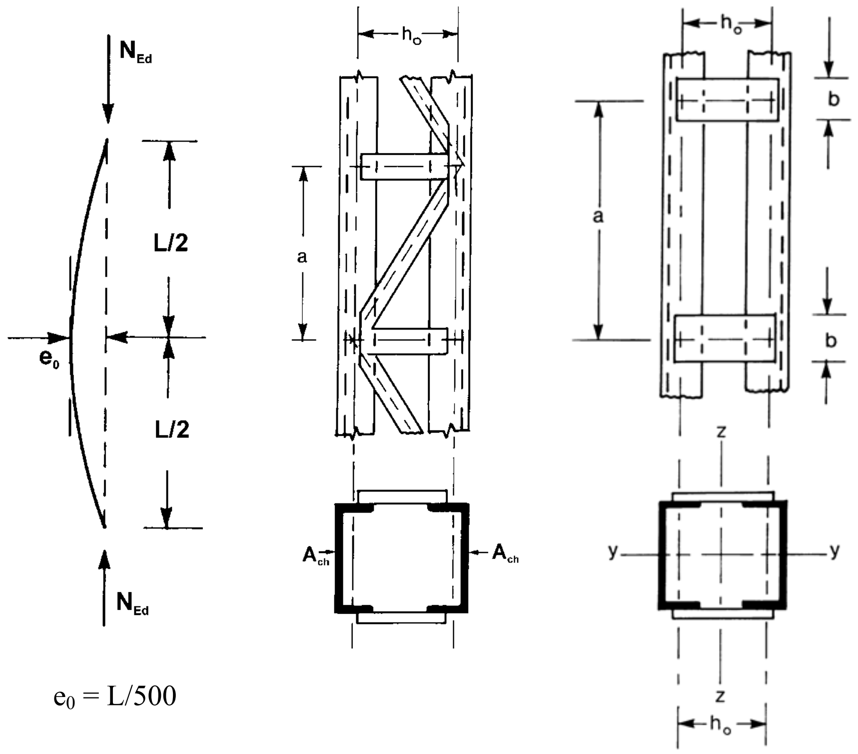


Figure 6.7: Uniform built-up columns with lacings and battenings

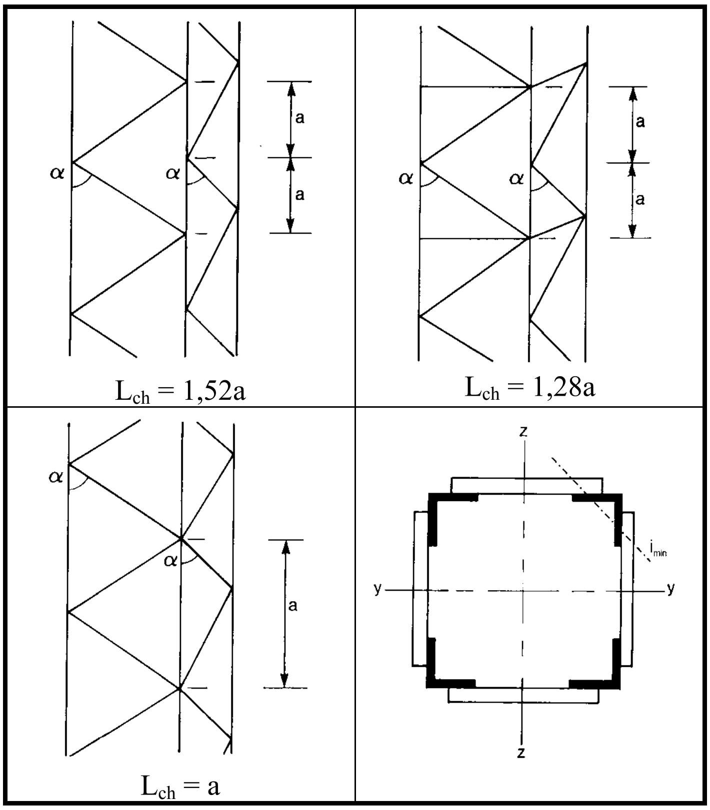


Figure 6.8: Lacings on four sides and buckling length L_{ch} of chords

(5) Checks should be performed for chords using the design chord forces $N_{ch,Ed}$ from compression forces N_{Ed} and moments M_{Ed} at mid span of the built-up member.

(6) For a member with two identical chords the design force $N_{ch,Ed}$ should be determined from:

$$N_{ch,Ed} = 0{,}5N_{Ed} + \frac{M_{Ed}h_0A_{ch}}{2I_{eff}} \tag{6.69}$$

where $M_{Ed} = \dfrac{N_{Ed}e_0 + M_{Ed}^{I}}{1 - \dfrac{N_{Ed}}{N_{cr}} - \dfrac{N_{Ed}}{S_v}}$

$N_{cr} = \dfrac{\pi^2 EI_{eff}}{L^2}$ is the effective critical force of the built-up member

N_{Ed} is the design value of the compression force to the built-up member

M_{Ed} is the design value of the maximum moment in the middle of the built-up member considering second order effects

M_{Ed}^{I} is the design value of the maximum moment in the middle of the built-up member without second order effects

h_0 is the distance between the centroids of chords

A_{ch} is the cross-sectional area of one chord

I_{eff} is the effective second moment of area of the built-up member, see 6.4.2 and 6.4.3

S_v is the shear stiffness of the lacings or battened panel, see 6.4.2 and 6.4.3.

(7) The checks for the lacings of laced built-up members or for the frame moments and shear forces of the battened panels of battened built-up members should be performed for the end panel taking account of the shear force in the built-up member:

$$V_{Ed} = \pi \frac{M_{Ed}}{L} \tag{6.70}$$

6.4.2 Laced compression members

6.4.2.1 Resistance of components of laced compression members

(1) The chords and diagonal lacings subject to compression should be designed for buckling.

NOTE Secondary moments may be neglected.

(2) For chords the buckling verification should be performed as follows:

$$\frac{N_{ch,Ed}}{N_{b,Rd}} \leq 1{,}0 \tag{6.71}$$

where $N_{ch,Ed}$ is the design compression force in the chord at mid-length of the built-up member according to 6.4.1(6)

and $N_{b,Rd}$ is the design value of the buckling resistance of the chord taking the buckling length L_{ch} from Figure 6.8.

(3) The shear stiffness S_V of the lacings should be taken from Figure 6.9.

(4) The effective second order moment of area of laced built-up members may be taken as:

$$I_{eff} = 0{,}5 h_0^2 A_{ch} \tag{6.72}$$

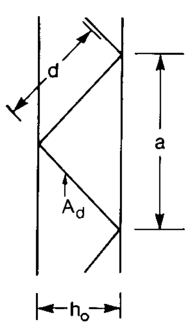
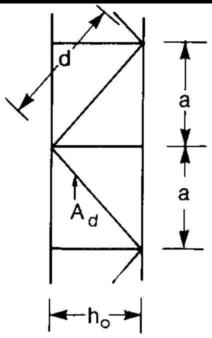
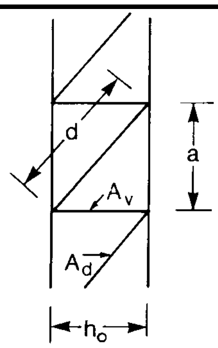
System			
S_V	$\frac{nEA_d a h_0^2}{2d^3}$	$\frac{nEA_d a h_0^2}{d^3}$	$\frac{nEA_d a h_0^2}{d^3\left[1+\frac{A_d h_0^3}{A_V d^3}\right]}$
n is the number of planes of lacings A_d and A_V refer to the cross sectional area of the bracings			

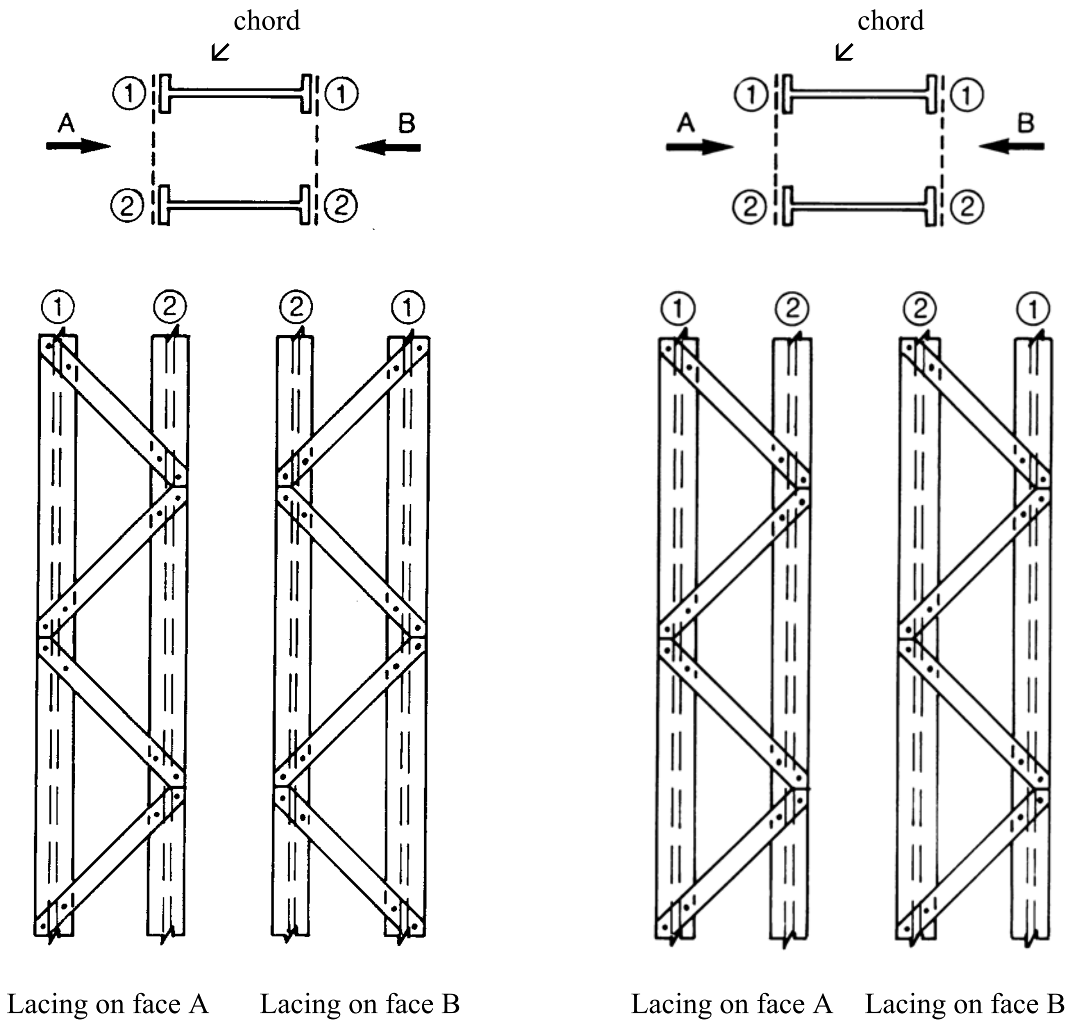
Figure 6.9: Shear stiffness of lacings of built-up members

6.4.2.2 Constructional details

(1) Single lacing systems in opposite faces of the built-up member with two parallel laced planes should be corresponding systems as shown in Figure 6.10(a), arranged so that one is the shadow of the other.

(2) When the single lacing systems on opposite faces of a built-up member with two parallel laced planes are mutually opposed in direction as shown in Figure 6.10(b), the resulting torsional effects in the member should be taken into account.

(3) Tie panels should be provided at the ends of lacing systems, at points where the lacing is interrupted and at joints with other members.



a) Corresponding lacing system (Recommended system)

b) Mutually opposed lacing system (Not recommended)

Figure 6.10: Single lacing system on opposite faces of a built-up member with two parallel laced planes

6.4.3 Battened compression members

6.4.3.1 Resistance of components of battened compression members

(1) The chords and the battens and their joints to the chords should be checked for the actual moments and forces in an end panel and at mid-span as indicated in Figure 6.11.

> **NOTE** For simplicity the maximum chord forces $N_{ch,Ed}$ may be combined with the maximum shear force V_{Ed}.

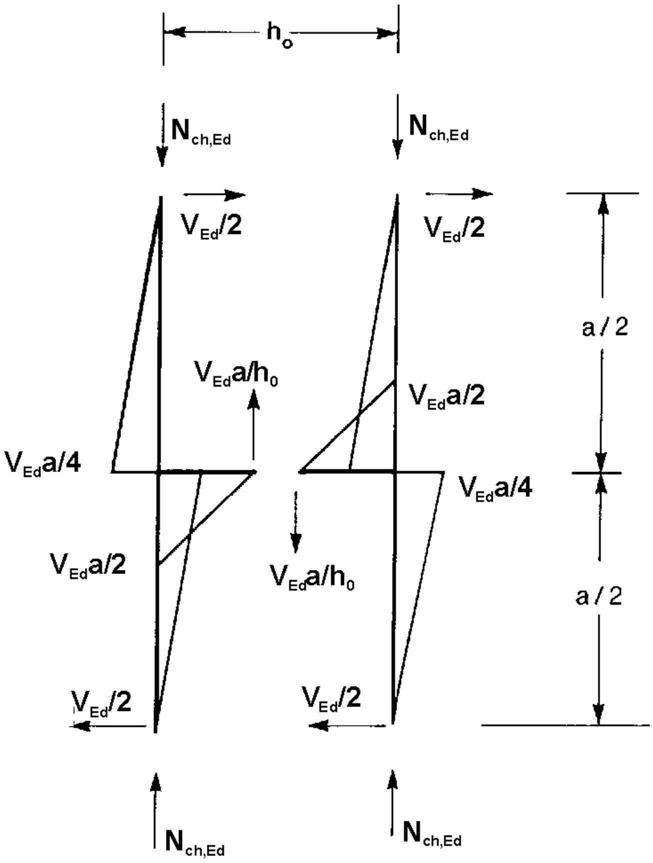


Figure 6.11: Moments and forces in an end panel of a battened built-up member

(2) The shear stiffness S_V should be taken as follows:

$$S_v = \frac{24EI_{ch}}{a^2\left[1+\frac{2I_{ch}}{nI_b}\frac{h_0}{a}\right]} \leq \frac{2\pi^2EI_{ch}}{a^2} \tag{6.73}$$

(3) The effective second moments of area of battened built-up members may be taken as:

$$I_{eff} = 0{,}5h_0^2A_{ch} + 2\mu I_{ch} \tag{6.74}$$

where I_{ch} = in plane second moment of area of one chord

I_b = in plane second moment of area of one batten

μ = efficiency factor from Table 6.8

n = number of planes of lacings

Table 6.8: Efficiency factor μ

Criterion	Efficiency factor μ
$\lambda \geq 150$	0
$75 < \lambda < 150$	$\mu = 2 - \frac{\lambda}{75}$
$\lambda \leq 75$	1,0
where $\lambda = \frac{L}{i_0}$; $i_0 = \sqrt{\frac{I_1}{2A_{ch}}}$; $I_1 = 0{,}5h_0^2A_{ch} + 2I_{ch}$	

6.4.3.2 Design details

(1) Battens should be provided at each end of a member.

(2) Where parallel planes of battens are provided, the battens in each plane should be arranged opposite each other.

(3) Battens should also be provided at intermediate points where loads are applied or lateral restraint is supplied.

6.4.4 Closely spaced built-up members

(1) Built-up compression members with chords in contact or closely spaced and connected through packing plates, see Figure 6.12, or star battened angle members connected by pairs of battens in two perpendicular planes, see Figure 6.13 should be checked for buckling as a single integral member ignoring the effect of shear stiffness ($S_V = \infty$), when the conditions in Table 6.9 are met.

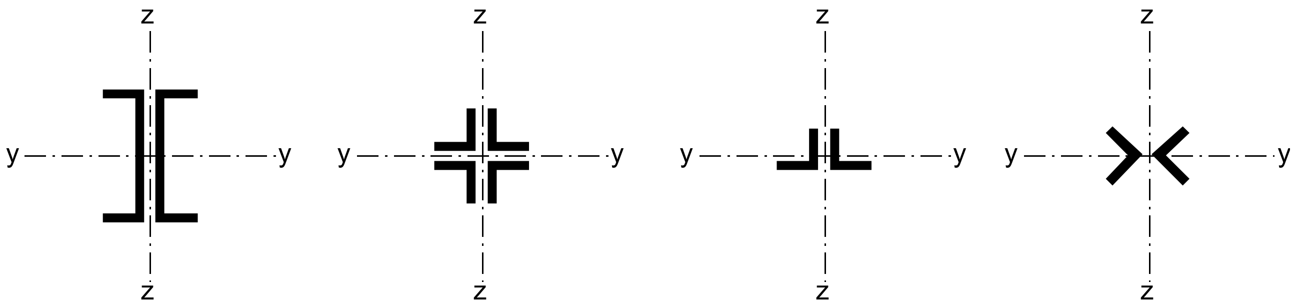


Figure 6.12: Closely spaced built-up members

Table 6.9: Maximum spacings for interconnections in closely spaced built-up or star battened angle members

Type of built-up member	Maximum spacing between interconnections *)
Members according to Figure 6.12 connected by bolts or welds	15 i_{min}
Members according to Figure 6.13 connected by pair of battens	70 i_{min}
*) centre-to-centre distance of interconnections i_{min} is the minimum radius of gyration of one chord or one angle	

(2) The shear forces to be transmitted by the battens should be determined from 6.4.3.1(1).

(3) In the case of unequal-leg angles, see Figure 6.13, buckling about the y-y axis may be verified with:

$$i_y = \frac{i_0}{1,15} \qquad (6.75)$$

where i_0 is the minimum radius of gyration of the built-up member.

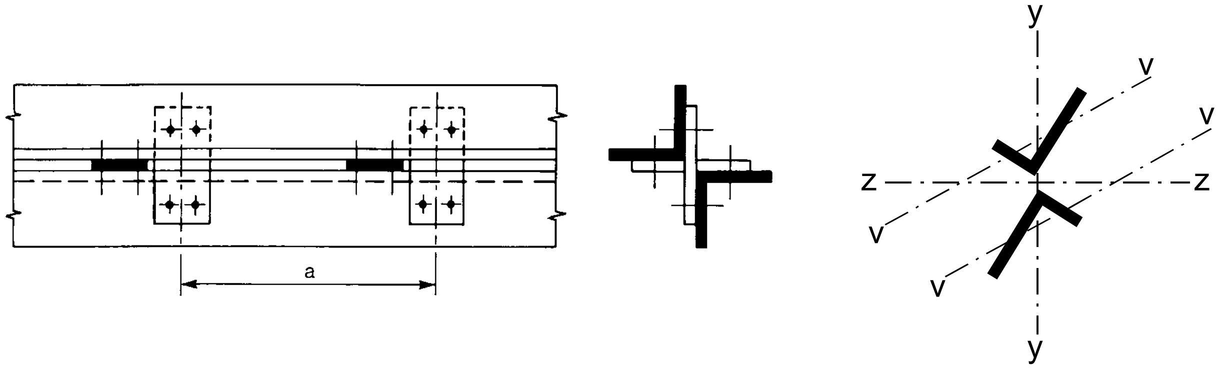


Figure 6.13: Star-battened angle members

7 Serviceability limit states

7.1 General

(1) A steel structure should be designed and constructed such that all relevant serviceability criteria are satisfied.

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

(3) Any serviceability limit state and the associated loading and analysis model should be specified for a project.

(4) Where plastic global analysis is used for the ultimate limit state, plastic redistribution of forces and moments at the serviceability limit state may occur. If so, the effects should be considered.

7.2 Serviceability limit states for buildings

7.2.1 Vertical deflections

(1)B With reference to EN 1990 – Annex A1.4 limits for vertical deflections according to Figure A1.1 should be specified for each project and agreed with the client.

NOTE B The National Annex may specify the limits.

7.2.2 Horizontal deflections

(1)B With reference to EN 1990 – Annex A1.4 limits for horizontal deflections according to Figure A1.2 should be specified for each project and agreed with the client.

NOTE B The National Annex may specify the limits.

7.2.3 Dynamic effects

(1)B With reference to EN 1990 – Annex A1.4.4 the vibrations of structures on which the public can walk should be limited to avoid significant discomfort to users, and limits should be specified for each project and agreed with the client.

NOTE B The National Annex may specify limits for vibration of floors.

Annex A [informative] – Method 1: Interaction factors k_{ij} for interaction formula in 6.3.3(4)

Table A.1: Interaction factors k_{ij} (6.3.3(4))

Interaction factors	Design assumptions: elastic cross-sectional properties class 3, class 4	Design assumptions: plastic cross-sectional properties class 1, class 2
k_{yy}	$C_{my}C_{mLT}\dfrac{\mu_y}{1-\dfrac{N_{Ed}}{N_{cr,y}}}$	$C_{my}C_{mLT}\dfrac{\mu_y}{1-\dfrac{N_{Ed}}{N_{cr,y}}}\dfrac{1}{C_{yy}}$
k_{yz}	$C_{mz}\dfrac{\mu_y}{1-\dfrac{N_{Ed}}{N_{cr,z}}}$	$C_{mz}\dfrac{\mu_y}{1-\dfrac{N_{Ed}}{N_{cr,z}}}\dfrac{1}{C_{yz}}0,6\sqrt{\dfrac{w_z}{w_y}}$
k_{zy}	$C_{my}C_{mLT}\dfrac{\mu_z}{1-\dfrac{N_{Ed}}{N_{cr,y}}}$	$C_{my}C_{mLT}\dfrac{\mu_z}{1-\dfrac{N_{Ed}}{N_{cr,y}}}\dfrac{1}{C_{zy}}0,6\sqrt{\dfrac{w_y}{w_z}}$
k_{zz}	$C_{mz}\dfrac{\mu_z}{1-\dfrac{N_{Ed}}{N_{cr,z}}}$	$C_{mz}\dfrac{\mu_z}{1-\dfrac{N_{Ed}}{N_{cr,z}}}\dfrac{1}{C_{zz}}$

Auxiliary terms:

$$\mu_y = \frac{1-\dfrac{N_{Ed}}{N_{cr,y}}}{1-\chi_y\dfrac{N_{Ed}}{N_{cr,y}}}$$

$$\mu_z = \frac{1-\dfrac{N_{Ed}}{N_{cr,z}}}{1-\chi_z\dfrac{N_{Ed}}{N_{cr,z}}}$$

$$w_y = \frac{W_{pl,y}}{W_{el,y}} \le 1,5$$

$$w_z = \frac{W_{pl,z}}{W_{el,z}} \le 1,5$$

$$n_{pl} = \frac{N_{Ed}}{N_{Rk}/\gamma_{M1}}$$

C_{my} see Table A.2

$$a_{LT} = 1-\frac{I_T}{I_y} \ge 0$$

$$C_{yy} = 1+(w_y-1)\left[\left(2-\frac{1,6}{w_y}C_{my}^2\,\bar\lambda_{max}-\frac{1,6}{w_y}C_{my}^2\,\bar\lambda_{max}^2\right)n_{pl}-b_{LT}\right] \ge \frac{W_{el,y}}{W_{pl,y}}$$

with $b_{LT} = 0,5\,a_{LT}\,\bar\lambda_0^2\,\dfrac{M_{y,Ed}}{\chi_{LT}\,M_{pl,y,Rd}}\,\dfrac{M_{z,Ed}}{M_{pl,z,Rd}}$

$$C_{yz} = 1+(w_z-1)\left[\left(2-14\,\frac{C_{mz}^2\,\bar\lambda_{max}^2}{w_z^5}\right)n_{pl}-c_{LT}\right] \ge 0,6\sqrt{\frac{w_z}{w_y}}\,\frac{W_{el,z}}{W_{pl,z}}$$

with $c_{LT} = 10\,a_{LT}\,\dfrac{\bar\lambda_0^2}{5+\bar\lambda_z^4}\,\dfrac{M_{y,Ed}}{C_{my}\,\chi_{LT}\,M_{pl,y,Rd}}$

$$C_{zy} = 1+(w_y-1)\left[\left(2-14\,\frac{C_{my}^2\,\bar\lambda_{max}^2}{w_y^5}\right)n_{pl}-d_{LT}\right] \ge 0,6\sqrt{\frac{w_y}{w_z}}\,\frac{W_{el,y}}{W_{pl,y}}$$

with $d_{LT} = 2\,a_{LT}\,\dfrac{\bar\lambda_0}{0,1+\bar\lambda_z^4}\,\dfrac{M_{y,Ed}}{C_{my}\,\chi_{LT}\,M_{pl,y,Rd}}\,\dfrac{M_{z,Ed}}{C_{mz}\,M_{pl,z,Rd}}$

$$C_{zz} = 1+(w_z-1)\left[\left(2-\frac{1,6}{w_z}C_{mz}^2\,\bar\lambda_{max}-\frac{1,6}{w_z}C_{mz}^2\,\bar\lambda_{max}^2\right)n_{pl}-e_{LT}\right] \ge \frac{W_{el,z}}{W_{pl,z}}$$

with $e_{LT} = 1,7\,a_{LT}\,\dfrac{\bar\lambda_0}{0,1+\bar\lambda_z^4}\,\dfrac{M_{y,Ed}}{C_{my}\,\chi_{LT}\,M_{pl,y,Rd}}$

Table A.1 (continued)

$$\bar{\lambda}_{max} = \max\begin{cases}\bar{\lambda}_y \\ \bar{\lambda}_z\end{cases}$$

$\bar{\lambda}_0$ = non-dimensional slenderness for lateral-torsional buckling due to uniform bending moment, i.e. ψ_y =1,0 in Table A.2

$\bar{\lambda}_{LT}$ = non-dimensional slenderness for lateral-torsional buckling

If $\bar{\lambda}_0 \leq 0{,}2\sqrt{C_1}\sqrt[4]{\left(1-\frac{N_{Ed}}{N_{cr,z}}\right)\left(1-\frac{N_{Ed}}{N_{cr,TF}}\right)}$:

$C_{my} = C_{my,0}$

$C_{mz} = C_{mz,0}$

$C_{mLT} = 1{,}0$

If $\bar{\lambda}_0 > 0{,}2\sqrt{C_1}\sqrt[4]{\left(1-\frac{N_{Ed}}{N_{cr,z}}\right)\left(1-\frac{N_{Ed}}{N_{cr,TF}}\right)}$:

$$C_{my} = C_{my,0} + (1 - C_{my,0})\frac{\sqrt{\varepsilon_y}\,a_{LT}}{1+\sqrt{\varepsilon_y}\,a_{LT}}$$

$$C_{mz} = C_{mz,0}$$

$$C_{mLT} = C_{my}^2 \frac{a_{LT}}{\sqrt{\left(1-\frac{N_{Ed}}{N_{cr,z}}\right)\left(1-\frac{N_{Ed}}{N_{cr,T}}\right)}} \geq 1$$

$\varepsilon_y = \frac{M_{y,Ed}}{N_{Ed}}\frac{A}{W_{el,y}}$ for class 1, 2 and 3 cross-sections

$\varepsilon_y = \frac{M_{y,Ed}}{N_{Ed}}\frac{A_{eff}}{W_{eff,y}}$ for class 4 cross-sections

$N_{cr,y}$ = elastic flexural buckling force about the y-y axis

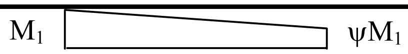
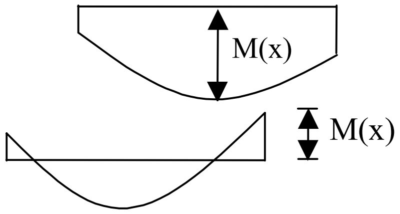
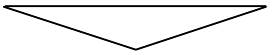
$N_{cr,z}$ = elastic flexural buckling force about the z-z axis

$N_{cr,T}$ = elastic torsional buckling force

I_T = St. Venant torsional constant

I_y = second moment of area about y-y axis

Table A.2: Equivalent uniform moment factors $C_{mi,0}$

Moment diagram	$C_{mi,0}$
 $-1 \le \psi \le 1$	$C_{mi,0} = 0{,}79 + 0{,}21\psi_i + 0{,}36(\psi_i - 0{,}33)\dfrac{N_{Ed}}{N_{cr.i}}$
	$C_{mi,0} = 1 + \left(\dfrac{\pi^2 E I_i \lvert\delta_x\rvert}{L^2 \lvert M_{i,Ed}(x)\rvert} - 1\right)\dfrac{N_{Ed}}{N_{cr.i}}$ $M_{i,Ed}(x)$ is the maximum moment $M_{y,Ed}$ or $M_{z,Ed}$ $\lvert\delta_x\rvert$ is the maximum member displacement along the member
 	$C_{mi,0} = 1 - 0{,}18\dfrac{N_{Ed}}{N_{cr.i}}$ $C_{mi,0} = 1 + 0{,}03\dfrac{N_{Ed}}{N_{cr.i}}$

Annex B [informative] – Method 2: Interaction factors k_{ij} for interaction formula in 6.3.3(4)

Table B.1: Interaction factors k_{ij} for members not susceptible to torsional deformations

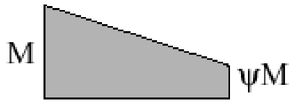
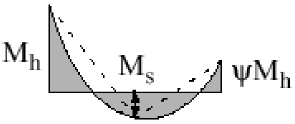
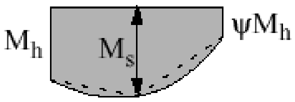
Interaction factors	Type of sections	Design assumptions: elastic cross-sectional properties class 3, class 4	Design assumptions: plastic cross-sectional properties class 1, class 2
k_{yy}	I-sections RHS-sections	$C_{my}\left(1+0,6\bar{\lambda}_y \frac{N_{Ed}}{\chi_y N_{Rk}/\gamma_{M1}}\right) \le C_{my}\left(1+0,6\frac{N_{Ed}}{\chi_y N_{Rk}/\gamma_{M1}}\right)$	$C_{my}\left(1+\left(\bar{\lambda}_y-0,2\right)\frac{N_{Ed}}{\chi_y N_{Rk}/\gamma_{M1}}\right) \le C_{my}\left(1+0,8\frac{N_{Ed}}{\chi_y N_{Rk}/\gamma_{M1}}\right)$
k_{yz}	I-sections RHS-sections	k_{zz}	$0,6\ k_{zz}$
k_{zy}	I-sections RHS-sections	$0,8\ k_{yy}$	$0,6\ k_{yy}$
k_{zz}	I-sections	$C_{mz}\left(1+0,6\bar{\lambda}_z \frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right) \le C_{mz}\left(1+0,6\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right)$	$C_{mz}\left(1+\left(2\bar{\lambda}_z-0,6\right)\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right) \le C_{mz}\left(1+1,4\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right)$
	RHS-sections		$C_{mz}\left(1+\left(\bar{\lambda}_z-0,2\right)\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right) \le C_{mz}\left(1+0,8\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right)$
For I- and H-sections and rectangular hollow sections under axial compression and uniaxial bending $M_{y,Ed}$ the coefficient k_{zy} may be $k_{zy} = 0$.			

Table B.2: Interaction factors k_{ij} for members susceptible to torsional deformations

Interaction factors	Design assumptions: elastic cross-sectional properties class 3, class 4	Design assumptions: plastic cross-sectional properties class 1, class 2
k_{yy}	k_{yy} from Table B.1	k_{yy} from Table B.1
k_{yz}	k_{yz} from Table B.1	k_{yz} from Table B.1
k_{zy}	$\left[1-\frac{0,05\bar{\lambda}_z}{\left(C_{mLT}-0,25\right)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right] \ge \left[1-\frac{0,05}{\left(C_{mLT}-0,25\right)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right]$	$\left[1-\frac{0,1\bar{\lambda}_z}{\left(C_{mLT}-0,25\right)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right] \ge \left[1-\frac{0,1}{\left(C_{mLT}-0,25\right)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right]$ for $\bar{\lambda}_z < 0,4$: $k_{zy} = 0,6+\bar{\lambda}_z \le 1-\frac{0,1\bar{\lambda}_z}{\left(C_{mLT}-0,25\right)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}$

k_{zz}	k_{zz} from Table B.1	k_{zz} from Table B.1

Table B.3: Equivalent uniform moment factors C_m in Tables B.1 and B.2

Moment diagram	range		C_{my} and C_{mz} and C_{mLT} uniform loading	C_{my} and C_{mz} and C_{mLT} concentrated load
		$-1 \le \psi \le 1$	$0,6 + 0,4\psi \ge 0,4$	
 $\alpha_s = M_s/M_h$	$0 \le \alpha_s \le 1$	$-1 \le \psi \le 1$	$0,2 + 0,8\alpha_s \ge 0,4$	$0,2 + 0,8\alpha_s \ge 0,4$
	$-1 \le \alpha_s < 0$	$0 \le \psi \le 1$	$0,1 - 0,8\alpha_s \ge 0,4$	$-0,8\alpha_s \ge 0,4$
		$-1 \le \psi < 0$	$0,1(1-\psi) - 0,8\alpha_s \ge 0,4$	$0,2(-\psi) - 0,8\alpha_s \ge 0,4$
 $\alpha_h = M_h/M_s$	$0 \le \alpha_h \le 1$	$-1 \le \psi \le 1$	$0,95 + 0,05\alpha_h$	$0,90 + 0,10\alpha_h$
	$-1 \le \alpha_h < 0$	$0 \le \psi \le 1$	$0,95 + 0,05\alpha_h$	$0,90 + 0,10\alpha_h$
		$-1 \le \psi < 0$	$0,95 + 0,05\alpha_h(1+2\psi)$	$0,90 - 0,10\alpha_h(1+2\psi)$
For members with sway buckling mode the equivalent uniform moment factor should be taken $C_{my} = 0,9$ or $C_{Mz} = 0,9$ respectively.				
C_{my} , C_{mz} and C_{mLT} should be obtained according to the bending moment diagram between the relevant braced points as follows:				

moment factor	bending axis	points braced in direction
C_{my}	y-y	z-z
C_{mz}	z-z	y-y
C_{mLT}	y-y	y-y

Annex AB [informative] – Additional design provisions

AB.1 Structural analysis taking account of material non-linearities

(1)B In case of material non-linearities the action effects in a structure may be determined by incremental approach to the design loads to be considered for the relevant design situation.

(2)B In this incremental approach each permanent or variable action should be increased proportionally.

AB.2 Simplified provisions for the design of continuous floor beams

(1)B For continuous beams with slabs in buildings without cantilevers on which uniformly distributed loads are dominant, it is sufficient to consider only the following load arrangements:

a) alternative spans carrying the design permanent and variable load ($\gamma_G G_k + \gamma_Q Q_k$), other spans carrying only the design permanent load $\gamma_G G_k$

b) any two adjacent spans carrying the design permanent and variable loads ($\gamma_G G_k + \gamma_Q Q_k$), all other spans carrying only the design permanent load $\gamma_G G_k$

NOTE 1 a) applies to sagging moments, b) to hogging moments.

NOTE 2 This annex is intended to be transferred to EN 1990 in a later stage.

Annex BB [informative] – Buckling of components of building structures

BB.1 Flexural buckling of members in triangulated and lattice structures

BB.1.1 General

(1)B For chord members generally and for out-of-plane buckling of web members, the buckling length L_{cr} may be taken as equal to the system length L, see BB.1.3(1)B, unless a smaller value can be justified by analysis.

(2)B The buckling length L_{cr} of an I or H section chord member may be taken as 0,9L for in-plane buckling and 1,0L for out-of-plane buckling, unless a smaller value is justified by analysis.

(3)B Web members may be designed for in-plane buckling using a buckling length smaller than the system length, provided the chords supply appropriate end restraint and the end connections supply appropriate fixity (at least 2 bolts if bolted).

(4)B Under these conditions, in normal triangulated structures the buckling length L_{cr} of web members for in-plane buckling may be taken as 0,9L, except for angle sections, see BB.1.2.

BB.1.2 Angles as web members

(1)B Provided that the chords supply appropriate end restraint to web members made of angles and the end connections of such web members supply appropriate fixity (at least two bolts if bolted), the eccentricities may be neglected and end fixities allowed for in the design of angles as web members in compression. The effective slenderness ratio $\bar{\lambda}_{eff}$ may be obtained as follows:

$$\bar{\lambda}_{eff,v} = 0,35 + 0,7\bar{\lambda}_v \quad \text{for buckling about v-v axis}$$

$$\bar{\lambda}_{eff,y} = 0,50 + 0,7\bar{\lambda}_y \quad \text{for buckling about y-y axis} \qquad \text{(BB.1)}$$

$$\bar{\lambda}_{eff,z} = 0,50 + 0,7\bar{\lambda}_z \quad \text{for buckling about z-z axis}$$

where $\bar{\lambda}$ is as defined in 6.3.1.2.

(2)B When only one bolt is used for end connections of angle web members the eccentricity should be taken into account using 6.2.9 and the buckling length L_{cr} should be taken as equal to the system length L.

BB.1.3 Hollow sections as members

(1)B The buckling length L_{cr} of a hollow section chord member may be taken as 0,9L for both in-plane and out-of-plane buckling, where L is the system length for the relevant plane. The in-plane system length is the distance between the joints. The out-of-plane system length is the distance between the lateral supports, unless a smaller value is justified by analysis.

(2)B The buckling length L_{cr} of a hollow section brace member (web member) with bolted connections may be taken as 1,0L for both in-plane and out-of-plane buckling.

(3)B For latticed girders with parallel chords and braces, for which the brace to chord diameter or width ratio β is less than 0,6 the buckling length L_{cr} of a hollow section brace member without cropping or flattening, welded around its perimeter to hollow section chords, may generally be taken as 0,75L for both in-plane and out-of-plane buckling, unless smaller values may be justified by tests or by calculations.

NOTE The National Annex may give more information on buckling lengths.

BB.2 Continuous restraints

BB.2.1 Continuous lateral restraints

(1)B If trapezoidal sheeting according to EN 1993-1-3 is connected to a beam and the condition expressed by equation (BB.2) is met, the beam at the connection may be regarded as being laterally restrained in the plane of the sheeting.

$$S \geq \left(EI_w \frac{\pi^2}{L^2} + GI_t + EI_z \frac{\pi^2}{L^2} 0{,}25h^2 \right) \frac{70}{h^2} \tag{BB.2}$$

where S is the shear stiffness (per unit of beam length) provided by the sheeting to the beam regarding its deformation in the plane of the sheeting to be connected to the beam at each rib.

I_w is the warping constant

I_t is the torsion constant

I_z is the second moment of area of the cross section about the minor axis of the cross section

L is the beam length

h is the depth of the beam

If the sheeting is connected to a beam at every second rib only, S should be substituted by 0,20S.

NOTE Eqation (BB.2) may also be used to determine the lateral stability of beam flanges used in combination with other types of cladding than trapezoidal sheeting, provided that the connections are of suitable design.

BB.2.2 Continuous torsional restraints

(1)B A beam may be considered as sufficiently restraint from torsional deformations if

$$C_{\vartheta,k} > \frac{M_{pl,k}^2}{EI_z} K_\vartheta K_\upsilon \tag{BB.3}$$

where $C_{\vartheta,k}$ = rotational stiffness (per unit of beam length) provided to the beam by the stabilizing continuum (e.g. roof structure) and the connections

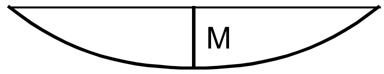
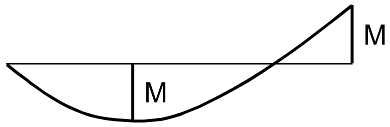
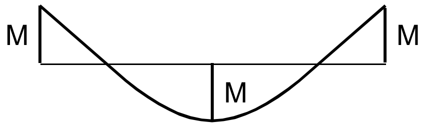
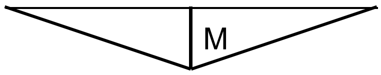
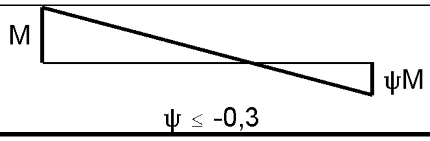
K_υ = 0,35 for elastic analysis

K_υ = 1,00 for plastic analysis

K_ϑ = factor for considering the moment distribution see Table BB.1 and the type of restraint

$M_{pl,k}$ = characteristic value of the plastic moment of the beam

Table BB.1: Factor K_ϑ for considering the moment distribution and the type of restraint

Case	Moment distribution	without translational restraint	with translational restraint
1		4,0	0
2a		3,5	0,12
2b			0,23
3		2,8	0
4		1,6	1,0
5		1,0	0,7

(2)B The rotational stiffness provided by the stabilizing continuum to the beam may be calculated from

$$\frac{1}{C_{\vartheta,k}} = \frac{1}{C_{\vartheta R,k}} + \frac{1}{C_{\vartheta C,k}} + \frac{1}{C_{\vartheta D,k}} \qquad \text{(BB.4)}$$

where $C_{\vartheta R,k}$ = rotational stiffness (per unit of the beam length) provided by the stabilizing continuum to the beam assuming a stiff connection to the member

$C_{\vartheta C,k}$ = rotational stiffness (per unit of the beam length) of the connection between the beam and the stabilizing continuum

$C_{\vartheta D,k}$ = rotational stiffness (per unit of the beam length) deduced from an analysis of the distorsional deformations of the beam cross sections, where the flange in compression is the free one; where the compression flange is the connected one or where distorsional deformations of the cross sections may be neglected (e.g. for usual rolled profiles) $C_{\vartheta D,k} = \infty$

NOTE For more information see EN 1993-1-3.

BB.3 Stable lengths of segment containing plastic hinges for out-of-plane buckling

BB.3.1 Uniform members made of rolled sections or equivalent welded I-sections

BB.3.1.1 Stable lengths between adjacent lateral restraints

(1)B Lateral torsional buckling effects may be ignored where the length L of the segment of a member between the restrained section at a plastic hinge location and the adjacent lateral restraint is not greater than L_m, where:

$$L_m = \frac{38 i_z}{\sqrt{\frac{1}{57{,}4}\left(\frac{N_{Ed}}{A}\right) + \frac{1}{756\, C_1^2}\left(\frac{W_{pl,y}^2}{A I_t}\right)\left(\frac{f_y}{235}\right)^2}} \qquad \text{(BB.5)}$$

where N_{Ed} is the design value of the compression force [N] in the member

A is the cross section area [mm²] of the member

$W_{pl,y}$ is the plastic section modulus of the member

I_t is the torsion constant of the member

f_y is the yield strength in [N/mm²]

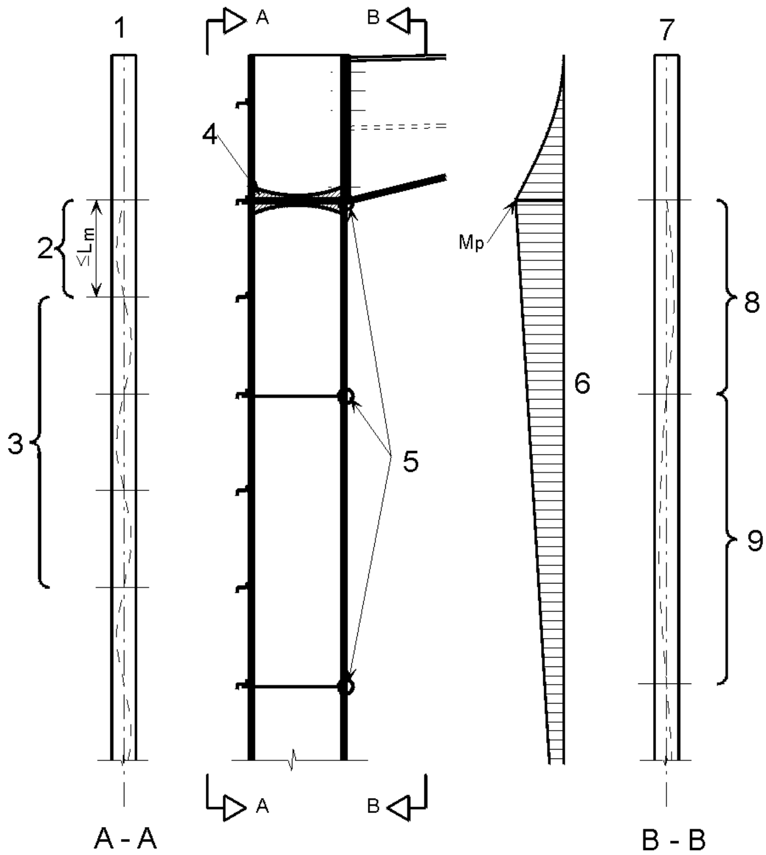
C_1 is a factor depending on the loading and end conditions to be taken from literature

provided that the member is restrained at the hinge as required by 6.3.5 and that the other end of the segment is restrained

- either by a lateral restraint to the compression flange where one flange is in compression throughout the length of the segment,
- or by a torsional restraint,
- or by a lateral restraint at the end of the segment and a torsional restraint to the member at a distance that satisfies the requirements for L_s,

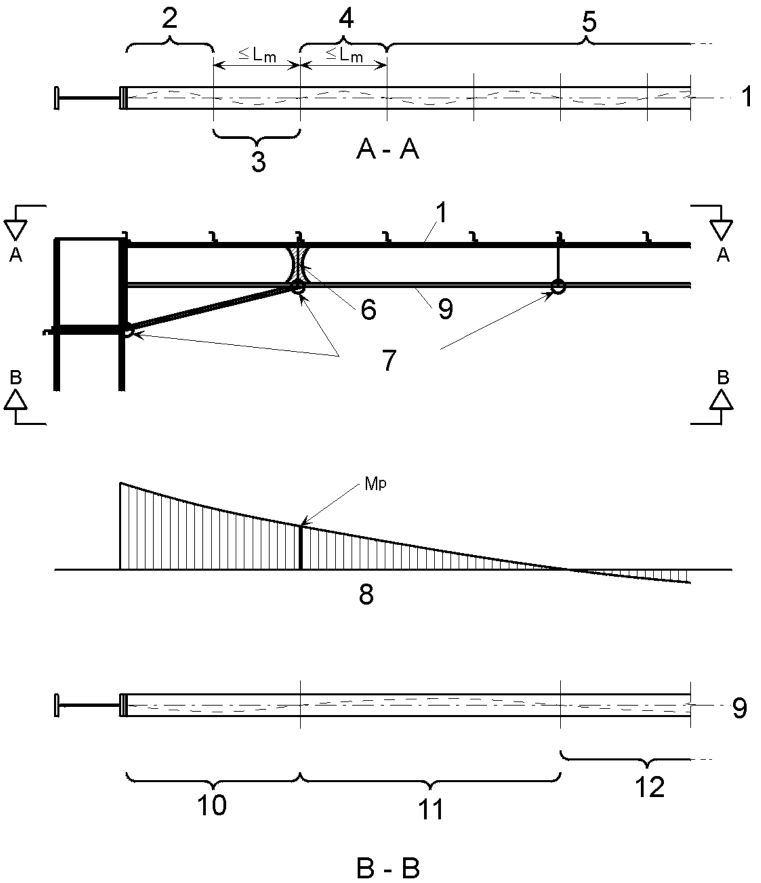
see Figure BB.1, Figure BB.2 and Figure BB3.

NOTE In general L_s is greater than L_m.



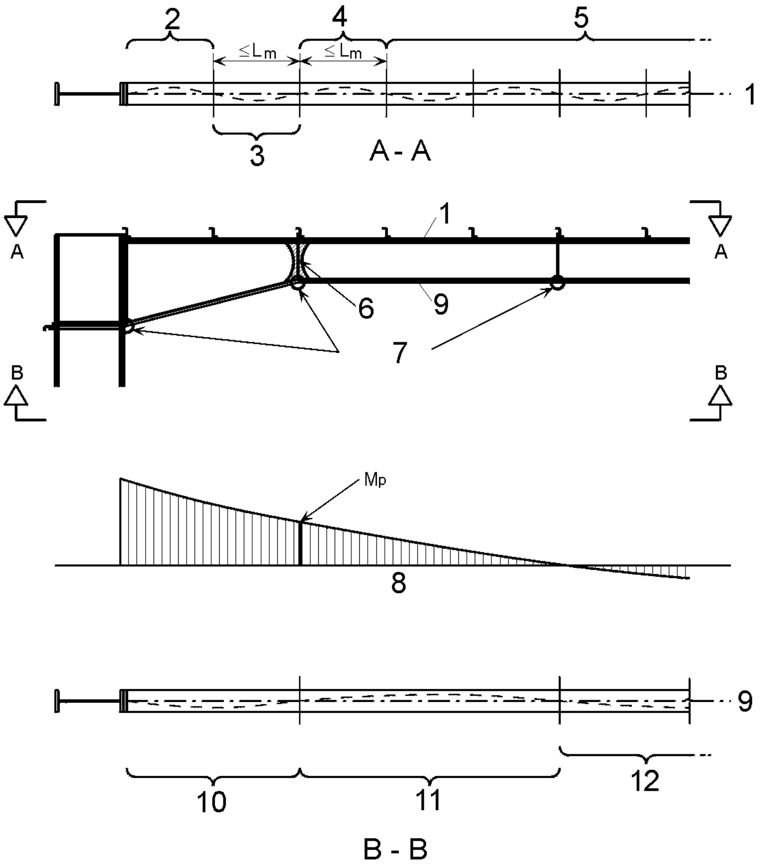
1 tension flange
2 plastic stable length (see BB.3.1.1)
3 elastic section (see 6.3)
4 plastic hinge
5 restraints
6 bending moment diagram
7 compression flange
8 plastic with tension flange restraint, stable length = L_s (see BB.3.1.2, equation (BB.7) or (BB.8))
9 elastic with tension flange restraint (see 6.3), χ and χ_{LT} from N_{cr} and M_{cr} including tension flange restraint

Figure BB.1: Checks in a member without a haunch



1 *tension flange*
2 *elastic section (see 6.3)*
3 *plastic stable length (see BB.3.2.1) or elastic (see 6.3.5.3(2)B)*
4 *plastic stable length (see BB.3.1.1)*
5 *elastic section (see 6.3)*
6 *plastic hinge*
7 *restraints*
8 *bending moment diagram*
9 *compression flange*
10 *plastic stable length (see BB.3.2) or elastic (see 6.3.5.3(2)B)*
11 *plastic stable length (see BB.3.1.2)*
12 *elastic section (see 6.3), χ and χ_{LT} from N_{cr} and M_{cr} including tension flange restraint*

Figure BB.2: Checks in a member with a three flange haunch



1 *tension flange*
2 *elastic section (see 6.3)*
3 *plastic stable length (see BB.3.2.1)*
4 *plastic stable length (see BB.3.1.1)*
5 *elastic section (see 6.3)*
6 *plastic hinge*
7 *restraints*
8 *bending moment diagram*
9 *compression flange*
10 *plastic stable length (see BB.3.2)*
11 *plastic stable length (see BB.3.1.2)*
12 *elastic section (see 6.3), χ and χ_{LT} from N_{cr} and M_{cr} including tension flange restraint*

Figure BB.3: Checks in a member with a two flange haunch

BB.3.1.2 Stable length between torsional restraints

(1)B Lateral torsional buckling effects may be ignored where the length L of the segment of a member between the restrained section at a plastic hinge location and the adjacent torsional restraint subject to a constant moment is not greater than L_k, provided that

- the member is restrained at the hinge as required by 6.3.5 and
- there are one or more intermediate lateral restraints between the torsional restraints at a spacing that satisfies the requirements for L_m, see BB.3.1.1,

where

$$L_k = \frac{\left(5,4 + \frac{600 f_y}{E}\right)\left(\frac{h}{t_f}\right) i_z}{\sqrt{5,4\left(\frac{f_y}{E}\right)\left(\frac{h}{t_f}\right)^2 - 1}} \qquad \text{(BB.6)}$$

(2)B Lateral torsional buckling effects may be ignored where the length L of the segment of a member between the restrained section at a plastic hinge location and the adjacent torsional restraint subject to a linear moment gradient and axial compression is not greater than L_s, provided that

- the member is restrained at the hinge as required by 6.3.5 and
- there are one or more intermediate lateral restraints between the torsional restraints at a spacing that satisfies the requirements for L_m, see BB.3.1.1,

where $$L_s = \sqrt{C_m}\, L_k \left(\frac{M_{pl,y,Rk}}{M_{N,y,Rk} + aN_{Ed}}\right) \qquad \text{(BB.7)}$$

C_m is the modification factor for linear moment gradient, see BB.3.3.1;

a is the distance between the centroid of the member with the plastic hinge and the centroid of the restraint members;

$M_{pl,y,Rk}$ is the characteristic plastic moment resistance of the cross section about the y-y axis

$M_{N,y,Rk}$ is the characteristic plastic moment resistance of the cross section about the y-y axis with reduction due to the axial force N_{Ed}

(3)B Lateral torsional buckling effects may be ignored where the length L of a segment of a member between the restrained section at a plastic hinge location and the adjacent torsional restraint subject to a non linear moment gradient and axial compression is not greater than L_s, provided that

- the member is restrained at the hinge as required by 6.3.5 and
- there are one or more intermediate lateral restraints between the torsional restraints at a spacing that satisfies the requirements for L_m, see BB3.1.1

where $$L_s = \sqrt{C_n}\, L_k \qquad \text{(BB.8)}$$

C_n is the modification factor for non-linear moment gradient, see BB.3.3.2,

see Figure BB.1, Figure BB.2 and Figure BB.3.

BB.3.2 Haunched or tapered members made of rolled sections or equivalent welded I-sections

BB.3.2.1 Stable length between adjacent lateral restraints

(1)B Lateral torsional buckling effects may be ignored where the length L of the segment of a member between the restrained section at a plastic hinge location and the adjacent lateral restraint is not greater than L_m, where

– for three flange haunches (see Figure BB.2)

$$L_m = \frac{38 i_z}{\sqrt{\frac{1}{57{,}4}\left(\frac{N_{Ed}}{A}\right) + \frac{1}{756\, C_1^2}\left(\frac{W_{pl,y}^2}{A I_t}\right)\left(\frac{f_y}{235}\right)^2}} \qquad \text{(BB.9)}$$

– for two flange haunches (see Figure BB.3)

$$L_m = 0{,}85 \frac{38 i_z}{\sqrt{\frac{1}{57{,}4}\left(\frac{N_{Ed}}{A}\right) + \frac{1}{756\, C_1^2}\left(\frac{W_{pl,y}^2}{A I_t}\right)\left(\frac{f_y}{235}\right)^2}} \qquad \text{(BB.10)}$$

where N_{Ed} is the design value of the compression force [N] in the member

$\frac{W_{pl,y}^2}{A I_t}$ is the maximum value in the segment

A is the cross sectional area [mm²] at the location where $\frac{W_{pl,y}^2}{A I_t}$ is a maximum of the tapered member

$W_{pl,y}$ is the plastic section modulus of the member

I_t is the torsional constant of the member

f_y is the yield strength in [N/mm²]

i_z is the minimum value of the radius of gyration in the segment

provided that the member is restrained at the hinge as required by 6.3.5 and that the other end of segment is restrained

– either by a lateral restraint to the compression flange where one flange is in compression throughout the length of the segment,

– or by a torsional restraint,

– or by a lateral restraint at the end of the segment and a torsional restraint to the member at a distance that satisfies the requirements for L_s.

BB.3.2.2 Stable length between torsional restraints

(1)B For non uniform members with constant flanges under linear or non-linear moment gradient and axial compression, lateral torsional buckling effects may be ignored where the length L of the segment of a member between the restrained section at a plastic hinge location and the adjacent torsional restraint is not greater than L_s, provided that

– the member is restrained at the hinge as required by 6.3.5 and

– there are one or more intermediate lateral restraints between the torsional restraints at a spacing that satisfies the requirements for L_m, see BB.3.2.1, where

– for three flange haunches (see Figure BB.2)

$$L_s = \frac{\sqrt{C_n}\ L_k}{c} \tag{BB.11}$$

– for two flange haunches (see Figure BB.3)

$$L_s = 0{,}85\frac{\sqrt{C_n}\ L_k}{c} \tag{BB.12}$$

where L_k is the length derived for a uniform member with a cross-section equal to the shallowest section, see BB.3.1.2

C_n see BB.3.3.2

c is the taper factor defined in BB.3.3.3

BB.3.3 Modification factors for moment gradients in members laterally restrained along the tension flange

BB.3.3.1 Linear moment gradients

(1)B The modification factor C_m may be determined from

$$C_m = \frac{1}{B_0 + B_1\beta_t + B_2\beta_t^{\ 2}} \tag{BB.13}$$

in which

$$B_0 = \frac{1+10\eta}{1+20\eta}$$

$$B_1 = \frac{5\sqrt{\eta}}{\pi + 10\sqrt{\eta}}$$

$$B_2 = \frac{0{,}5}{1+\pi\sqrt{\eta}} - \frac{0{,}5}{1+20\eta}$$

$$\eta = \frac{N_{crE}}{N_{crT}}$$

$$N_{crE} = \frac{\pi^2 E I_z}{L_t^{\ 2}}$$

L_t is the distance between the torsional restraints

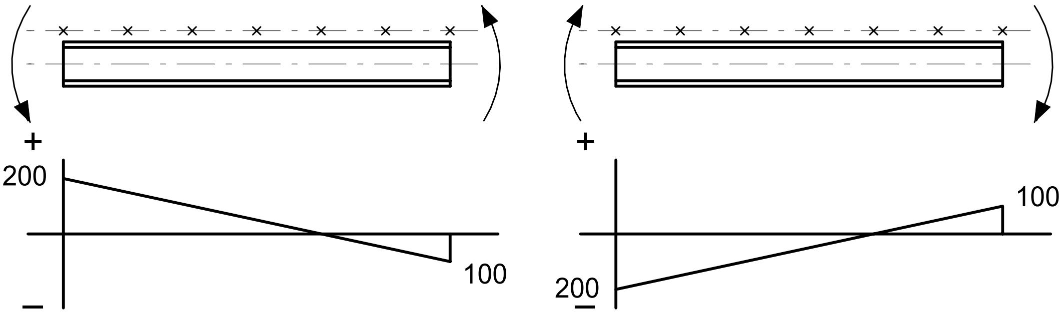
$$N_{crT} = \frac{1}{i_s^{\ 2}}\left(\frac{\pi^2 E I_z a^2}{L_t^{\ 2}} + \frac{\pi^2 E I_w}{L_t^{\ 2}} + G I_t\right)$$

is the elastic critical torsional buckling force for an I-section between restraints to both flanges at spacing L_t with intermediate lateral restraints to the tension flange.

$$i_s^2 = i_y^2 + i_z^2 + a^2$$

where a is the distance between the centroid of the member and the centroid of the restraining members, such as purlins restraining rafters

β_t is the ratio of the algebraically smaller end moment to the larger end moment. Moments that produce compression in the non-restrained flange should be taken as positive. If the ratio is less than –1,0 the value of β_t should be taken as –1,0, see Figure BB.4.



$$\beta_t = \frac{-100}{+200} = -0{,}5$$

$$\beta_t = \frac{-200}{+100} = -2$$

but $\beta_t \geq -1{,}0$ thus $\beta_t = -1{,}0$

Figure BB.4: Value of β_t

BB.3.3.2 Non linear moment gradients

(1)B The modification factor C_n may be determined from

$$C_n = \frac{12}{[R_1 + 3R_2 + 4R_3 + 3R_4 + R_5 + 2(R_S - R_E)]} \tag{BB.14}$$

in which R_1 to R_5 are the values of R according to (2)B at the ends, quarter points and mid-length, see Figure BB.5, and only positive values of R should be included.

In addition, only positive values of $(R_S - R_E)$ should be included, where

- R_E is the greater of R_1 or R_5
- R_s is the maximum value of R anywhere in the length L_y

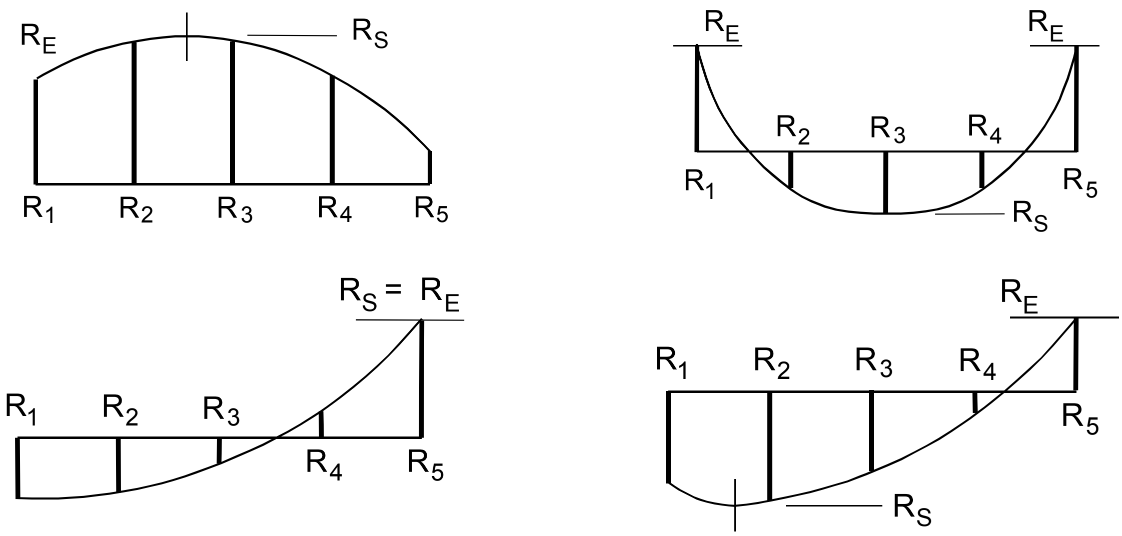


Figure BB.5: Moment ratios

(2)B The value of R should be obtained from:

$$R = \frac{M_{y,Ed} + a\,N_{Ed}}{f_y W_{pl,y}} \tag{BB.15}$$

where a is the distance between the centroid of the member and the centroid of the restraining members, such as purlins restraining rafters.

BB.3.3.3 Taper factor

(1)B For a non uniform member with constant flanges, for which $h \geq 1{,}2b$ and $h/t_f \geq 20$ the taper factor c should be obtained as follows:

– for tapered members or segments, see Figure BB.6(a):

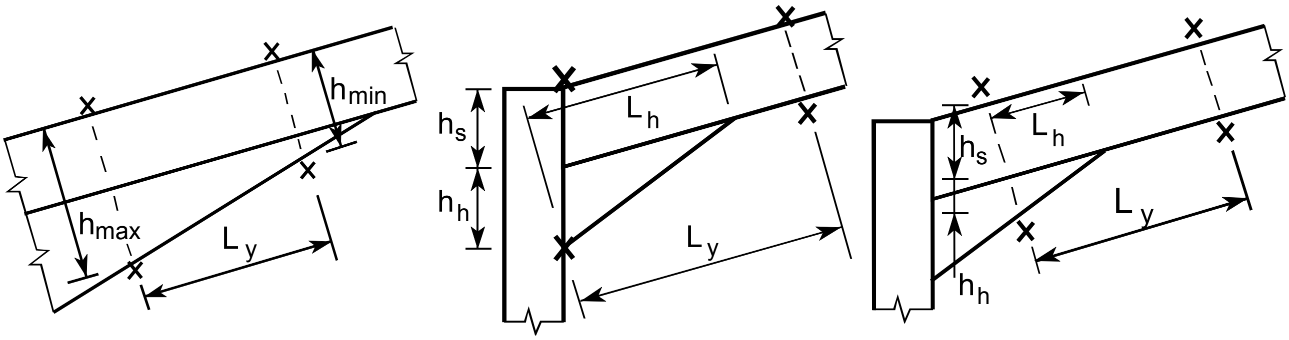
$$c = 1 + \frac{3}{\left(\frac{h}{t_f} - 9\right)} \left(\frac{h_{max}}{h_{min}} - 1\right)^{2/3} \tag{BB.16}$$

– for haunched members or segments, see Figures BB.6(b) and BB.6(c):

$$c = 1 + \frac{3}{\left(\frac{h}{t_f} - 9\right)} \left(\frac{h_h}{h_s}\right)^{2/3} \sqrt{\frac{L_h}{L_y}} \tag{BB.17}$$

where h_h is the additional depth of the haunch or taper, see Figure BB.6;
h_{max} is the maximum depth of cross-section within the length L_y , see Figure BB.6;
h_{min} is the minimum depth of cross-section within the length L_y , see Figure BB.6;
h_s is the vertical depth of the un-haunched section, see Figure BB.6;
L_h is the length of haunch within the length L_y , see Figure BB.6;
L_y is the length between points at which the compression flange is laterally restrained.

(h/t_f) is to be derived from the shallowest section.



(a) Tapered segment (b) Haunched segment (c) Haunched segment

x = restraint

Figure BB.6: Dimensions defining taper factor

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NA to BS EN 1993-1-1:2005

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Part 1-1: General rules and rules for buildings

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Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 8, an inside back cover and a back cover.

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National Annex (informative) to BS EN 1993-1-1:2005, Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings

Introduction

This National Annex has been prepared by BSI Subcommittee B/525/31, *Structural use of steel*. It is to be used in conjunction with BS EN 1993-1-1:2005.

NA.1 Scope

This National Annex gives:

a) the decisions for the National Determined Parameters described in the following subclauses of BS EN 1993-1-1:2005:

- **2.3.1**(1)
- **3.1**(2)
- **3.2.1**(1)
- **3.2.2**(1)
- **3.2.3**(1)
- **3.2.3**(3)B
- **3.2.4**(1)B
- **5.2.1**(3)
- **5.2.2**(8)
- **5.3.2**(3)
- **5.3.2**(11)
- **5.3.4**(3)
- **6.1**(1)
- **6.1**(1)B
- **6.3.2.2**(2)
- **6.3.2.3**(1)
- **6.3.2.3**(2)
- **6.3.2.4**(1)B
- **6.3.2.4**(2)B
- **6.3.3**(5)
- **6.3.4**(1)
- **7.2.1**(1)B
- **7.2.2**(1)B
- **7.2.3**(1)B
- **BB.1.3**(3)B

b) Decisions on the status of BS EN 1993-1-1:2005 informative annexes; and

c) References to non-contradictory complementary information.

NA.2 Nationally Determined Parameters

NA.2.1 General

Decisions for the Nationally Determined Parameters decided in BS EN 1993-1-1:2005 are given in clauses **NA.2.2** to **NA.2.26**.

NA.2.2 Actions and environmental influences [BS EN 1993-1-1:2005, 2.3.1(1)]

There are no additional regional, climatic or accidental situations to consider.

NA.2.3 Other Steel material and products [BS EN 1993-1-1:2005, 3.1(2)]

If other steels are used, due allowance should be made for variations in properties, including ductility and weldability. Further information on the ductility requirements for steel is given in BS EN 1993-1-1:2005, **3.2.2**(1).

Steel castings and forgings may be used for components in bearings, junctions and other similar parts. Castings should conform to BS EN 10293 and forgings should conform to BS EN 10250-2. Further guidance on steel castings is given in reference [1].

For higher strength steels see BS EN 1993-1-12.

NA.2.4 Material properties [BS EN 1993-1-1:2005, 3.2.1(1)]

The nominal values of the yield strength f_y and the ultimate strength f_u for structural steel should be those obtained from the product standard. The ultimate strength f_u should be taken as the lowest value of the range given for R_m in the product standard. Further information on the yield and ultimate strength for structural steel is also given in **NA.4**.

NA.2.5 Ductility requirements [BS EN 1993-1-1:2005, 3.2.2(1)]

a) Elastic global analysis

The limiting values for the ratio f_u/f_y, the elongation at failure and the ultimate strain ε_u for elastic global analysis are given below.

f_u/f_y, $\geqslant 1.10$;

Elongation at failure not less than 15%;

$\varepsilon_u \geqslant 15\varepsilon_y$.

b) Plastic global analysis

Plastic global analysis should not be used for bridges. For buildings the limiting values for the ratio f_u/f_y, the elongation at failure and the ultimate strain ε_u for plastic global analysis are given below.

$f_u/f_y \geqslant 1.15$;

Elongation at failure not less than 15%;

$\varepsilon_u \geqslant 20\varepsilon_y$.

NA.2.6 Fracture toughness [BS EN 1993-1-1:2005, 3.2.3(1)]

For buildings and other quasi-statically loaded structures the lowest service temperature in the steel should be taken as the lowest air temperature which may be taken as –5°C for internal steelwork and –15°C for external steelwork.

For bridges the lowest service temperature in the steel should be determined according to the NA to BS EN 1991-1-5 for the bridge location. For structures susceptible to fatigue it is recommended that the requirements for bridges should be applied.

In other cases (e.g. the internal steelwork in cold stores) the lowest service temperature in the steel should be taken as the lowest air temperature expected to occur within the intended design life of the structure.

NA.2.7 Toughness properties for members in compression [BS EN 1993-1-1:2005, 3.2.3(3)B]

The recommendations given in the NA to BS EN 1993-1-10 should be used.

NA.2.8 Through-thickness properties [BS EN 1993-1-1:2005, 3.2.4(1)B]

The recommendations given in the NA to BS EN 1993-1-10 should be used.

NA.2.9 Effects of deformed geometry of the structure [BS EN 1993-1-1:2005, 5.2.1(3)]

For plastic analysis of clad structures provided that the stiffening effects of masonry infill wall panels or diaphragms of profiled steel sheeting are not taken into account:

$\alpha_{cr} \geqslant 10$

For plastic analysis of portal frames subject to gravity loads only with frame imperfections:

$\alpha_{cr} \geqslant 5$

provided the following conditions are satisfied:

a) The span, L, does not exceed 5 times the mean height of the columns

b) h_r satisfies the criterion:

$(h_r/s_a)^2 + (h_r/s_b)^2 \leqslant 0.5$

in which sa and sb are the horizontal distances from the apex to the columns.

NOTE For a symmetrical frame this expression simplifies to $h_r \leqslant 0.25L$.

NA.2.10 Structural stability of frames [BS EN 1993-1-1:2005, 5.2.2(8)]

This method should only be used for frames that comply with **5.2.2(6)**. In such cases the sway moments in the beams and beam-to-column connections should be multiplied by k_r unless a smaller value is shown to be adequate by analysis. k_r may be evaluated using the following expression provided that $\alpha_{cr} \geqslant 3.0$:

$$k_r = \frac{1}{1 - \frac{1}{\alpha_{cr}}}$$

NA.2.11 Design values of initial local bow imperfection [BS EN 1993-1-1:2005, 5.3.2(3)]

For elastic analysis of the cross-section, the initial imperfections for an individual section about a particular axis should be back-calculated from the formula for the buckling curves given in BS EN 1993-1-1:2005, **6.3** using the elastic section modulus.

For plastic analysis of the cross-section, the initial imperfections for an individual section about a particular axis should be back-calculated from the formula for the buckling curves given in BS EN 1993-1-1:2005, **6.3** using the full plastic section modulus.

NA.2.12 Amplitude of imperfections [BS EN 1993-1-1:2005, 5.3.2(11)]

The method given in BS EN 1993-1-1:2005, **5.3.2**(11) should not be used for buildings.

NA.2.13 Imperfections for lateral-torsional bucking in bending [BS EN 1993-1-1:2005, 5.3.4(3)]

The value of k should be taken as 1.0.

NA.2.14 Partial factors for structures not covered by BS EN 1993 Part 2 to Part 6 [BS EN 1993-1-1:2005, 6.1(1)]

For structures not covered by BS EN 1993 Part 2 to Part 6, the partial factors should be appropriate for the structure and agreed with the client.

NA.2.15 Partial safety factors for buildings [BS EN 1993-1-1:2005, 6.1(1)]

For buildings the following partial factors should be used:

$\gamma_{M0} = 1.00$

$\gamma_{M1} = 1.00$

$\gamma_{M2} = 1.10$

NA.2.16 Imperfection factors for lateral torsional buckling [BS EN 1993-1-1:2005, 6.3.2.2(2)]

The recommended values given in BS EN 1993-1-1:2005, Table 6.3 and Table 6.4 should be used.

NA.2.17 Lateral torsional buckling for rolled sections or equivalent welded sections [BS EN 1993-1-1:2005, 6.3.2.3(1)]

For buildings and bridges the following values of $\lambda_{LT,0}$ and β should be used:

a) For rolled sections and hot-finished and cold-formed hollow sections:

$\lambda_{LT,0} = 0.4$

$\beta = 0.75$

b) For welded sections:

$\lambda_{LT,0} = 0.2$

$\beta = 1.00$

BS EN 1993-1-1:2005, Table 6.5 should be replaced with the following table:

Cross-section	Limits	Buckling curve
Rolled doubly symmetric I and H sections and hot-finished hollow sections	$h/b \leqslant 2$	b
	$2.0 < h/b \leqslant 3.1$	c
	$h/b > 3.1$	d
Angles (for moments in the major principal plane)		d
All other hot-rolled sections.		d
Welded doubly symmetric sections and cold-formed hollow sections	$h/b \leqslant 2$	c
	$2.0 \leqslant h/b < 3.1$	d

NA.2.18 Modification factor, f [BS EN 1993-1-1:2005, 6.3.2.3(2)]

The recommended expression for f should be used in which k_c is given by:

$$k_c = \frac{1}{\sqrt{C_1}}$$

where:

$$C_1 = \frac{M_{cr} \text{ for the actual bending moment diagram}}{M_{cr} \text{ for a uniform bending moment diagram}}$$

values of C_1 are given in the references listed in **NA.4**.

NA.2.19 The slenderness limit λ_{c0} [BS EN 1993-1-1:2005, 6.3.2.4(1)B]

For I, H, channel and box sections used in buildings the value of λ_{c0} should be taken as 0.4.

NA.2.20 Modification factor, k_{fl} [BS EN 1993-1-1:2005, 6.3.2.4(2)B]

The value of the modification factor k_{fl} should be taken as:

k_{fl} = 1.0 for hot rolled I-sections;

k_{fl} =1.0 for welded I-sections with $h/b \leqslant 2$;

k_{fl} = 0.9 for other sections.

NA.2.21 Interactions factors k_{yy}, k_{yz}, k_{zy} and k_{zz} [BS EN 1993-1-1:2005, 6.3.3(5)]

The interaction factors k_{yy}, k_{yz}, k_{zy}, k_{zz} for doubly symmetric sections may be determined using either alternative Method 1 (given in BS EN 1993-1-1:2005, Annex A) or alternative Method 2 (given in BS EN 1993-1-1:2005, Annex B). Alternative Method 2 (given in BS EN 1993-1-1:2005, Annex B) may also be used for sections that are not doubly symmetric when modified in accordance with **NA.3.2**.

NA.2.22 General method for lateral and lateral torsional buckling of structural components [BS EN 1993-1-1:2005, 6.3.4(1)]

This method is only valid for nominally straight components subject to in-plane monoaxial bending and/or compression.

In this method χ_{op} should be taken as the minimum value of χ and χ_{LT}. Where χ is determined in accordance with BS EN 1993-1-1:2005, **6.3.1** for lateral buckling and χ_{LT} is determined in accordance with BS EN 1993-1-1:2005, **6.3.2** for lateral torsional buckling

NA.2.23 Vertical deflections [BS EN 1993-1-1:2005, 7.2.1(1)B]

The following table gives suggested limits for calculated vertical deflections of certain members under the characteristic load combination due to variable loads and should not include permanent loads. Circumstances may arise where greater or lesser values would be more appropriate. Other members may also need deflection limits.

On low pitch and flat roofs the possibility of ponding should be investigated.

Vertical deflection	
Cantilevers	Length/180
Beams carrying plaster or other brittle finish	Span/360
Other beams (except purlins and sheeting rails)	Span/200
Purlins and sheeting rails	To suit the characteristics of particular cladding

NA.2.24 Horizontal deflections [BS EN 1993-1-1:2005, 7.2.2(1)B]

The following table gives suggested limits for calculated horizontal deflections of certain members under the characteristic load combination due to variable load. Circumstances may arise where greater or lesser values would be more appropriate. Other members may also need deflection limits.

Horizontal deflection	
Tops of columns in single-storey buildings except portal frames	Height/300
Columns in portal frame buildings, not supporting crane runways	To suit the characteristics of the particular cladding
In each storey of a building with more than one storey	Height of that storey/300

NA.2.25 Dynamic effects [BS EN 1993-1-1:2005, 7.2.3(1)B]

Reference should be made to specialist literature as appropriate. For floor vibrations see **NA.4**.

NA.2.26 Hollow section buckling lengths in lattice girders [BS EN 1993-1-1:2005, BB.1.3(3)B]

The recommended values may be used and further information is given in **NA.4**.

NA.3 Decisions on the status of informative annexes

NA.3.1 BS EN 1993-1-1:2005, Annex A

BS EN 1993-1-1:2005, Annex A may be used. The scope of Method 1 given in Annex A should be limited to doubly symmetric sections.

NA.3.2 BS EN 1993-1-1:2005, Annex B

BS EN 1993-1-1:2005, Annex B may be used.

Where applied to sections that are not doubly symmetric $\bar{\lambda}_z$ and χ_z should be taken as the values of $\bar{\lambda}$ and χ from the highest value of $\bar{\lambda}_T$ to BS EN 1993-1-1, 6.3.1.3 or $\bar{\lambda}$ to BS EN 1993-1-1, **6.3.1.4**.

Where the sections are not I, H or hollow sections Class 1 and Class 2 sections should be designed as Class 3 sections.

NA.3.3 BS EN 1993-1-1:2005, Annex AB

BS EN 1993-1-1:2005, Annex AB may be used.

NA.3.4 BS EN 1993-1-1:2005, Annex BB

BS EN 1993-1-1:2005, Annex BB may be used.

NA.4 References to non-contradictory complementary information

References cited in this National Annex to non-contradictory, complementary information can be found at www.steel-ncci.co.uk. Whilst this material is likely to be technically authoritative, not all of it has been reviewed by the UK national committee, and users should satisfy themselves of its fitness for their particular purpose. In particular, they should be aware that material indicated as not having been endorsed by the committee might contain elements that are in conflict with the Eurocode.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NA to BS EN 1991-1-5, *UK National Annex to Eurocode 3: Design of steel structures – Part 1-5: Plated structural elements*

BS EN 1993 (Parts 2 to 6), *Eurocode 3 – Design of steel structures*

NA to BS EN 1993-1-10[1)], *UK National Annex to Eurocode 3: Design of steel structures – Part 1-10: Material toughness and through-thickness properties*

BS EN 1993-1-12, *Eurocode 3: Design of steel structures – Part 1-12: Supplementary rules for high strength steels*

BS EN 10025-2:2004, *Hot rolled products of structural steels – Part 2: Technical delivery conditions for non-alloy structural steels*

BS EN 10250-2, *Open steel die forgings for general engineering purposes – Part 2: Non-alloy quality and special steels*

BS EN 10293, *Steel castings for general engineering uses*

Other publications

[1] Castings in steel construction, SCI publication P 172, The Steel Construction Institute, Silwood Park, Ascot, Berkshire SL5 7QN.

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Part 1-5: Plated structural elements

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British Standards

National foreword

This British Standard was published by BSI. It is the UK implementation of EN 1993-1-5:2006. It partially supersedes BS 449-2:1969, BS 5400-3:2000 and BS 5950-1:2000. These standards will be withdrawn by March 2010 at the latest.

The UK participation in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/31, Structural use of steel.

A list of organizations represented on B/525/31 can be obtained on request to its secretary.

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Eurocode 3 - Design of steel structures - Part 1-5: Plated structural elements

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Eurocode 3 - Bemessung und konstruktion von Stahlbauten - Teil 1-5: Plattenbeulen

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Ref. No. EN 1993-1-5:2006: E

Content

Foreword

This European Standard EN 1993-1-5,, Eurocode 3: Design of steel structures Part 1.5: Plated structural elements, 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 1993-1-5.

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 1993-1-5

This standard gives alternative procedures, values and recommendations with notes indicating where national choices may have to be made. The National Standard implementing EN 1993-1-5 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 1993-1-5 through:

- 2.2(5)
- 3.3(1)
- 4.3(6)
- 5.1(2)
- 6.4(2)
- 8(2)
- 9.1(1)
- 9.2.1(9)
- 10(1)
- 10(5)
- C.2(1)
- C.5(2)
- C.8(1)
- C.9(3)
- D.2.2(2)

1 Introduction

1.1 Scope

(1) EN 1993-1-5 gives design requirements of stiffened and unstiffened plates which are subject to in-plane forces.

(2) Effects due to shear lag, in-plane load introduction and plate buckling for I-section girders and box girders are covered. Also covered are plated structural components subject to in-plane loads as in tanks and silos. The effects of out-of-plane loading are outside the scope of this document.

NOTE 1: The rules in this part complement the rules for class 1, 2, 3 and 4 sections, see EN 1993-1-1.

NOTE 2: For the design of slender plates which are subject to repeated direct stress and/or shear and also fatigue due to out-of-plane bending of plate elements (breathing) see EN 1993-2 and EN 1993-6.

NOTE 3: For the effects of out-of-plane loading and for the combination of in-plane effects and out-of-plane loading effects see EN 1993-2 and EN 1993-1-7.

NOTE 4: Single plate elements may be considered as flat where the curvature radius r satisfies:

$$r \geq \frac{a^2}{t} \tag{1.1}$$

where a is the panel width

t is the plate thickness

1.2 Normative references

(1) This European Standard 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 Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 1993-1-1 *Eurocode 3 :Design of steel structures: Part 1-1: General rules and rules for buildings*

1.3 Terms and definitions

For the purpose of this standard, the following terms and definitions apply:

1.3.1
elastic critical stress
stress in a component at which the component becomes unstable when using small deflection elastic theory of a perfect structure

1.3.2
membrane stress
stress at mid-plane of the plate

1.3.3
gross cross-section
the total cross-sectional area of a member but excluding discontinuous longitudinal stiffeners

1.3.4
effective cross-section and effective width
the gross cross-section or width reduced for the effects of plate buckling or shear lag or both; to distinguish between their effects the word “effective” is clarified as follows:
“effective^{p}“ denotes effects of plate buckling

"effective^{s}" denotes effects of shear lag
"effective" denotes effects of plate buckling and shear lag

1.3.5
plated structure
a structure built up from nominally flat plates which are connected together; the plates may be stiffened or unstiffened

1.3.6
stiffener
a plate or section attached to a plate to resist buckling or to strengthen the plate; a stiffener is denoted:

- longitudinal if its direction is parallel to the member;
- transverse if its direction is perpendicular to the member.

1.3.7
stiffened plate
plate with transverse or longitudinal stiffeners or both

1.3.8
subpanel
unstiffened plate portion surrounded by flanges and/or stiffeners

1.3.9
hybrid girder
girder with flanges and web made of different steel grades; this standard assumes higher steel grade in flanges compared to webs

1.3.10
sign convention
unless otherwise stated compression is taken as positive

1.4 Symbols

(1) In addition to those given in EN 1990 and EN 1993-1-1, the following symbols are used:

$A_{s\ell}$ total area of all the longitudinal stiffeners of a stiffened plate;

A_{st} gross cross sectional area of one transverse stiffener;

A_{eff} effective cross sectional area;

$A_{c,eff}$ effective^{p} cross sectional area;

$A_{c,eff,loc}$ effective^{p} cross sectional area for local buckling;

a length of a stiffened or unstiffened plate;

b width of a stiffened or unstiffened plate;

b_{w} clear width between welds;

b_{eff} effective^{s} width for elastic shear lag;

F_{Ed} design transverse force;

h_{w} clear web depth between flanges;

L_{eff} effective length for resistance to transverse forces, see 6;

$M_{f.Rd}$ design plastic moment of resistance of a cross-section consisting of the flanges only;

$M_{pl.Rd}$ design plastic moment of resistance of the cross-section (irrespective of cross-section class);

M_{Ed} design bending moment;

N_{Ed} design axial force;

t thickness of the plate;

V_{Ed} design shear force including shear from torque;

W_{eff} effective elastic section modulus;

β effective^{s} width factor for elastic shear lag;

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

2 Basis of design and modelling

2.1 General

(1)P The effects of shear lag and plate buckling shall be taken into account at the ultimate, serviceability or fatigue limit states.

NOTE: Partial factors γ_{M0} and γ_{M1} used in this part are defined for different applications in the National Annexes of EN 1993-1 to EN 1993-6.

2.2 Effective width models for global analysis

(1)P The effects of shear lag and of plate buckling on the stiffness of members and joints shall be taken into account in the global analysis.

(2) The effects of shear lag of flanges in global analysis may be taken into account by the use of an effective^{s} width. For simplicity this effective^{s} width may be assumed to be uniform over the length of the span.

(3) For each span of a member the effective^{s} width of flanges should be taken as the lesser of the full width and $L/8$ per side of the web, where L is the span or twice the distance from the support to the end of a cantilever.

(4) The effects of plate buckling in elastic global analysis may be taken into account by effective^{p} cross sectional areas of the elements in compression, see 4.3.

(5) For global analysis the effect of plate buckling on the stiffness may be ignored when the effective^{p} cross-sectional area of an element in compression is larger than ρ_{lim} times the gross cross-sectional area of the same element.

NOTE 1: The parameter ρ_{lim} may be given in the National Annex. The value ρ_{lim} = 0,5 is recommended.

NOTE 2: For determining the stiffness when (5) is not fulfilled, see Annex E.

2.3 Plate buckling effects on uniform members

(1) Effective^{p} width models for direct stresses, resistance models for shear buckling and buckling due to transverse loads as well as interactions between these models for determining the resistance of uniform members at the ultimate limit state may be used when the following conditions apply:

- panels are rectangular and flanges are parallel;
- the diameter of any unstiffened open hole or cut out does not exceed $0{,}05b$, where b is the width of the panel.

NOTE: The rules may apply to non rectangular panels provided the angle α_{limit} (see Figure 2.1) is not greater than 10 degrees. If α_{limit} exceeds 10, panels may be assessed assuming it to be a rectangular panel based on the larger of b_1 and b_2 of the panel.

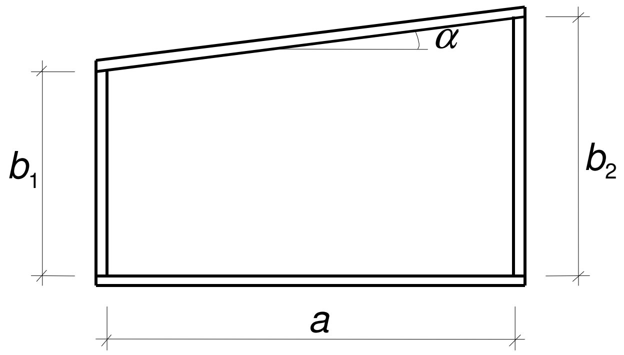


Figure 2.1: Definition of angle α

(2) For the calculation of stresses at the serviceability and fatigue limit state the effective^{s} area may be used if the condition in 3.1 is fulfilled. For ultimate limit states the effective area according to 3.3 should be used with β replaced by β_{ult}.

2.4 Reduced stress method

(1) As an alternative to the use of the effective^{p} width models for direct stresses given in sections 4 to 7, the cross sections may be assumed to be class 3 sections provided that the stresses in each panel do not exceed the limits specified in section 10.

NOTE: The reduced stress method is analogous to the effective^{p} width method (see 2.3) for single plated elements. However, in verifying the stress limitations no load shedding has been assumed between the plated elements of the cross section.

2.5 Non uniform members

(1) Non uniform members (e.g. haunched members, non rectangular panels) or members with regular or irregular large openings may be analysed using Finite Element (FE) methods.

NOTE 1: See Annex B for non uniform members.

NOTE 2: For FE-calculations see Annex C.

2.6 Members with corrugated webs

(1) For members with corrugated webs, the bending stiffness should be based on the flanges only and webs should be considered to transfer shear and transverse loads.

NOTE: For plate buckling resistance of flanges in compression and the shear resistance of webs see Annex D.

3 Shear lag in member design

3.1 General

(1) Shear lag in flanges may be neglected if $b_0 < L_e/50$ where b_0 is taken as the flange outstand or half the width of an internal element and L_e is the length between points of zero bending moment, see 3.2.1(2).

(2) Where the above limit for b_0 is exceeded the effects due to shear lag in flanges should be considered at serviceability and fatigue limit state verifications by the use of an effective[s] width according to 3.2.1 and a stress distribution according to 3.2.2. For the ultimate limit state verification an effective area according to 3.3 may be used.

(3) Stresses due to patch loading in the web applied at the flange level should be determined from 3.2.3.

3.2 Effective[s] width for elastic shear lag

3.2.1 Effective width

(1) The effective[s] width b_{eff} for shear lag under elastic conditions should be determined from:

$$b_{eff} = \beta\, b_0 \tag{3.1}$$

where the effective[s] factor β is given in Table 3.1.

This effective width may be relevant for serviceability and fatigue limit states.

(2) Provided adjacent spans do not differ more than 50% and any cantilever span is not larger than half the adjacent span the effective lengths L_e may be determined from Figure 3.1. For all other cases L_e should be taken as the distance between adjacent points of zero bending moment.

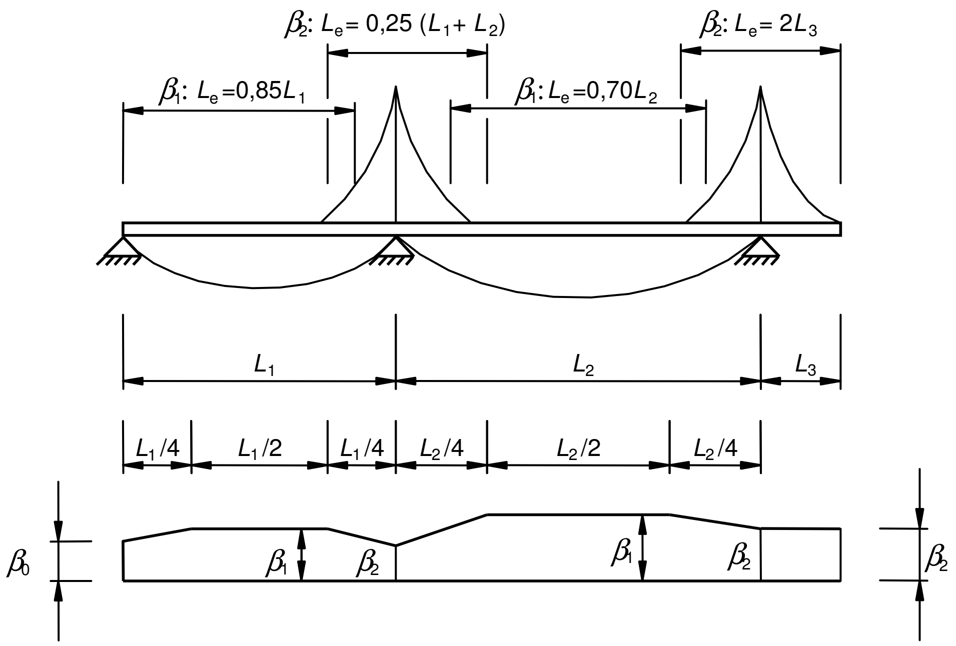
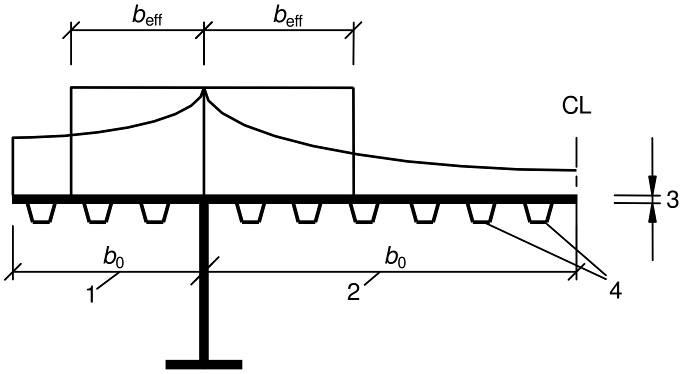


Figure 3.1: Effective length L_e for continuous beam and distribution of effective[s] width



1 for flange outstand
2 for internal flange
3 plate thickness t
4 stiffeners with $A_{s\ell} = \sum A_{s\ell i}$

Figure 3.2: Notations for shear lag

Table 3.1: Effective width factor β

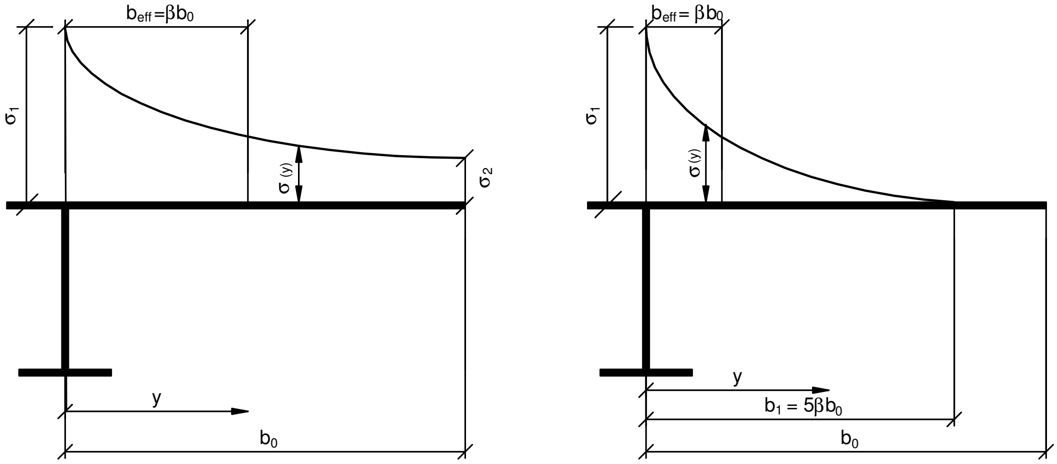
κ	Verification	β – value
$\kappa \le 0,02$		$\beta = 1,0$
$0,02 < \kappa \le 0,70$	sagging bending	$\beta = \beta_1 = \dfrac{1}{1+6,4\,\kappa^2}$
	hogging bending	$\beta = \beta_2 = \dfrac{1}{1+6,0\left(\kappa - \dfrac{1}{2500\,\kappa}\right)+1,6\,\kappa^2}$
$> 0,70$	sagging bending	$\beta = \beta_1 = \dfrac{1}{5,9\,\kappa}$
	hogging bending	$\beta = \beta_2 = \dfrac{1}{8,6\,\kappa}$
all κ	end support	$\beta_0 = (0,55 + 0,025 / \kappa)\,\beta_1$, but $\beta_0 < \beta_1$
all κ	Cantilever	$\beta = \beta_2$ at support and at the end

$\kappa = \alpha_0\, b_0 / L_e$ with $\alpha_0 = \sqrt{1 + \dfrac{A_{s\ell}}{b_0 t}}$

in which $A_{s\ell}$ is the area of all longitudinal stiffeners within the width b_0 and other symbols are as defined in Figure 3.1 and Figure 3.2.

3.2.2 Stress distribution due to shear lag

(1) The distribution of longitudinal stresses across the flange plate due to shear lag should be obtained from Figure 3.3.



$$\beta > 0{,}20:$$
$$\sigma_2 = 1{,}25\,(\beta - 0{,}20)\,\sigma_1$$
$$\sigma(y) = \sigma_2 + (\sigma_1 - \sigma_2)\,(1 - y/b_0)^4$$

$$\beta \le 0{,}20:$$
$$\sigma_2 = 0$$
$$\sigma(y) = \sigma_1 (1 - y/b_1)^4$$

σ_1 is calculated with the effective width of the flange b_{eff}

Figure 3.3: Distribution of stresses due to shear lag

3.2.3 In-plane load effects

(1) The elastic stress distribution in a stiffened or unstiffened plate due to the local introduction of in-plane forces (patch loads), see Figure 3.4, should be determined from:

$$\sigma_{z,Ed} = \frac{F_{Ed}}{b_{eff}\left(t_w + a_{st,l}\right)} \tag{3.2}$$

with: $b_{eff} = s_e \sqrt{1 + \left(\frac{z}{s_e\ n}\right)^2}$

$$n = 0{,}636 \sqrt{1 + \frac{0{,}878\ a_{st,1}}{t_w}}$$

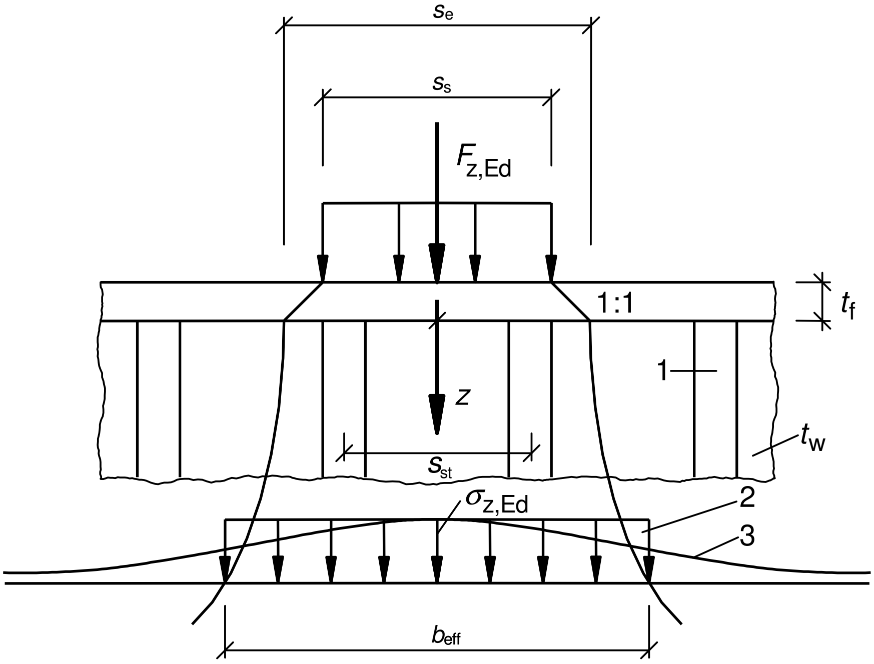
$$s_e = s_s + 2\,t_f$$

where $a_{\mathrm{st,1}}$ is the gross cross-sectional area of the stiffeners smeared over the length s_e. This may be taken, conservatively, as the area of the stiffeners divided by the spacing s_{st};

t_w is the web thickness;

z is the distance to flange.

NOTE: The equation (3.2) is valid when $s_{st}/s_e \le 0{,}5$; otherwise the contribution of stiffeners should be neglected.



1 stiffener
2 simplified stress distribution
3 actual stress distribution

Figure 3.4: In-plane load introduction

NOTE: The above stress distribution may also be used for the fatigue verification.

3.3 Shear lag at the ultimate limit state

(1) At the ultimate limit state shear lag effects may be determined as follows:

a) elastic shear lag effects as determined for serviceability and fatigue limit states,

b) combined effects of shear lag and of plate buckling,

c) elastic-plastic shear lag effects allowing for limited plastic strains.

NOTE 1: The National Annex may choose the method to be applied. Unless specified otherwise in EN 1993-2 to EN 1993-6, the method in NOTE 3 is recommended.

NOTE 2: The combined effects of plate buckling and shear lag may be taken into account by using A_{eff} as given by:

$$A_{eff} = A_{c,eff}\,\beta_{ult} \tag{3.3}$$

where $A_{\mathrm{c,eff}}$ is the effective[p] area of the compression flange due to plate buckling (see 4.4 and 4.5);

β_{ult} is the effective[s] width factor for the effect of shear lag at the ultimate limit state, which may be taken as β determined from Table 3.1 with α_0 replaced by

$$\alpha_0^* = \sqrt{\frac{A_{c,eff}}{b_0\ t_f}} \tag{3.4}$$

t_{f} is the flange thickness.

NOTE 3: Elastic-plastic shear lag effects allowing for limited plastic strains may be taken into account using A_{eff} as follows:

$$A_{eff} = A_{c,eff} \beta^{\kappa} \geq A_{c,eff} \beta \tag{3.5}$$

where β and κ are taken from Table 3.1.

The expressions in NOTE 2 and NOTE 3 may also be applied for flanges in tension in which case $A_{c,eff}$ should be replaced by the gross area of the tension flange.

4 Plate buckling effects due to direct stresses at the ultimate limit state

4.1 General

(1) This section gives rules to account for plate buckling effects from direct stresses at the ultimate limit state when the following criteria are met:

a) The panels are rectangular and flanges are parallel or nearly parallel (see 2.3);

b) Stiffeners, if any, are provided in the longitudinal or transverse direction or both;

c) Open holes and cut outs are small (see 2.3);

d) Members are of uniform cross section;

e) No flange induced web buckling occurs.

NOTE 1: For compression flange buckling in the plane of the web see section 8.

NOTE 2: For stiffeners and detailing of plated members subject to plate buckling see section 9.

4.2 Resistance to direct stresses

(1) The resistance of plated members may be determined using the effective areas of plate elements in compression for class 4 sections using cross sectional data (A_{eff}, I_{eff}, W_{eff}) for cross sectional verifications and member verifications for column buckling and lateral torsional buckling according to EN 1993-1-1.

(2) Effective[p] areas should be determined on the basis of the linear strain distributions with the attainment of yield strain in the mid plane of the compression plate.

4.3 Effective cross section

(1) In calculating longitudinal stresses, account should be taken of the combined effect of shear lag and plate buckling using the effective areas given in 3.3.

(2) The effective cross sectional properties of members should be based on the effective areas of the compression elements and on the effective[s] area of the tension elements due to shear lag.

(3) The effective area A_{eff} should be determined assuming that the cross section is subject only to stresses due to uniform axial compression. For non-symmetrical cross sections the possible shift e_N of the centroid of the effective area A_{eff} relative to the centre of gravity of the gross cross-section, see Figure 4.1, gives an additional moment which should be taken into account in the cross section verification using 4.6.

(4) The effective section modulus W_{eff} should be determined assuming the cross section is subject only to bending stresses, see Figure 4.2. For biaxial bending effective section moduli should be determined about both main axes.

NOTE: As an alternative to 4.3(3) and (4) a single effective section may be determined from N_{Ed} and M_{Ed} acting simultaneously. The effects of e_N should be taken into account as in 4.3(3). This requires an iterative procedure.

(5) The stress in a flange should be calculated using the elastic section modulus with reference to the mid-plane of the flange.

(6) Hybrid girders may have flange material with yield strength f_{yf} up to $\phi_h \times f_{yw}$ provided that:

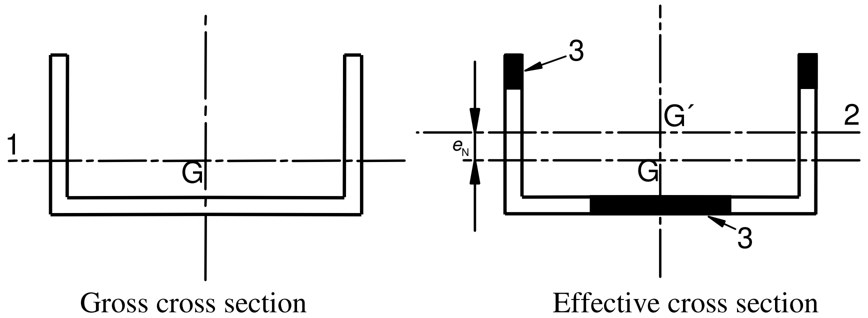
a) the increase of flange stresses caused by yielding of the web is taken into account by limiting the stresses in the web to f_{yw} ;

b) f_{yf} (rather than f_{yw}) is used in determining the effective area of the web.

NOTE: The National Annex may specify the value ϕ_h. A value of ϕ_h = 2,0 is recommended.

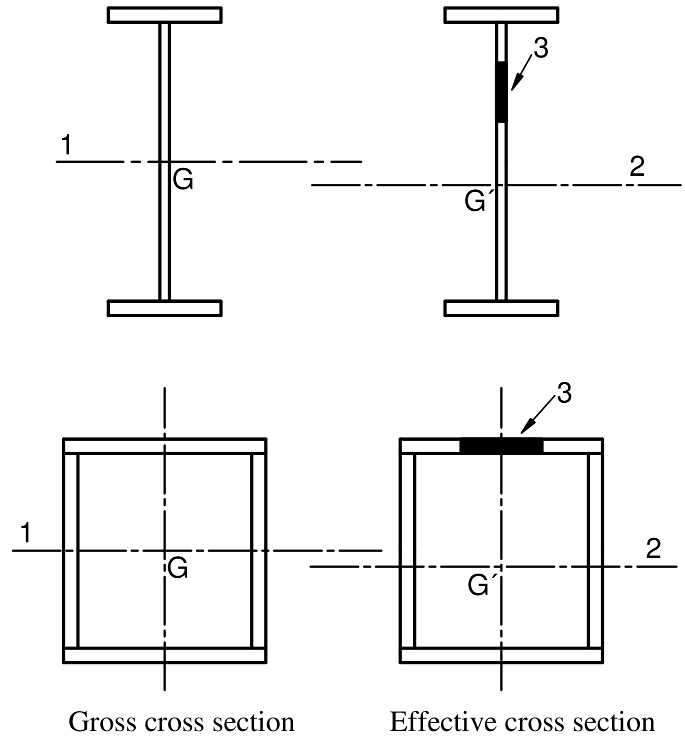
(7) The increase of deformations and of stresses at serviceability and fatigue limit states may be ignored for hybrid girders complying with 4.3(6) including the NOTE.

(8) For hybrid girders complying with 4.3(6) the stress range limit in EN 1993-1-9 may be taken as $1,5 f_{yf}$.



G centroid of the gross cross section
G´ centroid of the effective cross section
1 centroidal axis of the gross cross section
2 centroidal axis of the effective cross section
3 non effective zone

Figure 4.1: Class 4 cross-sections - axial force



G centroid of the gross cross section
G´ centroid of the effective cross section
1 centroidal axis of the gross cross section
2 centroidal axis of the effective cross section
3 non effective zone

Figure 4.2: Class 4 cross-sections - bending moment

4.4 Plate elements without longitudinal stiffeners

(1) The effective[p] areas of flat compression elements should be obtained using Table 4.1 for internal elements and Table 4.2 for outstand elements. The effective[p] area of the compression zone of a plate with the gross cross-sectional area A_c should be obtained from:

$$A_{c,eff} = \rho\, A_c \tag{4.1}$$

where ρ is the reduction factor for plate buckling.

(2) The reduction factor ρ may be taken as follows:

– internal compression elements:

$\rho = 1{,}0$ for $\overline{\lambda}_p \leq 0{,}673$

$$\rho = \frac{\overline{\lambda}_p - 0{,}055\,(3+\psi)}{\overline{\lambda}_p^2} \leq 1{,}0 \quad \text{for } \overline{\lambda}_p > 0{,}673 \text{ , where } (3+\psi) \geq 0 \tag{4.2}$$

– outstand compression elements:

$\rho = 1{,}0$ for $\overline{\lambda}_p \leq 0{,}748$

$$\rho = \frac{\overline{\lambda}_p - 0{,}188}{\overline{\lambda}_p^2} \leq 1{,}0 \quad \text{for } \overline{\lambda}_p > 0{,}748 \tag{4.3}$$

where $\overline{\lambda}_p = \sqrt{\dfrac{f_y}{\sigma_{cr}}} = \dfrac{\overline{b}/t}{28{,}4\,\varepsilon\,\sqrt{k_\sigma}}$

ψ is the stress ratio determined in accordance with 4.4(3) and 4.4(4)

$\overline{b}$ is the appropriate width to be taken as follows (for definitions, see Table 5.2 of EN 1993-1-1)

- b_w for webs;
- b for internal flange elements (except RHS);
- b - 3 t for flanges of RHS;
- c for outstand flanges;
- h for equal-leg angles;
- h for unequal-leg angles;

k_σ is the buckling factor corresponding to the stress ratio ψ and boundary conditions. For long plates k_σ is given in Table 4.1 or Table 4.2 as appropriate;

t is the thickness;

σ_{cr} is the elastic critical plate buckling stress see equation (A.1) in Annex A.1(2) and Table 4.1 and Table 4.2;

$$\varepsilon = \sqrt{\frac{235}{f_y\left[N/mm^2\right]}}$$

(3) For flange elements of I-sections and box girders the stress ratio ψ used in Table 4.1 and Table 4.2 should be based on the properties of the gross cross-sectional area, due allowance being made for shear lag in the flanges if relevant. For web elements the stress ratio ψ used in Table 4.1 should be obtained using a stress distribution based on the effective area of the compression flange and the gross area of the web.

NOTE: If the stress distribution results from different stages of construction (as e.g. in a composite bridge) the stresses from the various stages may first be calculated with a cross section consisting of effective flanges and gross web and these stresses are added together. This resulting stress distribution determines an effective web section that can be used for all stages to calculate the final stress distribution for stress analysis.

(4) Except as given in 4.4(5), the plate slenderness $\overline{\lambda}_p$ of an element may be replaced by:

$$\overline{\lambda}_{p,red} = \overline{\lambda}_p \sqrt{\frac{\sigma_{com,Ed}}{f_y / \gamma_{M0}}} \tag{4.4}$$

where $\sigma_{\mathrm{com,Ed}}$ is the maximum design compressive stress in the element determined using the effective[p] area of the section caused by all simultaneous actions.

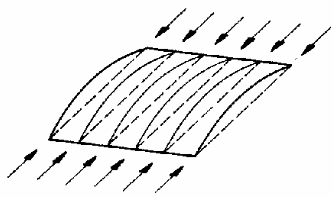
NOTE 1: The above procedure is conservative and requires an iterative calculation in which the stress ratio ψ (see Table 4.1 and Table 4.2) is determined at each step from the stresses calculated on the effective[p] cross-section defined at the end of the previous step.

NOTE 2: See also alternative procedure in Annex E.

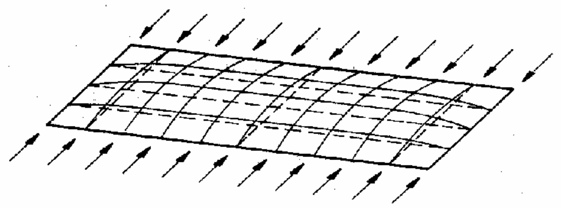
(5) For the verification of the design buckling resistance of a class 4 member using 6.3.1, 6.3.2 or 6.3.4 of EN 1993-1-1, either the plate slenderness $\overline{\lambda}_p$ or $\overline{\lambda}_{p,red}$ with $\sigma_{\mathrm{com,Ed}}$ based on second order analysis with global imperfections should be used.

(6) For aspect ratios $a/b < 1$ a column type of buckling may occur and the check should be performed according to 4.5.4 using the reduction factor ρ_c.

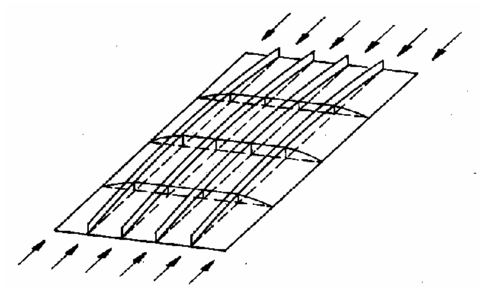
NOTE: This applies e.g. for flat elements between transverse stiffeners where plate buckling could be column-like and require a reduction factor ρ_c close to χ_c as for column buckling, see Figure 4.3 a) and b). For plates with longitudinal stiffeners column type buckling may also occur for $a/b \geq 1$, see Figure 4.3 c).



a) column-like behaviour of plates without longitudinal supports



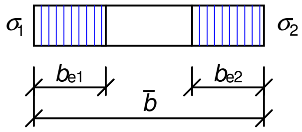
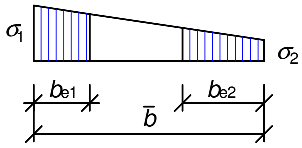
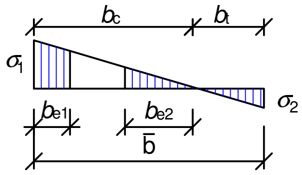
b) column-like behaviour of an unstiffened plate with a small aspect ratio α



c) column-like behaviour of a longitudinally stiffened plate with a large aspect ratio α

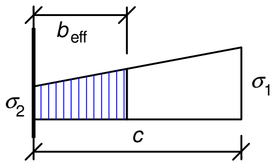
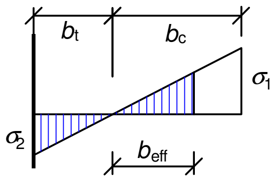
Figure 4.3: Column-like behaviour

Table 4.1: Internal compression elements

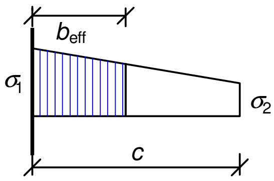
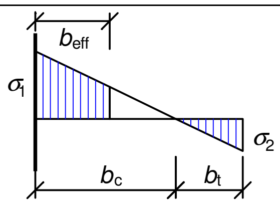
Stress distribution (compression positive)	Effective^{p} width b_{eff}
	$\underline{\psi = 1}$: $b_{eff} = \rho\ \bar{b}$ $b_{e1} = 0{,}5\ b_{eff}$ $\quad b_{e2} = 0{,}5\ b_{eff}$
	$\underline{1 > \psi \geq 0}$: $b_{eff} = \rho\ \bar{b}$ $b_{e1} = \dfrac{2}{5-\psi} b_{eff}$ $\quad b_{e2} = b_{eff} - b_{e1}$
	$\underline{\psi < 0}$: $b_{eff} = \rho\ b_c = \rho\ \bar{b}\ / (1-\psi)$ $b_{e1} = 0{,}4\ b_{eff}$ $\quad b_{e2} = 0{,}6\ b_{eff}$

$\psi = \sigma_2/\sigma_1$	1	$1 > \psi > 0$	0	$0 > \psi > -1$	-1	$-1 > \psi > -3$
Buckling factor k_σ	4,0	$8{,}2\ /\ (1{,}05 + \psi)$	7,81	$7{,}81 - 6{,}29\psi + 9{,}78\psi^2$	23,9	$5{,}98\ (1 - \psi)^2$

Table 4.2: Outstand compression elements

Stress distribution (compression positive)	Effective^{p} width b_{eff}
	$\underline{1 > \psi \geq 0}$: $b_{eff} = \rho\ c$
	$\underline{\psi < 0}$: $b_{eff} = \rho\ b_c = \rho\ c\ / (1-\psi)$

$\psi = \sigma_2/\sigma_1$	1	0	-1	$1 \geq \psi \geq -3$
Buckling factor k_σ	0,43	0,57	0,85	$0{,}57 - 0{,}21\psi + 0{,}07\psi^2$

Stress distribution (compression positive)	Effective^{p} width b_{eff}
	$\underline{1 > \psi \geq 0}$: $b_{eff} = \rho\ c$
	$\underline{\psi < 0}$: $b_{eff} = \rho\ b_c = \rho\ c\ / (1-\psi)$

$\psi = \sigma_2/\sigma_1$	1	$1 > \psi > 0$	0	$0 > \psi > -1$	-1
Buckling factor k_σ	0,43	$0{,}578\ /\ (\psi + 0{,}34)$	1,70	$1{,}7 - 5\psi + 17{,}1\psi^2$	23,8

4.5 Stiffened plate elements with longitudinal stiffeners

4.5.1 General

(1) For plates with longitudinal stiffeners the effective^{p} areas from local buckling of the various subpanels between the stiffeners and the effective^{p} areas from the global buckling of the stiffened panel should be accounted for.

(2) The effective^{p} section area of each subpanel should be determined by a reduction factor in accordance with 4.4 to account for local plate buckling. The stiffened plate with effective^{p} section areas for the stiffeners should be checked for global plate buckling (by modelling it as an equivalent orthotropic plate) and a reduction factor ρ should be determined for overall plate buckling.

(3) The effective^{p} area of the compression zone of the stiffened plate should be taken as:

$$A_{c,eff} = \rho_c \ A_{c,eff,loc} + \sum b_{edge,eff}\, t \tag{4.5}$$

where $A_{c,eff,loc}$ is the effective^{p} section areas of all the stiffeners and subpanels that are fully or partially in the compression zone except the effective parts supported by an adjacent plate element with the width $b_{edge,eff}$, see example in Figure 4.4.

(4) The area $A_{c,eff,loc}$ should be obtained from:

$$A_{c,eff,loc} = A_{s\ell,eff} + \sum_c \rho_{loc}\ b_{c,loc}\ t \tag{4.6}$$

where $\sum_c$ applies to the part of the stiffened panel width that is in compression except the parts $b_{edge,eff}$, see Figure 4.4;

$A_{s\ell,eff}$ is the sum of the effective^{p} sections according to 4.4 of all longitudinal stiffeners with gross area $A_{s\ell}$ located in the compression zone;

$b_{c,loc}$ is the width of the compressed part of each subpanel;

ρ_{loc} is the reduction factor from 4.4(2) for each subpanel.

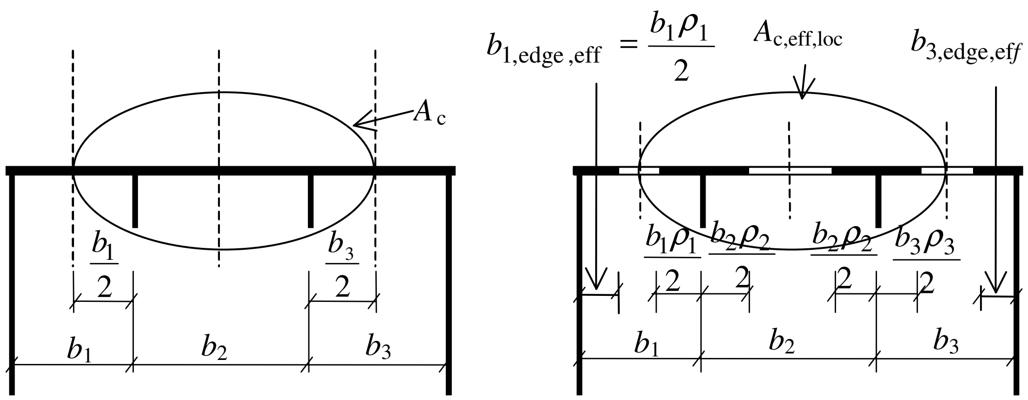


Figure 4.4: Stiffened plate under uniform compression

NOTE: For non-uniform compression see Figure A.1.

(5) In determining the reduction factor ρ_c for overall buckling, the reduction factor for column-type buckling, which is more severe than the reduction factor than for plate buckling, should be considered.

(6) Interpolation should be carried out in accordance with 4.5.4(1) between the reduction factor ρ for plate buckling and the reduction factor χ_c for column buckling to determine ρ_c see 4.5.4.

(7) The reduction of the compressed area $A_{c,eff,loc}$ through ρ_c may be taken as a uniform reduction across the whole cross section.

(8) If shear lag is relevant (see 3.3), the effective cross-sectional area $A_{c,eff}$ of the compression zone of the stiffened plate should then be taken as $A^*_{c,eff}$ accounting not only for local plate buckling effects but also for shear lag effects.

(9) The effective cross-sectional area of the tension zone of the stiffened plate should be taken as the gross area of the tension zone reduced for shear lag if relevant, see 3.3.

(10) The effective section modulus W_{eff} should be taken as the second moment of area of the effective cross section divided by the distance from its centroid to the mid depth of the flange plate.

4.5.2 Plate type behaviour

(1) The relative plate slenderness $\overline{\lambda}_p$ of the equivalent plate is defined as:

$$\overline{\lambda}_p = \sqrt{\frac{\beta_{A,c}\, f_y}{\sigma_{cr,p}}} \tag{4.7}$$

with $\beta_{A,c} = \dfrac{A_{c,eff,loc}}{A_c}$

where A_c is the gross area of the compression zone of the stiffened plate except the parts of subpanels supported by an adjacent plate, see Figure 4.4 (to be multiplied by the shear lag factor if shear lag is relevant, see 3.3);

$A_{c,eff,loc}$ is the effective area of the same part of the plate (including shear lag effect, if relevant) with due allowance made for possible plate buckling of subpanels and/or stiffeners.

(2) The reduction factor ρ for the equivalent orthotropic plate is obtained from 4.4(2) provided $\overline{\lambda}_p$ is calculated from equation (4.7).

NOTE: For calculation of $\sigma_{cr,p}$ see Annex A.

4.5.3 Column type buckling behaviour

(1) The elastic critical column buckling stress $\sigma_{cr,c}$ of an unstiffened (see 4.4) or stiffened (see 4.5) plate should be taken as the buckling stress with the supports along the longitudinal edges removed.

(2) For an unstiffened plate the elastic critical column buckling stress $\sigma_{cr,c}$ may be obtained from

$$\sigma_{cr,c} = \frac{\pi^2\, E\, t^2}{12\left(1-\nu^2\right)a^2} \tag{4.8}$$

(3) For a stiffened plate $\sigma_{cr,c}$ may be determined from the elastic critical column buckling stress $\sigma_{cr,sl}$ of the stiffener closest to the panel edge with the highest compressive stress as follows:

$$\sigma_{cr,s\ell} = \frac{\pi^2\, E\, I_{s\ell,1}}{A_{s\ell,1}\, a^2} \tag{4.9}$$

where $I_{s\ell,1}$ is the second moment of area of the gross cross section of the stiffener and the adjacent parts of the plate, relative to the out-of-plane bending of the plate;

$A_{s\ell,1}$ is the gross cross-sectional area of the stiffener and the adjacent parts of the plate according to Figure A.1.

NOTE: $\sigma_{cr,c}$ may be obtained from $\sigma_{cr,c} = \sigma_{cr,s\ell} \dfrac{b_c}{b_{s\ell,1}}$, where $\sigma_{cr,c}$ is related to the compressed edge of the plate, and , b_{sl1} and b_c are geometric values from the stress distribution used for the extrapolation, see Figure A.1.

(4) The relative column slenderness $\bar{\lambda}_c$ is defined as follows:

$$\bar{\lambda}_c = \sqrt{\frac{f_y}{\sigma_{cr,c}}} \quad \text{for unstiffened plates} \tag{4.10}$$

$$\bar{\lambda}_c = \sqrt{\frac{\beta_{A,c}\, f_y}{\sigma_{cr,c}}} \quad \text{for stiffened plates} \tag{4.11}$$

with $\beta_{A,c} = \dfrac{A_{s\ell,1,eff}}{A_{s\ell,1}}$;

$A_{s\ell,1}$ is defined in 4.5.3(3);

$A_{s\ell,1,eff}$ is the effective cross-sectional area of the stiffener and the adjacent parts of the plate with due allowance for plate buckling, see Figure A.1.

(5) The reduction factor χ_c should be obtained from 6.3.1.2 of EN 1993-1-1. For unstiffened plates $\alpha = 0{,}21$ corresponding to buckling curve a should be used. For stiffened plates its value should be increased to:

$$\alpha_e = \alpha + \frac{0{,}09}{i/e} \tag{4.12}$$

with $i = \sqrt{\dfrac{I_{s\ell,1}}{A_{s\ell,1}}}$

e = max (e_1, e_2) is the largest distance from the respective centroids of the plating and the one-sided stiffener (or of the centroids of either set of stiffeners when present on both sides) to the neutral axis of the effective column, see Figure A.1;

α = 0,34 (curve b) for closed section stiffeners;

= 0,49 (curve c) for open section stiffeners.

4.5.4 Interaction between plate and column buckling

(1) The final reduction factor ρ_c should be obtained by interpolation between χ_c and ρ as follows:

$$\rho_c = (\rho - \chi_c)\,\xi\,(2-\xi) + \chi_c \tag{4.13}$$

where $\xi = \dfrac{\sigma_{cr,p}}{\sigma_{cr,c}} - 1$ but $0 \le \xi \le 1$

$\sigma_{cr,p}$ is the elastic critical plate buckling stress, see Annex A.1(2);

$\sigma_{cr,c}$ is the elastic critical column buckling stress according to 4.5.3(2) and (3), respectively;

χ_c is the reduction factor due to column buckling.

ρ is the reduction factor due to plate buckling, see 4.4(1).

4.6 Verification

(1) Member verification for uniaxial bending should be performed as follows:

$$\eta_1 = \frac{N_{Ed}}{\frac{f_y\ A_{eff}}{\gamma_{M0}}} + \frac{M_{Ed} + N_{Ed}\ e_N}{\frac{f_y\ W_{eff}}{\gamma_{M0}}} \leq 1{,}0 \quad (4.14)$$

where A_{eff} is the effective cross-section area in accordance with 4.3(3);

e_N is the shift in the position of neutral axis, see 4.3(3);

M_{Ed} is the design bending moment;

N_{Ed} is the design axial force;

W_{eff} is the effective elastic section modulus, see 4.3(4);

γ_{M0} is the partial factor, see application parts EN 1993-2 to 6.

NOTE: For members subject to compression and biaxial bending the above equation (4.14) may be modified as follows:

$$\eta_1 = \frac{N_{Ed}}{\frac{f_y\ A_{eff}}{\gamma_{M0}}} + \frac{M_{y,Ed} + N_{Ed}\ e_{y,N}}{\frac{f_y\ W_{y,eff}}{\gamma_{M0}}} + \frac{M_{z,Ed} + N_{Ed}\ e_{z,N}}{\frac{f_y\ W_{z,eff}}{\gamma_{M0}}} \leq 1{,}0 \quad (4.15)$$

$M_{y,Ed}$, $M_{z,Ed}$ are the design bending moments with respect to y–y and z–z axes respectively;

e_{yN}, e_{zN} are the eccentricities with respect to the neutral axis.

(2) Action effects M_{Ed} and N_{Ed} should include global second order effects where relevant.

(3) The plate buckling verification of the panel should be carried out for the stress resultants at a distance 0,4a or 0,5b, whichever is the smallest, from the panel end where the stresses are the greater. In this case the gross sectional resistance needs to be checked at the end of the panel.

5 Resistance to shear

5.1 Basis

(1) This section gives rules for shear resistance of plates considering shear buckling at the ultimate limit state where the following criteria are met:

a) the panels are rectangular within the angle limit stated in 2.3;

b) stiffeners, if any, are provided in the longitudinal or transverse direction or both;

c) all holes and cut outs are small (see 2.3);

d) members are of uniform cross section.

(2) Plates with h_w/t greater than $\frac{72}{\eta}\varepsilon$ for an unstiffened web, or $\frac{31}{\eta}\varepsilon\sqrt{k_\tau}$ for a stiffened web, should be checked for resistance to shear buckling and should be provided with transverse stiffeners at the supports, where $\varepsilon = \sqrt{\frac{235}{f_y\left[N/mm^2\right]}}$.

NOTE 1: h_w see Figure 5.1 and for k_τ see 5.3(3).

NOTE 2: The National Annex will define η. The value η = 1,20 is recommended for steel grades up to and including S460. For higher steel grades η = 1,00 is recommended.

5.2 Design resistance

(1) For unstiffened or stiffened webs the design resistance for shear should be taken as:

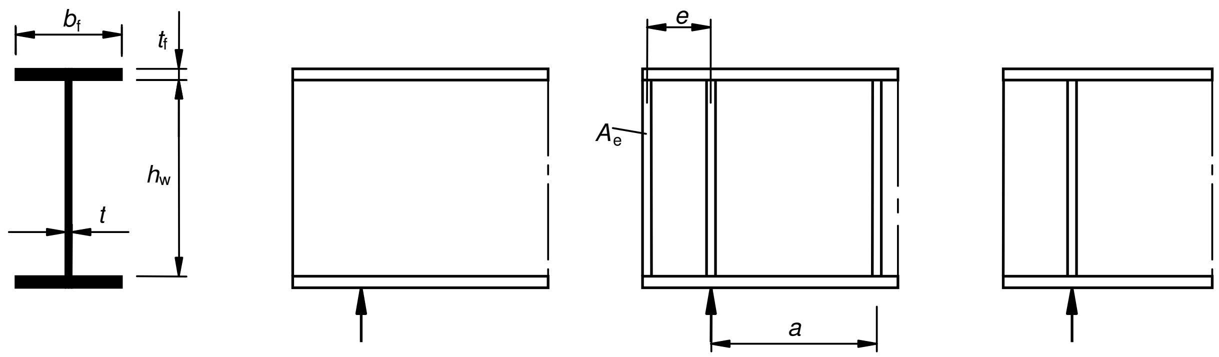
$$V_{b,Rd} = V_{bw,Rd} + V_{bf,Rd} \leq \frac{\eta\, f_{yw}\, h_w\, t}{\sqrt{3}\,\gamma_{M1}} \tag{5.1}$$

in which the contribution from the web is given by:

$$V_{bw,Rd} = \frac{\chi_w\, f_{yw}\, h_w\, t}{\sqrt{3}\,\gamma_{M1}} \tag{5.2}$$

and the contribution from the flanges $V_{bf,Rd}$ is according to 5.4.

(2) Stiffeners should comply with the requirements in 9.3 and welds should fulfil the requirement given in 9.3.5.



Cross section notations   a) No end post   b) Rigid end post   c) Non-rigid end post

Figure 5.1: End supports

5.3 Contribution from the web

(1) For webs with transverse stiffeners at supports only and for webs with either intermediate transverse stiffeners or longitudinal stiffeners or both, the factor χ_w for the contribution of the web to the shear buckling resistance should be obtained from Table 5.1 or Figure 5.2.

Table 5.1: Contribution from the web χ_w to shear buckling resistance

	Rigid end post	Non-rigid end post
$\bar{\lambda}_w < 0{,}83/\eta$	η	η
$0{,}83/\eta \leq \bar{\lambda}_w < 1{,}08$	$0{,}83/\bar{\lambda}_w$	$0{,}83/\bar{\lambda}_w$
$\bar{\lambda}_w \geq 1{,}08$	$1{,}37/(0{,}7+\bar{\lambda}_w)$	$0{,}83/\bar{\lambda}_w$

NOTE: See 6.2.6 in EN 1993-1-1.

(2) Figure 5.1 shows various end supports for girders:

a) No end post, see 6.1 (2), type c);

b) Rigid end posts, see 9.3.1; this case is also applicable for panels at an intermediate support of a continuous girder;

c) Non rigid end posts see 9.3.2.

(3) The slenderness parameter $\overline{\lambda}_w$ in Table 5.1 and Figure 5.2 should be taken as:

$$\overline{\lambda}_w = 0{,}76\sqrt{\frac{f_{yw}}{\tau_{cr}}} \tag{5.3}$$

where $\tau_{cr} = k_\tau\ \sigma_E$ (5.4)

NOTE 1: Values for σ_E and k_τ may be taken from Annex A.

NOTE 2: The slenderness parameter $\overline{\lambda}_w$ may be taken as follows:

a) transverse stiffeners at supports only:

$$\overline{\lambda}_w = \frac{h_w}{86{,}4\, t\, \varepsilon} \tag{5.5}$$

b) transverse stiffeners at supports and intermediate transverse or longitudinal stiffeners or both:

$$\overline{\lambda}_w = \frac{h_w}{37{,}4\, t\, \varepsilon\, \sqrt{k_\tau}} \tag{5.6}$$

in which k_τ is the minimum shear buckling coefficient for the web panel.

NOTE 3: Where non-rigid transverse stiffeners are also used in addition to rigid transverse stiffeners, k_τ is taken as the minimum of the values from the web panels between any two transverse stiffeners (e.g. $a_2 \times h_w$ and $a_3 \times h_w$) and that between two rigid stiffeners containing non-rigid transverse stiffeners (e.g. $a_4 \times h_w$).

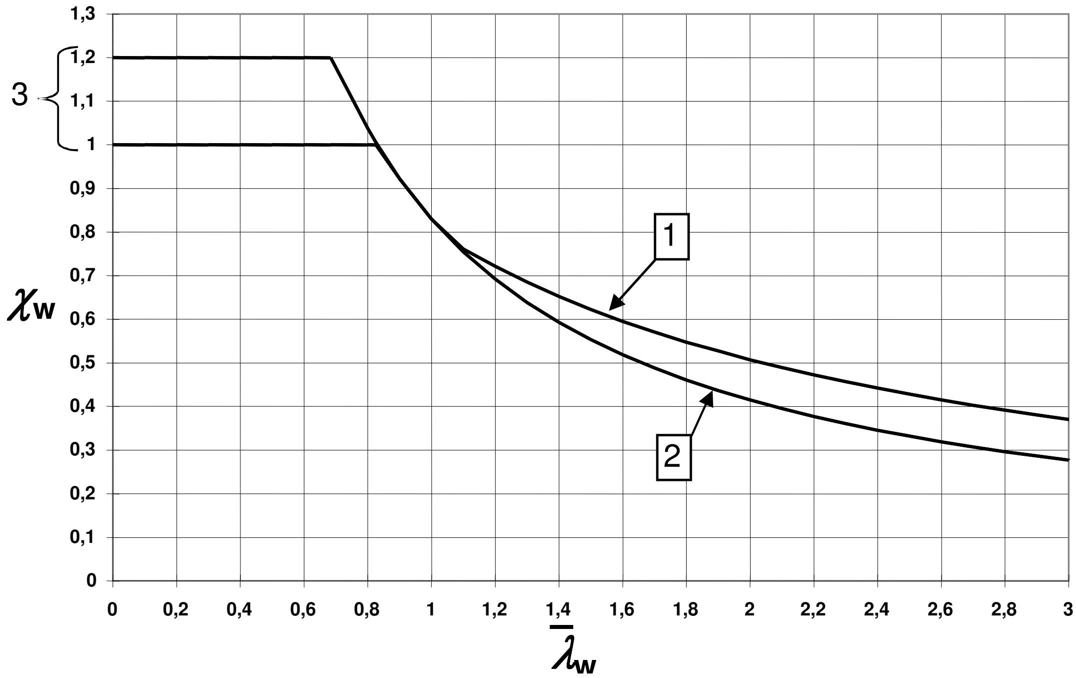
NOTE 4: Rigid boundaries may be assumed for panels bordered by flanges and rigid transverse stiffeners. The web buckling analysis can then be based on the panels between two adjacent transverse stiffeners (e.g. $a_1 \times h_w$ in Figure 5.3).

NOTE 5: For non-rigid transverse stiffeners the minimum value k_τ may be obtained from the buckling analysis of the following:

1. a combination of two adjacent web panels with one flexible transverse stiffener
2. a combination of three adjacent web panels with two flexible transverse stiffeners

For procedure to determine k_τ see Annex A.3.

(4) The second moment of area of a longitudinal stiffener should be reduced to 1/3 of its actual value when calculating k_τ. Formulae for k_τ taking this reduction into account in A.3 may be used.



1 Rigid end post
2 Non-rigid end post
3 Range of recommended η

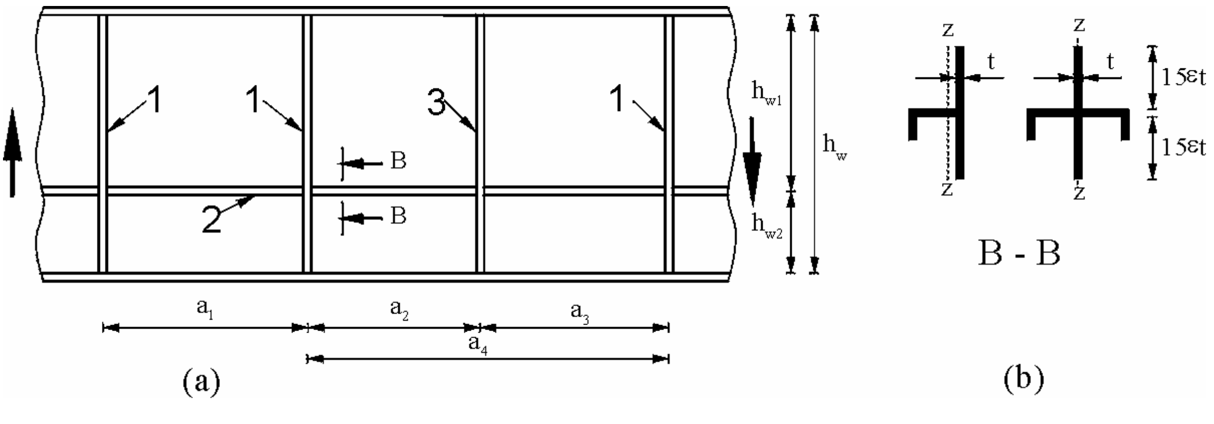
Figure 5.2: Shear buckling factor χ_w

(5) For webs with longitudinal stiffeners the slenderness parameter $\bar{\lambda}_w$ in (3) should not be taken as less than

$$\bar{\lambda}_w = \frac{h_{wi}}{37{,}4\, t\, \varepsilon \sqrt{k_{\tau i}}} \tag{5.7}$$

where h_{wi} and $k_{\tau i}$ refer to the subpanel with the largest slenderness parameter $\bar{\lambda}_w$ of all subpanels within the web panel under consideration.

NOTE: To calculate $k_{\tau i}$ the expression given in A.3 may be used with $k_{\tau st} = 0$.



1 Rigid transverse stiffener
2 Longitudinal stiffener
3 Non-rigid transverse stiffener

Figure 5.3: Web with transverse and longitudinal stiffeners

5.4 Contribution from flanges

(1) When the flange resistance is not completely utilized in resisting the bending moment ($M_{Ed} < M_{f,Rd}$) the contribution from the flanges should be obtained as follows:

$$V_{bf,Rd} = \frac{b_f\, t_f^2\, f_{yf}}{c\, \gamma_{M1}} \left(1 - \left(\frac{M_{Ed}}{M_{f,Rd}} \right)^2 \right) \tag{5.8}$$

b_f and t_f are taken for the flange which provides the least axial resistance,

b_f being taken as not larger than $15\varepsilon t_f$ on each side of the web,

$M_{f,Rd} = \dfrac{M_{f,k}}{\gamma_{M0}}$ is the moment of resistance of the cross section consisting of the effective area of the flanges only,

$$c = a \left(0{,}25 + \frac{1{,}6\, b_f t_f^2\, f_{yf}}{t\, h_w^2\, f_{yw}} \right)$$

(2) When an axial force N_{Ed} is present, the value of $M_{f,Rd}$ should be reduced by multiplying it by the following factor:

$$\left(1 - \frac{N_{Ed}}{\dfrac{(A_{f1} + A_{f2})\, f_{yf}}{\gamma_{M0}}} \right) \tag{5.9}$$

where A_{f1} and A_{f2} are the areas of the top and bottom flanges respectively.

5.5 Verification

(1) The verification should be performed as follows:

$$\eta_3 = \frac{V_{Ed}}{V_{b,Rd}} \le 1{,}0 \tag{5.10}$$

where V_{Ed} is the design shear force including shear from torque.

6 Resistance to transverse forces

6.1 Basis

(1) The design resistance of the webs of rolled beams and welded girders should be determined in accordance with 6.2, provided that the compression flange is adequately restrained in the lateral direction.

(2) The load is applied as follows:

a) through the flange and resisted by shear forces in the web, see Figure 6.1 (a);

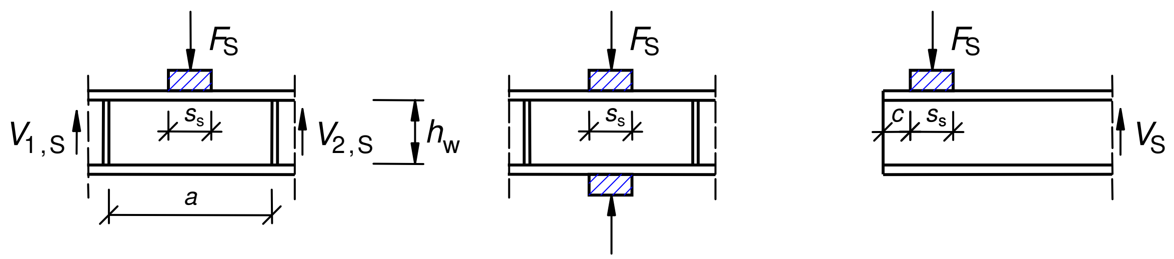
b) through one flange and transferred through the web directly to the other flange, see Figure 6.1 (b).

c) through one flange adjacent to an unstiffened end, see Figure 6.1 (c)

(3) For box girders with inclined webs the resistance of both the web and flange should be checked. The internal forces to be taken into account are the components of the external load in the plane of the web and flange respectively.

(4) The interaction of the transverse force, bending moment and axial force should be verified using 7.2.

Type (a) Type (b) Type (c)



$$k_F = 6 + 2\left(\frac{h_w}{a}\right)^2 \qquad k_F = 3{,}5 + 2\left(\frac{h_w}{a}\right)^2 \qquad k_F = 2 + 6\left(\frac{s_s + c}{h_w}\right) \le 6$$

Figure 6.1: Buckling coefficients for different types of load application

6.2 Design resistance

(1) For unstiffened or stiffened webs the design resistance to local buckling under transverse forces should be taken as

$$F_{Rd} = \frac{f_{yw}\, L_{eff}\, t_w}{\gamma_{M1}} \tag{6.1}$$

where t_w is the thickness of the web;

f_{yw} is the yield strength of the web;

L_{eff} is the effective length for resistance to transverse forces, which should be determined from

$$L_{eff} = \chi_F\, \ell_y \tag{6.2}$$

where ℓ_y is the effective loaded length, see 6.5, appropriate to the length of stiff bearing s_s, see 6.3;

χ_F is the reduction factor due to local buckling, see 6.4(1).

6.3 Length of stiff bearing

(1) The length of stiff bearing s_s on the flange should be taken as the distance over which the applied load is effectively distributed at a slope of 1:1, see Figure 6.2. However, s_s should not be taken as larger than h_w.

(2) If several concentrated forces are closely spaced, the resistance should be checked for each individual force as well as for the total load with s_s as the centre-to-centre distance between the outer loads.

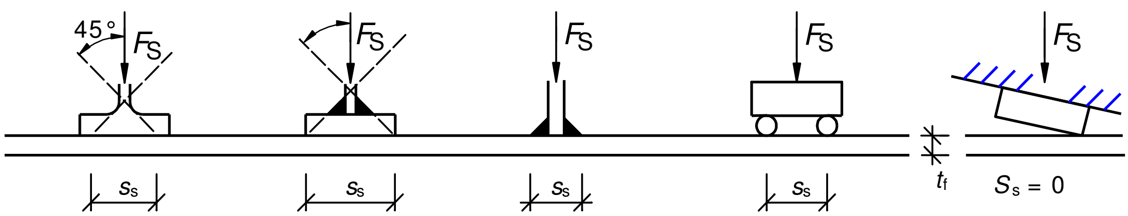


Figure 6.2: Length of stiff bearing

(3) If the bearing surface of the applied load rests at an angle to the flange surface, see Figure 6.2, s_s should be taken as zero.

6.4 Reduction factor χ_F for effective length for resistance

(1) The reduction factor χ_F should be obtained from:

$$\chi_F = \frac{0,5}{\overline{\lambda}_F} \leq 1,0 \tag{6.3}$$

where $$\overline{\lambda}_F = \sqrt{\frac{\ell_y t_w f_{yw}}{F_{cr}}} \tag{6.4}$$

$$F_{cr} = 0,9\, k_F E \frac{t_w^3}{h_w} \tag{6.5}$$

(2) For webs without longitudinal stiffeners k_F should be obtained from Figure 6.1.

NOTE: For webs with longitudinal stiffeners information may be given in the National Annex. The following rules are recommended:

For webs with longitudinal stiffeners k_F may be taken as

$$k_F = 6 + 2\left[\frac{h_w}{a}\right]^2 + \left[5,44\frac{b_1}{a} - 0,21\right]\sqrt{\gamma_s} \tag{6.6}$$

where b_1 is the depth of the loaded subpanel taken as the clear distance between the loaded flange and the stiffener

$$\gamma_s = 10,9\frac{I_{s\ell,1}}{h_w t_w^3} \leq 13\left[\frac{a}{h_w}\right]^3 + 210\left[0,3 - \frac{b_1}{a}\right] \tag{6.7}$$

where $I_{s\ell,1}$ is the second moment of area of the stiffener closest to the loaded flange including contributing parts of the web according to Figure 9.1.

Equation (6.6) is valid for $0,05 \leq \frac{b_1}{a} \leq 0,3$ and $\frac{b_1}{h_w} \leq 0,3$ and loading according to type a) in Figure 6.1.

(3) ℓ_y should be obtained from 6.5.

6.5 Effective loaded length

(1) The effective loaded length ℓ_y should be calculated as follows:

$$m_1 = \frac{f_{yf} b_f}{f_{yw} t_w} \tag{6.8}$$

$$m_2 = 0,02\left(\frac{h_w}{t_f}\right)^2 \quad \text{if } \overline{\lambda}_F > 0,5$$
$$m_2 = 0 \quad \text{if } \overline{\lambda}_F \leq 0,5 \tag{6.9}$$

For box girders, b_f in equation (6.8) should be limited to $15\varepsilon t_f$ on each side of the web.

(2) For types a) and b) in Figure 6.1, ℓ_y should be obtained using:

$$\ell_y = s_s + 2\, t_f \left(1 + \sqrt{m_1 + m_2}\right) \text{, but } \ell_y \leq \text{distance between adjacent transverse stiffeners} \tag{6.10}$$

(3) For type c) ℓ_y should be taken as the smallest value obtained from the equations (6.11), (6.12) and (6.13).

$$\ell_y = \ell_e + t_f \sqrt{\frac{m_1}{2} + \left(\frac{\ell_e}{t_f}\right)^2 + m_2} \tag{6.11}$$

$$\ell_y = \ell_e + t_f \sqrt{m_1 + m_2} \tag{6.12}$$

$$\ell_e = \frac{k_F E\, t_w^2}{2\, f_{yw} h_w} \leq s_s + c \tag{6.13}$$

6.6 Verification

(1) The verification should be performed as follows:

$$\eta_2 = \frac{F_{Ed}}{\dfrac{f_{yw}\, L_{eff}\, t_w}{\gamma_{M1}}} \leq 1{,}0 \tag{6.14}$$

where F_{Ed} is the design transverse force;

L_{eff} is the effective length for resistance to transverse forces, see 6.2(2);

t_w is the thickness of the plate.

7 Interaction

7.1 Interaction between shear force, bending moment and axial force

(1) Provided that $\bar{\eta}_3$ (see below) does not exceed 0,5 , the design resistance to bending moment and axial force need not be reduced to allow for the shear force. If $\bar{\eta}_3$ is more than 0,5 the combined effects of bending and shear in the web of an I or box girder should satisfy:

$$\bar{\eta}_1 + \left(1 - \frac{M_{f,Rd}}{M_{pl,Rd}}\right)\left(2\bar{\eta}_3 - 1\right)^2 \leq 1{,}0 \qquad for\ \bar{\eta}_1 \geq \frac{M_{f,Rd}}{M_{pl,Rd}} \tag{7.1}$$

where $M_{f,Rd}$ is the design plastic moment of resistance of the section consisting of the effective area of the flanges;

$M_{pl,Rd}$ is the design plastic resistance of the cross section consisting of the effective area of the flanges and the fully effective web irrespective of its section class.

$$\bar{\eta}_1 = \frac{M_{Ed}}{M_{pl,Rd}}$$

$$\bar{\eta}_3 = \frac{V_{Ed}}{V_{bw,Rd}}$$

In addition the requirements in sections 4.6 and 5.5 should be met.

Action effects should include global second order effects of members where relevant.

(2) The criterion given in (1) should be verified at all sections other than those located at a distance less than $h_w/2$ from a support with vertical stiffeners.

(3) The plastic moment of resistance $M_{f,Rd}$ may be taken as the product of the yield strength, the effective area of the flange with the smallest value of $A_f f_y / \gamma_{M0}$ and the distance between the centroids of the flanges.

(4) If an axial force N_{Ed} is present, $M_{pl,Rd}$ and $M_{f,Rd}$ should be reduced in accordance with 6.2.9 of EN 1993-1-1 and 5.4(2) respectively. When the axial force is so large that the whole web is in compression 7.1(5) should be applied.

(5) A flange in a box girder should be verified using 7.1(1) taking $M_{f,Rd} = 0$ and τ_{Ed} taken as the average shear stress in the flange which should not be less than half the maximum shear stress in the flange and $\overline{\eta}_1$ is taken as η_1 according to 4.6(1). In addition the subpanels should be checked using the average shear stress within the subpanel and χ_w determined for shear buckling of the subpanel according to 5.3, assuming the longitudinal stiffeners to be rigid.

7.2 Interaction between transverse force, bending moment and axial force

(1) If the girder is subjected to a concentrated transverse force acting on the compression flange in conjunction with bending and axial force, the resistance should be verified using 4.6, 6.6 and the following interaction expression:

$$\eta_2 + 0{,}8\,\eta_1 \leq 1{,}4 \tag{7.2}$$

(2) If the concentrated load is acting on the tension flange the resistance should be verified according to section 6. Additionally 6.2.1(5) of EN 1993-1-1 should be met.

8 Flange induced buckling

(1) To prevent the compression flange buckling in the plane of the web, the following criterion should be met:

$$\frac{h_w}{t_w} \leq k \frac{E}{f_{yf}} \sqrt{\frac{A_w}{A_{fc}}} \tag{8.1}$$

where A_w is the cross section area of the web;

A_{fc} is the effective cross section area of the compression flange;

h_w is the depth of the web;

t_w is the thickness of the web.

The value of the factor k should be taken as follows:

- plastic rotation utilized $k = 0{,}3$
- plastic moment resistance utilized $k = 0{,}4$
- elastic moment resistance utilized $k = 0{,}55$

(2) When the girder is curved in elevation, with the compression flange on the concave face, the following criterion should be met:

$$\frac{h_w}{t_w} \leq \frac{k \dfrac{E}{f_{yf}} \sqrt{\dfrac{A_w}{A_{fc}}}}{\sqrt{1 + \dfrac{h_w E}{3\, r\, f_{yf}}}} \tag{8.2}$$

r is the radius of curvature of the compression flange.

NOTE: The National Annex may give further information on flange induced buckling.

9 Stiffeners and detailing

9.1 General

(1) This section gives design rules for stiffeners in plated structures which supplement the plate buckling rules specified in sections 4 to 7.

NOTE: The National Annex may give further requirements on stiffeners for specific applications.

(2) When checking the buckling resistance, the section of a stiffener may be taken as the gross area comprising the stiffener plus a width of plate equal to $15\varepsilon t$ but not more than the actual dimension available, on each side of the stiffener avoiding any overlap of contributing parts to adjacent stiffeners, see Figure 9.1.

(3) The axial force in a transverse stiffener should be taken as the sum of the force resulting from shear (see 9.3.3(3)) and any external loads.

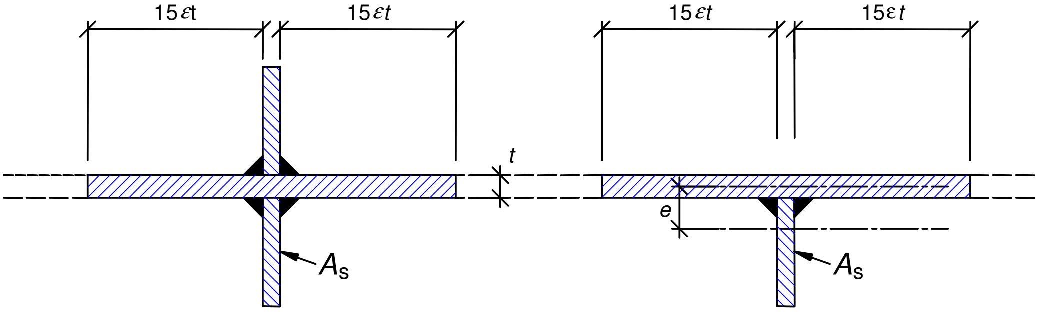


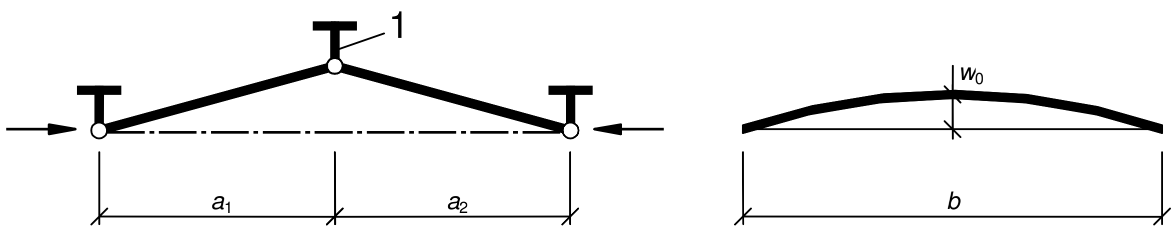
Figure 9.1: Effective cross-section of stiffener

9.2 Direct stresses

9.2.1 Minimum requirements for transverse stiffeners

(1) In order to provide a rigid support for a plate with or without longitudinal stiffeners, intermediate transverse stiffeners should satisfy the criteria given below.

(2) The transverse stiffener should be treated as a simply supported member subject to lateral loading with an initial sinusoidal imperfection w_0 equal to $s/300$, where s is the smallest of a_1, a_2 or b, see Figure 9.2 , where a_1 and a_2 are the lengths of the panels adjacent to the transverse stiffener under consideration and b is the height between the centroids of the flanges or span of the transverse stiffener. Eccentricities should be accounted for.



1 Transverse stiffener

Figure 9.2: Transverse stiffener

(3) The transverse stiffener should carry the deviation forces from the adjacent compressed panels under the assumption that both adjacent transverse stiffeners are rigid and straight together with any external load

and axial force according to the NOTE to 9.3.3(3). The compressed panels and the longitudinal stiffeners are considered to be simply supported at the transverse stiffeners.

(4) It should be verified that using a second order elastic method analysis both the following criteria are satisfied at the ultimate limit state:

– that the maximum stress in the stiffener should not exceed f_y/γ_{M1};

– that the additional deflection should not exceed b/300.

(5) In the absence of an axial force in the transverse stiffener both the criteria in (4) above may be assumed to be satisfied provided that the second moment of area I_{st} of the transverse stiffeners is not less than:

$$I_{st} = \frac{\sigma_m}{E}\left(\frac{b}{\pi}\right)^4 \left(1 + w_0 \frac{300}{b} u\right) \tag{9.1}$$

where $\sigma_m = \frac{\sigma_{cr,c}}{\sigma_{cr,p}} \frac{N_{Ed}}{b} \left(\frac{1}{a_1} + \frac{1}{a_2}\right)$

$$u = \frac{\pi^2 \, E \, e_{\max}}{\frac{f_y \, 300 \, b}{\gamma_{M1}}} \geq 1{,}0$$

$e_{\max}$ is the maximum distance from the extreme fibre of the stiffener to the centroid of the stiffener;

N_{Ed} is the maximum compressive force of the adjacent panels but not less than the maximum compressive stress times half the effective[p] compression area of the panel including stiffeners;

$\sigma_{cr,c}$, $\sigma_{cr,p}$ are defined in 4.5.3 and Annex A.

NOTE: Where out of plane loading is applied to the transverse stiffeners reference should be made to EN 1993-2 and EN 1993-1-7.

(6) If the stiffener carries axial compression this should be increased by $\Delta N_{st} = \sigma_m b^2 / \pi^2$ in order to account for deviation forces. The criteria in (4) apply but ΔN_{st} need not be considered when calculating the uniform stresses from axial load in the stiffener.

(7) As a simplification the requirement of (4) may, in the absence of axial forces, be verified using a first order elastic analysis taking account of the following additional equivalent uniformly distributed lateral load q acting on the length b:

$$q = \frac{\pi}{4} \sigma_m (w_0 + w_{el}) \tag{9.2}$$

where σ_m is defined in (5) above;

w_0 is defined in Figure 9.2;

w_{el} is the elastic deformation, that may be either determined iteratively or be taken as the maximum additional deflection b/300.

(8) Unless a more advanced method of analysis is carried out in order to prevent torsional buckling of stiffeners with open cross-sections, the following criterion should be satisfied:

$$\frac{I_T}{I_p} \geq 5{,}3 \frac{f_y}{E} \tag{9.3}$$

where I_p is the polar second moment of area of the stiffener alone around the edge fixed to the plate;

I_T is the St. Venant torsional constant for the stiffener alone.

(9) Where warping stiffness is considered stiffeners should either fulfil (8) or the criterion

$$\sigma_{cr} \geq \theta f_y \tag{9.4}$$

where σ_{cr} is the elastic critical stress for torsional buckling not considering rotational restraint from the plate;

θ is a parameter to ensure class 3 behaviour.

NOTE: The parameter θ may be given in the National Annex. The value $\theta = 6$ is recommended.

9.2.2 Minimum requirements for longitudinal stiffeners

(1) The requirements concerning torsional buckling in 9.2.1(8) and (9) also apply to longitudinal stiffeners.

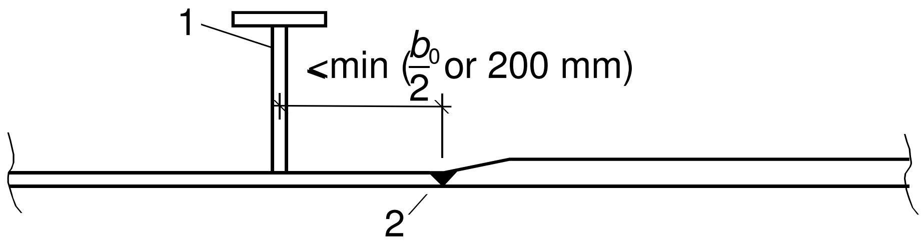
(2) Discontinuous longitudinal stiffeners that do not pass through openings made in the transverse stiffeners or are not connected to either side of the transverse stiffeners should be:

- used only for webs (i.e. not allowed in flanges);
- neglected in global analysis;
- neglected in the calculation of stresses;
- considered in the calculation of the effective[p] widths of web sub-panels;
- considered in the calculation of the elastic critical stresses.

(3) Strength assessments for stiffeners should be performed according to 4.5.3 and 4.6.

9.2.3 Welded plates

(1) Plates with changes in plate thickness should be welded adjacent to the transverse stiffener, see Figure 9.3. The effects of eccentricity need not be taken into account unless the distance to the stiffener from the welded junction exceeds $b_0/2$ or 200 mm whichever is the smallest, where b_0 is the width of the plate between longitudinal stiffeners.



1 Transverse stiffener
2 Transverse weld

Figure 9.3: Welded plates

9.2.4 Cut outs in stiffeners

(1) The dimensions of cut outs in longitudinal stiffeners should be as shown in Figure 9.4.

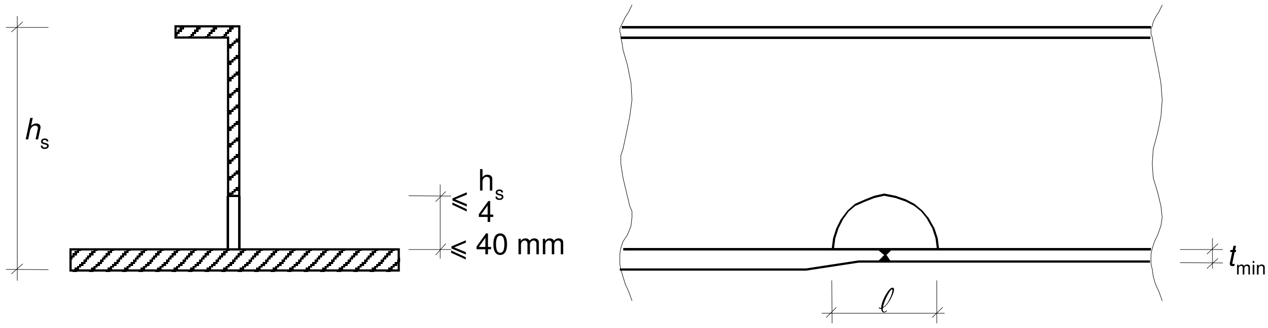


Figure 9.4: Cut outs in longitudinal stiffeners

(2) The length ℓ should not exceed:

$\ell \leq 6\, t_{\min}$ for flat stiffeners in compression

$\ell \leq 8\, t_{\min}$ for other stiffeners in compression

$\ell \leq 15\, t_{\min}$ for stiffeners without compression
where $t_{\min}$ is the lesser of the plate thicknesses

(3) The limiting values ℓ in (2) for stiffeners in compression may be increased by $\sqrt{\frac{\sigma_{x,Rd}}{\sigma_{x,Ed}}}$ when $\sigma_{x,Ed} \leq \sigma_{x,Rd}$ and $\ell \leq 15 t_{\min}$.

$\sigma_{x,Ed}$ is the compression stress at the location of the cut-out

(4) The dimensions of cut outs in transverse stiffeners should be as shown in Figure 9.5.

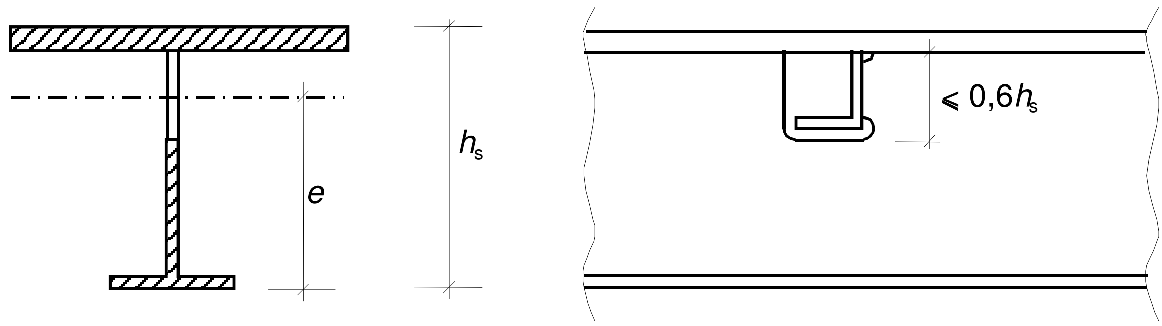


Figure 9.5: Cut outs in transverse stiffeners

(5) The gross web adjacent to the cut out should resist a shear force V_{Ed}, where

$$V_{Ed} = \frac{I_{net}}{e}\frac{f_{yk}}{\gamma_{M0}}\frac{\pi}{b_G} \qquad (9.5)$$

I_{net} is the second moment of area for the net section of the transverse stiffener;

e is the maximum distance from the underside of the flange plate to the neutral axis of net section, see Figure 9.5;

b_G is the length of the transverse stiffener between the flanges.

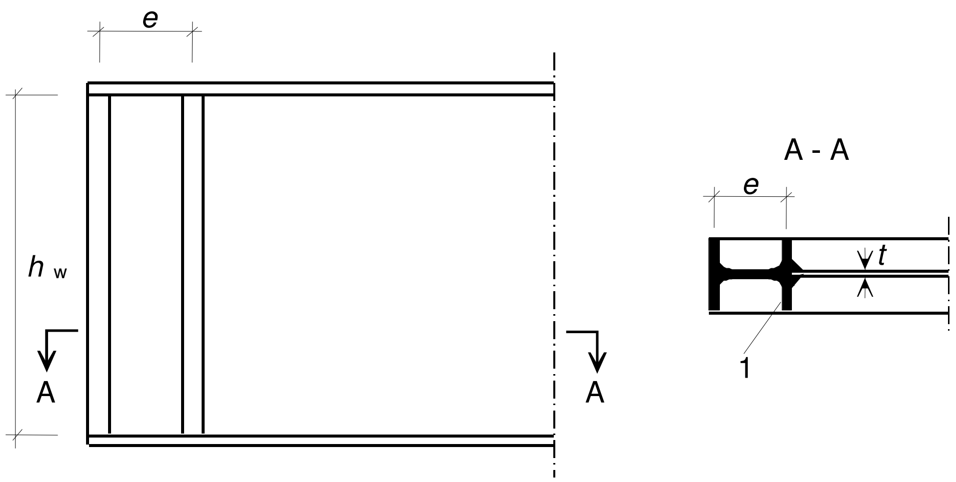
9.3 Shear

9.3.1 Rigid end post

(1) The rigid end post (see Figure 5.1) should act as a bearing stiffener resisting the reaction from the support (see 9.4), and should be designed as a short beam resisting the longitudinal membrane stresses in the plane of the web.

NOTE: For the effects of eccentricity due to movements of bearings, see EN 1993-2.

(2) A rigid end post should comprise of two double-sided transverse stiffeners that form the flanges of a short beam of length h_w, see Figure 5.1 (b). The strip of web plate between the stiffeners forms the web of the short beam. Alternatively, a rigid end post may be in the form of a rolled section, connected to the end of the web plate as shown in Figure 9.6.



1 Inserted section

Figure 9.6: Rolled section forming an end-post

(3) Each double sided stiffener consisting of flats should have a cross sectional area of at least $4h_w t^2 / e$, where e is the centre to centre distance between the stiffeners and $e > 0{,}1\, h_w$, see Figure 5.1 (b). Where a rolled section other than flats is used for the end-post its section modulus should be not less than $4h_w t^2$ for bending around a horizontal axis perpendicular to the web.

(4) As an alternative the girder end may be provided with a single double-sided stiffener and a vertical stiffener adjacent to the support so that the subpanel resists the maximum shear when designed with a non-rigid end post.

9.3.2 Stiffeners acting as non-rigid end post

(1) A non-rigid end post may be a single double sided stiffener as shown in Figure 5.1 (c). It may act as a bearing stiffener resisting the reaction at the girder support (see 9.4).

9.3.3 Intermediate transverse stiffeners

(1) Intermediate stiffeners that act as rigid supports to interior panels of the web should be designed for strength and stiffness.

(2) When flexible intermediate transverse stiffeners are used, their stiffness should be considered in the calculation of k_τ in 5.3(5).

(3) The effective section of intermediate stiffeners acting as rigid supports for web panels should have a minimum second moment of area I_{st}:

$$\begin{aligned} &if\ a / h_w < \sqrt{2}: \quad I_{st} \geq 1{,}5\, h_w^3\, t^3 / a^2 \\ &if\ a / h_w \geq \sqrt{2}: \quad I_{st} \geq 0{,}75\, h_w\, t^3 \end{aligned} \tag{9.6}$$

NOTE: Intermediate rigid stiffeners may be designed for an axial force equal to $\left(V_{Ed} - \frac{1}{\overline{\lambda}_w^2} f_{yw} h_w t / \left(\sqrt{3}\ \gamma_{M1} \right) \right)$ according to 9.2.1(3). In the case of variable shear forces the check is performed for the shear force at the distance $0{,}5h_w$ from the edge of the panel with the largest shear force.

9.3.4 Longitudinal stiffeners

(1) If longitudinal stiffeners are taken into account in the stress analysis they should be checked for direct stresses for the cross sectional resistance.

9.3.5 Welds

(1) The web to flange welds may be designed for the nominal shear flow V_{Ed} / h_w if V_{Ed} does not exceed $\chi_w f_{yw} h_w t / \left(\sqrt{3}\ \gamma_{M1} \right)$. For larger values V_{Ed} the weld between flanges and webs should be designed for the shear flow $\eta\ f_{yw} t / \left(\sqrt{3}\ \gamma_{M1} \right)$.

(2) In all other cases welds should be designed to transfer forces along and across welds making up sections taking into account analysis method (elastic/plastic) and second order effects.

9.4 Transverse loads

(1) If the design resistance of an unstiffened web is insufficient, transverse stiffeners should be provided.

(2) The out-of-plane buckling resistance of the transverse stiffener under transverse loads and shear force (see 9.3.3(3)) should be determined from 6.3.3 or 6.3.4 of EN 1993-1-1, using buckling curve *c*. When both ends are assumed to be fixed laterally a buckling length ℓ of not less than $0{,}75h_w$ should be used. A larger value of ℓ should be used for conditions that provide less end restraint. If the stiffeners have cut outs at the loaded end, the cross sectional resistance should be checked at this end.

(3) Where single sided or other asymmetric stiffeners are used, the resulting eccentricity should be allowed for using 6.3.3 or 6.3.4 of EN 1993-1-1. If the stiffeners are assumed to provide lateral restraint to the compression flange they should comply with the stiffness and strength criteria in the design for lateral torsional buckling.

10 Reduced stress method

(1) The reduced stress method may be used to determine the stress limits for stiffened or unstiffened plates.

NOTE 1: This method is an alternative to the effective width method specified in section 4 to 7 in respect of the following:

- $\sigma_{x,Ed}$, $\sigma_{z,Ed}$ and τ_{Ed} are considered as acting together
- the stress limits of the weakest part of the cross section may govern the resistance of the full cross section.

NOTE 2: The stress limits may also be used to determine equivalent effective areas. The National Annex may give limits of application for the methods.

(2) For unstiffened or stiffened panels subjected to combined stresses $\sigma_{x,Ed}$, $\sigma_{z,Ed}$ and τ_{Ed} class 3 section properties may be assumed, where

$$\frac{\rho\,\alpha_{ult,k}}{\gamma_{M1}} \geq 1 \qquad (10.1)$$

where $\alpha_{ult,k}$ is the minimum load amplifier for the design loads to reach the characteristic value of resistance of the most critical point of the plate, see (4);

ρ is the reduction factor depending on the plate slenderness $\overline{\lambda}_p$ to take account of plate buckling, see (5);

γ_{M1} is the partial factor applied to this method.

(3) The plate slenderness $\overline{\lambda}_p$ should be taken from

$$\overline{\lambda}_p = \sqrt{\frac{\alpha_{ult,k}}{\alpha_{cr}}} \qquad (10.2)$$

where α_{cr} is the minimum load amplifier for the design loads to reach the elastic critical load of the plate under the complete stress field, see (6)

NOTE 1: For calculating α_{cr} for the complete stress field, the stiffened plate may be modelled using the rules in section 4 and 5 without reduction of the second moment of area of longitudinal stiffeners as specified in 5.3(4).

NOTE 2: When α_{cr} cannot be determined for the panel and its subpanels as a whole, separate checks for the subpanel and the full panel may be applied.

(4) In determining $\alpha_{ult,k}$ the yield criterion may be used for resistance:

$$\frac{1}{\alpha_{ult,k}^2} = \left(\frac{\sigma_{x,Ed}}{f_y}\right)^2 + \left(\frac{\sigma_{z,Ed}}{f_y}\right)^2 - \left(\frac{\sigma_{x,Ed}}{f_y}\right)\left(\frac{\sigma_{z,Ed}}{f_y}\right) + 3\left(\frac{\tau_{Ed}}{f_y}\right)^2 \qquad (10.3)$$

where $\sigma_{x,Ed}$, $\sigma_{z,Ed}$ and τ_{Ed} are the components of the stress field in the ultimate limit state.

NOTE: By using the equation (10.3) it is assumed that the resistance is reached when yielding occurs without plate buckling.

(5) The reduction factor ρ may be determined using either of the following methods:

a) the minimum value of the following reduction factors:

ρ_x for longitudinal stresses from 4.5.4(1) taking into account column-like behaviour where relevant;

ρ_z for transverse stresses from 4.5.4(1) taking into account column-like behaviour where relevant;

χ_w for shear stresses from 5.2(1);

each calculated for the slenderness $\overline{\lambda}_p$ according to equation (10.2).

NOTE: This method leads to the verification formula:

$$\left(\frac{\sigma_{x,Ed}}{f_y/\gamma_{M1}}\right)^2+\left(\frac{\sigma_{z,Ed}}{f_y/\gamma_{M1}}\right)^2-\left(\frac{\sigma_{x,Ed}}{f_y/\gamma_{M1}}\right)\left(\frac{\sigma_{z,Ed}}{f_y/\gamma_{M1}}\right)+3\left(\frac{\tau_{Ed}}{f_y/\gamma_{M1}}\right)^2\leq\rho^2 \qquad (10.4)$$

NOTE: For determining ρ_z for transverse stresses the rules in section 4 for direct stresses σ_x should be applied to σ_z in the z-direction. For consistency section 6 should not be applied.

b) a value interpolated between the values of ρ_x, ρ_z and χ_w as determined in a) by using the formula for $\alpha_{ult,k}$ as interpolation function

NOTE: This method leads to the verification format:

$$\left(\frac{\sigma_{x,Ed}}{\rho_x f_y/\gamma_{M1}}\right)^2+\left(\frac{\sigma_{z,Ed}}{\rho_z f_y/\gamma_{M1}}\right)^2-\left(\frac{\sigma_{x,Ed}}{\rho_x f_y/\gamma_{M1}}\right)\left(\frac{\sigma_{z,Ed}}{\rho_z f_y/\gamma_{M1}}\right)+3\left(\frac{\tau_{Ed}}{\chi_w f_y/\gamma_{M1}}\right)^2\leq 1 \qquad (10.5)$$

NOTE 1: Since verification formulae (10.3), (10.4) and (10.5) include an interaction between shear force, bending moment, axial force and transverse force, section 7 should not be applied.

NOTE 2: The National Annex may give further information on the use of equations (10.4) and (10.5). In case of panels with tension and compression it is recommended to apply equations (10.4) and (10.5) only for the compressive parts.

(6) Where α_{cr} values for the complete stress field are not available and only $\alpha_{cr,i}$ values for the various components of the stress field $\sigma_{x,Ed}$, $\sigma_{z,Ed}$ and τ_{Ed} can be used, the α_{cr} value may be determined from:

$$\frac{1}{\alpha_{cr}}=\frac{1+\psi_x}{4\,\alpha_{cr,x}}+\frac{1+\psi_z}{4\,\alpha_{cr,z}}+\left[\left(\frac{1+\psi_x}{4\,\alpha_{cr,x}}+\frac{1+\psi_z}{4\,\alpha_{cr,z}}\right)^2+\frac{1-\psi_x}{2\,\alpha_{cr,x}^2}+\frac{1-\psi_z}{2\,\alpha_{cr,z}^2}+\frac{1}{\alpha_{cr,\tau}^2}\right]^{1/2} \qquad (10.6)$$

where $\alpha_{cr,x}=\dfrac{\sigma_{cr,x}}{\sigma_{x,Ed}}$

$\alpha_{cr,z}=\dfrac{\sigma_{cr,z}}{\sigma_{z,Ed}}$

$\alpha_{cr,\tau}=\dfrac{\tau_{cr,\tau}}{\tau_{\tau,Ed}}$

and $\sigma_{cr,x}$, $\sigma_{cr,z}$, τ_{cr}, ψ_x and ψ_z are determined from sections 4 to 6.

(7) Stiffeners and detailing of plate panels should be designed according to section 9.

Annex A [informative] – Calculation of critical stresses for stiffened plates

A.1 Equivalent orthotropic plate

(1) Plates with at least three longitudinal stiffeners may be treated as equivalent orthotropic plates.

(2) The elastic critical plate buckling stress of the equivalent orthotropic plate may be taken as:

$$\sigma_{cr,p} = k_{\sigma,p}\, \sigma_E \tag{A.1}$$

where $\sigma_E = \dfrac{\pi^2\, E\, t^2}{12\left(1-\nu^2\right)b^2} = 190000\left(\dfrac{t}{b}\right)^2 \quad in\,[MPa]$

$k_{\sigma,p}$ is the buckling coefficient according to orthotropic plate theory with the stiffeners smeared over the plate;

b is defined in Figure A.1;

t is the thickness of the plate.

NOTE 1: The buckling coefficient $k_{\sigma,p}$ is obtained either from appropriate charts for smeared stiffeners or relevant computer simulations; alternatively charts for discretely located stiffeners may be used provided local buckling in the subpanels can be ignored and treated separately.

NOTE 2: $\sigma_{cr,p}$ is the elastic critical plate buckling stress at the edge of the panel where the maximum compression stress occurs, see Figure A.1.

NOTE 3: Where a web is of concern, the width b in equations (A.1) and (A.2) should be replaced by h_w.

NOTE 4: For stiffened plates with at least three equally spaced longitudinal stiffeners the plate buckling coefficient $k_{\sigma,p}$ (global buckling of the stiffened panel) may be approximated by:

$$\begin{aligned} k_{\sigma,p} &= \frac{2\left(\left(1+\alpha^2\right)^2+\gamma-1\right)}{\alpha^2(\psi+1)(1+\delta)} \quad if \quad \alpha \le \sqrt[4]{\gamma} \\ k_{\sigma,p} &= \frac{4\left(1+\sqrt{\gamma}\right)}{(\psi+1)(1+\delta)} \quad if \quad \alpha > \sqrt[4]{\gamma} \end{aligned} \tag{A.2}$$

with: $\psi = \dfrac{\sigma_2}{\sigma_1} \ge 0{,}5$

$\gamma = \dfrac{I_{sl}}{I_p}$

$\delta = \dfrac{\Sigma A_{sl}}{A_p}$

$\alpha = \dfrac{a}{b} \ge 0{,}5$

where: I_{sl} is the second moment of area of the whole stiffened plate;

I_p is the second moment of area for bending of the plate $= \dfrac{bt^3}{12\left(1-\upsilon^2\right)} = \dfrac{bt^3}{10{,}92}$;

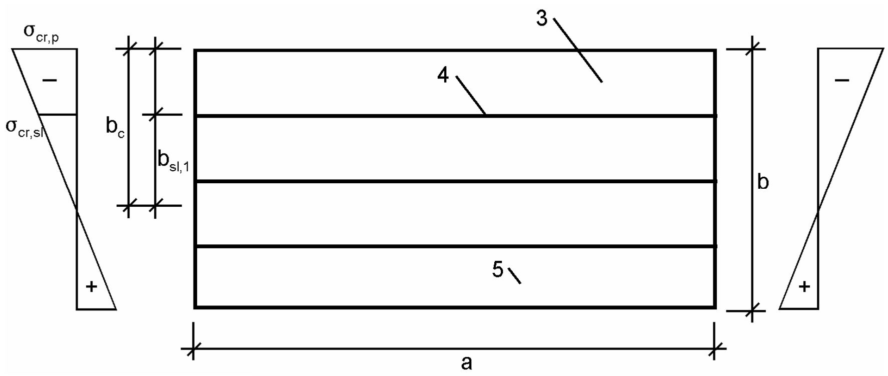
ΣA_{sl} is the sum of the gross areas of the individual longitudinal stiffeners;

A_p is the gross area of the plate $= bt$;

σ_1 is the larger edge stress;

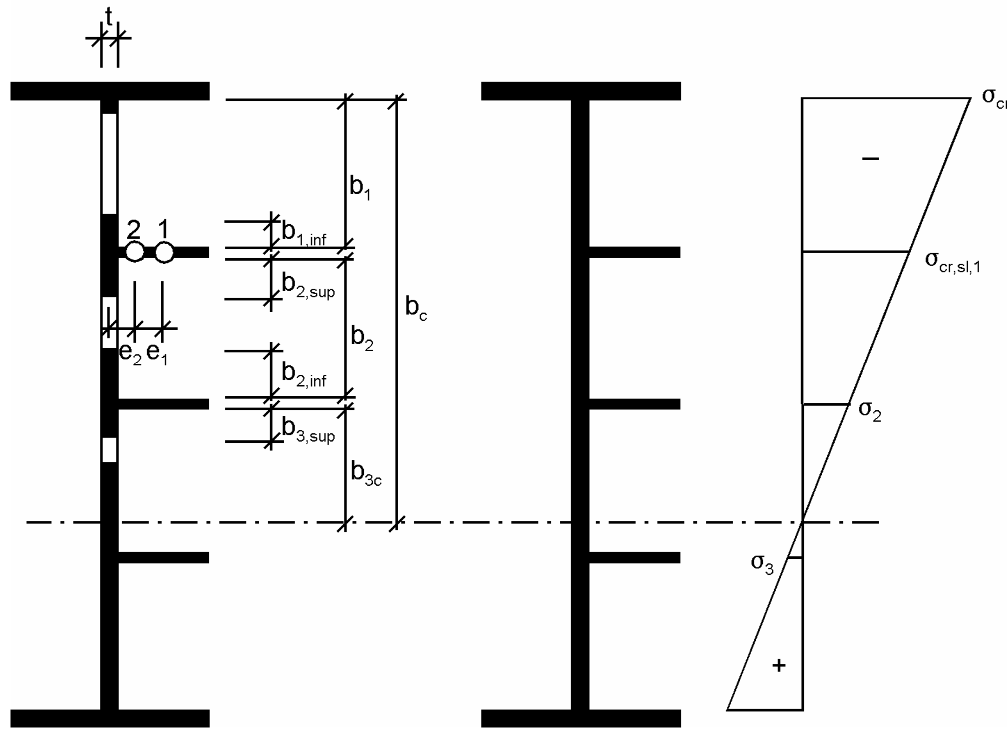
σ_2 is the smaller edge stress;

a, b and t are as defined in Figure A.1.



1 centroid of stiffeners
2 centroid of columns = stiffeners + accompanying plating
3 subpanel
4 stiffener
5 plate thickness t

$e = \max(e_1, e_2)$



	width for gross area	width for effective area according to Table 4.1	condition for ψ_i
$b_{1,\mathrm{inf}}$	$\frac{3-\psi_1}{5-\psi_1} b_1$	$\frac{3-\psi_1}{5-\psi_1} b_{1,eff}$	$\psi_1 = \frac{\sigma_{cr,sl,1}}{\sigma_{cr,p}} > 0$
$b_{2,\mathrm{sup}}$	$\frac{2}{5-\psi_2} b_2$	$\frac{2}{5-\psi_2} b_{2,eff}$	$\psi_2 = \frac{\sigma_2}{\sigma_{cr,sl,1}} > 0$
$b_{2,\mathrm{inf}}$	$\frac{3-\psi_2}{5-\psi_2} b_2$	$\frac{3-\psi_2}{5-\psi_2} b_{2,eff}$	$\psi_2 > 0$
$b_{3,\mathrm{sup}}$	$0{,}4\, b_{3c}$	$0{,}4\, b_{3c,\mathrm{eff}}$	$\psi_3 = \frac{\sigma_3}{\sigma_2} < 0$

Figure A.1: Notations for longitudinally stiffened plates

A.2 Critical plate buckling stress for plates with one or two stiffeners in the compression zone

A.2.1 General procedure

(1) If the stiffened plate has only one longitudinal stiffener in the compression zone the procedure in A.1 may be simplified by a fictitious isolated strut supported on an elastic foundation reflecting the plate effect in the direction perpendicular to this strut. The elastic critical stress of the strut may be obtained from A.2.2.

(2) For calculation of $A_{s\ell,1}$ and $I_{s\ell,1}$ the gross cross-section of the column should be taken as the gross area of the stiffener and adjacent parts of the plate described as follows. If the subpanel is fully in compression, a portion $(3-\psi)/(5-\psi)$ of its width b_1 should be taken at the edge of the panel and $2/(5-\psi)$ at the edge with the highest stress. If the stress changes from compression to tension within the subpanel, a portion 0,4 of the width b_c of the compressed part of this subpanel should be taken as part of the column, see Figure A.2 and also Table 4.1. ψ is the stress ratio relative to the subpanel in consideration.

(3) The effective[p] cross-sectional area $A_{s\ell,eff}$ of the column should be taken as the effective[p] cross-section of the stiffener and the adjacent effective[p] parts of the plate, see Figure A.1. The slenderness of the plate elements in the column may be determined according to 4.4(4), with $\sigma_{com,Ed}$ calculated for the gross cross-section of the plate.

(4) If $\rho_c f_y/\gamma_{M1}$, with ρ_c determined according to 4.5.4(1), is greater than the average stress in the column $\sigma_{com,Ed}$ no further reduction of the effective[p] area of the column should be made. Otherwise the effective area in (4.6) should be modified as follows:

$$A_{c,eff,loc} = \frac{\rho_c \; f_y \; A_{sl,1}}{\sigma_{com,Ed} \; \gamma_{M1}} \tag{A.3}$$

(5) The reduction mentioned in A.2.1(4) should be applied only to the area of the column. No reduction need be applied to other compressed parts of the plate, except for checking buckling of subpanels.

(6) As an alternative to using an effective[p] area according to A.2.1(4), the resistance of the column may be determined from A.2.1(5) to (7) and checked to ensure that it exceeds the average stress $\sigma_{com,Ed}$.

NOTE: The method outlined in (6) may be used in the case of multiple stiffeners in which the restraining effect from the plate is neglected, that is the fictitious column is considered free to buckle out of the plane of the web.

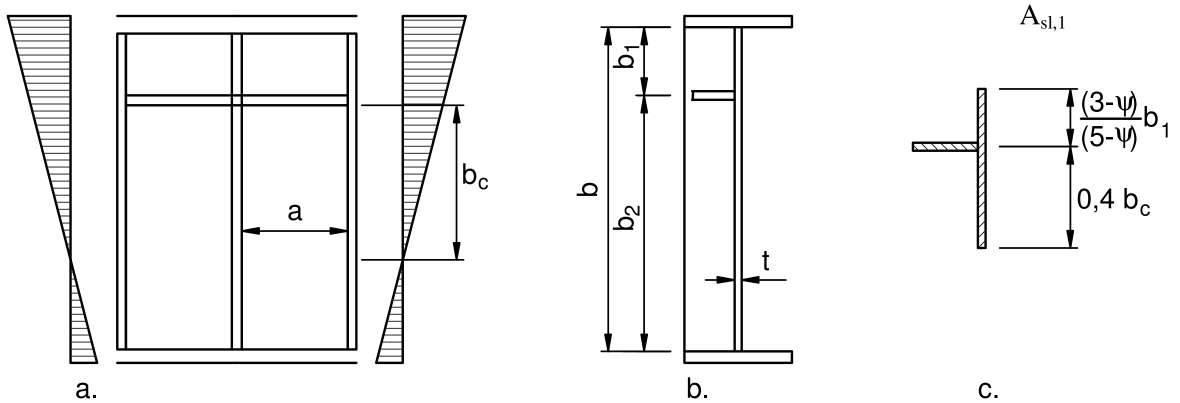


Figure A.2: Notations for a web plate with single stiffener in the compression zone

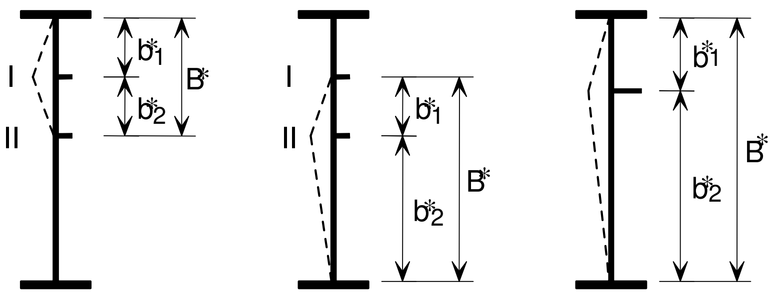
(7) If the stiffened plate has two longitudinal stiffeners in the compression zone, the one stiffener procedure described in A.2.1(1) may be applied, see Figure A.3. First, it is assumed that one of the stiffeners

buckles while the other one acts as a rigid support. Buckling of both the stiffeners simultaneously is accounted for by considering a single lumped stiffener that is substituted for both individual ones such that:

a) its cross-sectional area and its second moment of area I_{sl} are respectively the sum of that for the individual stiffeners

b) it is positioned at the location of the resultant of the respective forces in the individual stiffeners

For each of these situations illustrated in Figure A.3 a relevant value of $\sigma_{cr.p}$ is computed, see A.2.2(1), with $b_1 = b_1^*$ and $b_2 = b_2^*$ and $B^* = b_1^* + b_2^*$, see Figure A.3.



Stiffener I　　Stiffener II　　Lumped stiffener

Cross-sectional area	$A_{s\ell,I}$	$A_{s\ell,II}$	$A_{s\ell,I} + A_{s\ell,II}$
Second moment of area	$I_{s\ell,I}$	$I_{s\ell,II}$	$I_{s\ell,I} + I_{s\ell,II}$

Figure A.3: Notations for plate with two stiffeners in the compression zone

A.2.2 Simplified model using a column restrained by the plate

(1) In the case of a stiffened plate with one longitudinal stiffener located in the compression zone, the elastic critical buckling stress of the stiffener can be calculated as follows ignoring stiffeners in the tension zone:

$$\sigma_{cr,s\ell} = \frac{1{,}05\,E}{A_{s\ell,1}} \frac{\sqrt{I_{s\ell,1}\,t^3\,b}}{b_1\,b_2} \qquad if\ a \geq a_c$$
$$\sigma_{cr,s\ell} = \frac{\pi^2\,E\,I_{s\ell,1}}{A_{s\ell,1}\,a^2} + \frac{E\,t^3\,b\,a^2}{4\,\pi^2\,(1-\nu^2)\,A_{s\ell,1}\,b_1^2\,b_2^2} \qquad if\ a \leq a_c \tag{A.4}$$

with $a_c = 4{,}33\sqrt[4]{\dfrac{I_{s\ell,1}\,b_1^2\,b_2^2}{t^3\,b}}$

where $A_{s\ell,1}$ is the gross area of the column obtained from A.2.1(2)

$I_{s\ell,1}$ is the second moment of area of the gross cross-section of the column defined in A.2.1(2) about an axis through its centroid and parallel to the plane of the plate;

b_1, b_2 are the distances from the longitudinal edges of the web to the stiffener ($b_1+b_2 = b$).

NOTE: For determining $\sigma_{cr,c}$ see NOTE to 4.5.3(3).

(2) In the case of a stiffened plate with two longitudinal stiffeners located in the compression zone the elastic critical plate buckling stress should be taken as the lowest of those computed for the three cases using

equation (A.4) with $b_1 = b_1^*$, $b_2 = b_2^*$ and $b = B^*$. The stiffeners in the tension zone should be ignored in the calculation.

A.3 Shear buckling coefficients

(1) For plates with rigid transverse stiffeners and without longitudinal stiffeners or with more than two longitudinal stiffeners, the shear buckling coefficient k_τ can be obtained as follows:

$$\begin{aligned} k_\tau &= 5{,}34 + 4{,}00\,(h_w / a)^2 + k_{\tau s\ell} \quad \textit{when } a/h_w \geq 1 \\ k_\tau &= 4{,}00 + 5{,}34\,(h_w / a)^2 + k_{\tau s\ell} \quad \textit{when } a/h_w < 1 \end{aligned} \tag{A.5}$$

where $k_{\tau s\ell} = 9\left(\dfrac{h_w}{a}\right)^2 \sqrt[4]{\left(\dfrac{I_{s\ell}}{t^3\, h_w}\right)^3}$ *but not less than* $\dfrac{2{,}1}{t}\sqrt[3]{\dfrac{I_{s\ell}}{h_w}}$

a is the distance between transverse stiffeners (see Figure 5.3);

$I_{s\ell}$ is the second moment of area of the longitudinal stiffener about the z–z axis, see Figure 5.3 (b). For webs with two or more longitudinal stiffeners, not necessarily equally spaced, $I_{s\ell}$ is the sum of the stiffness of the individual stiffeners.

NOTE: No intermediate non-rigid transverse stiffeners are allowed for in equation (A.5).

(2) The equation (A.5) also applies to plates with one or two longitudinal stiffeners, if the aspect ratio $\alpha = \dfrac{a}{h_w}$ satisfies $\alpha \geq 3$. For plates with one or two longitudinal stiffeners and an aspect ratio $\alpha < 3$ the shear buckling coefficient should be taken from:

$$k_\tau = 4{,}1 + \frac{6{,}3 + 0{,}18\dfrac{I_{s\ell}}{t^3 h_w}}{\alpha^2} + 2{,}2\sqrt[3]{\frac{I_{s\ell}}{t^3 h_w}} \tag{A.6}$$

Annex B [informative] – Non-uniform members

B.1 General

(1) The rules in section 10 are applicable to webs of members with non parallel flanges as in haunched beams and to webs with regular or irregular openings and non orthogonal stiffeners.

(2) α_{ult} and α_{crit} may be obtained from FE-methods, see Annex C.

(3) The reduction factors ρ_x , ρ_z and χ_w for $\bar{\lambda}_p$ may be obtained from the appropriate plate buckling curves, see sections 4 and 5.

NOTE: The reduction factor ρ may be obtained as follows:

$$\rho = \frac{1}{\phi_p + \sqrt{\phi_p^2 - \bar{\lambda}_p}} \tag{B.1}$$

where $\phi_p = \frac{1}{2}\left(1 + \alpha_p\left(\bar{\lambda}_p - \bar{\lambda}_{p0}\right) + \bar{\lambda}_p\right)$

and $\bar{\lambda}_p = \sqrt{\frac{\alpha_{ult,k}}{\alpha_{cr}}}$

This procedure applies to ρ_x, ρ_z and χ_w. The values of $\bar{\lambda}_{p0}$ and α_p are given in Table B.1. These values have been calibrated against the plate buckling curves in sections 4 and 5 and give a direct correlation to the equivalent geometric imperfection, by :

$$e_0 = \alpha_p\left(\bar{\lambda}_p - \bar{\lambda}_{p0}\right)\frac{t}{6}\,\frac{1 - \frac{\rho\bar{\lambda}_p}{\gamma_{M1}}}{1 - \rho\bar{\lambda}_p} \tag{B.2}$$

Table B.1: Values for $\bar{\lambda}_{p0}$ and α_p

Product	predominant buckling mode	α_p	$\bar{\lambda}_{p0}$
hot rolled	direct stress for $\psi \geq 0$	0,13	0,70
	direct stress for $\psi < 0$ shear transverse stress		0,80
welded or cold formed	direct stress for $\psi \geq 0$	0,34	0,70
	direct stress for $\psi < 0$ shear transverse stress		0,80

B.2 Interaction of plate buckling and lateral torsional buckling

(1) The method given in B.1 may be extended to the verification of combined plate buckling and lateral torsional buckling of members by calculating α_{ult} and α_{crit} as follows:

α_{ult} is the minimum load amplifier for the design loads to reach the characteristic value of resistance of the most critical cross section, neglecting any plate buckling and lateral torsional buckling;

α_{cr} is the minimum load amplifier for the design loads to reach the elastic critical resistance of the member including plate buckling and lateral torsional buckling modes.

(2) When α_{cr} contains lateral torsional buckling modes, the reduction factor ρ used should be the minimum of the reduction factor according to B.1(3) and the χ_{LT} – value for lateral torsional buckling according to 6.3.3 of EN 1993-1-1.

Annex C [informative] – Finite Element Methods of analysis (FEM)

C.1 General

(1) Annex C gives guidance on the use of FE-methods for ultimate limit state, serviceability limit state or fatigue verifications of plated structures.

NOTE 1: For FE-calculation of shell structures see EN 1993-1-6.

NOTE 2: This guidance is intended for engineers who are experienced in the use of Finite Element methods.

(2) The choice of the FE-method depends on the problem to be analysed and based on the following assumptions:

Table C.1: Assumptions for FE-methods

No	Material behaviour	Geometric behaviour	Imperfections, see section C.5	Example of use
1	linear	linear	no	elastic shear lag effect, elastic resistance
2	non linear	linear	no	plastic resistance in ULS
3	linear	non linear	no	critical plate buckling load
4	linear	non linear	yes	elastic plate buckling resistance
5	non linear	non linear	yes	elastic-plastic resistance in ULS

C.2 Use

(1) In using FEM for design special care should be taken to

- the modelling of the structural component and its boundary conditions;
- the choice of software and documentation;
- the use of imperfections;
- the modelling of material properties;
- the modelling of loads;
- the modelling of limit state criteria;
- the partial factors to be applied.

NOTE: The National Annex may define the conditions for the use of FEM analysis in design.

C.3 Modelling

(1) The choice of FE-models (shell models or volume models) and the size of mesh determine the accuracy of results. For validation sensitivity checks with successive refinement may be carried out.

(2) The FE-modelling may be carried out either for:

- the component as a whole or
- a substructure as a part of the whole structure.

NOTE: An example for a component could be the web and/or the bottom plate of continuous box girders in the region of an intermediate support where the bottom plate is in compression. An example for a substructure could be a subpanel of a bottom plate subject to biaxial stresses.

(3) The boundary conditions for supports, interfaces and applied loads should be chosen such that results obtained are conservative.

(4) Geometric properties should be taken as nominal.

(5) All imperfections should be based on the shapes and amplitudes as given in section C.5.

(6) Material properties should conform to C.6(2).

C.4 Choice of software and documentation

(1) The software should be suitable for the task and be proven reliable.

NOTE: Reliability can be proven by appropriate bench mark tests.

(2) The mesh size, loading, boundary conditions and other input data as well as the output should be documented in a way that they can be reproduced by third parties.

C.5 Use of imperfections

(1) Where imperfections need to be included in the FE-model these imperfections should include both geometric and structural imperfections.

(2) Unless a more refined analysis of the geometric imperfections and the structural imperfections is carried out, equivalent geometric imperfections may be used.

NOTE 1: Geometric imperfections may be based on the shape of the critical plate buckling modes with amplitudes given in the National Annex. 80 % of the geometric fabrication tolerances is recommended.

NOTE 2: Structural imperfections in terms of residual stresses may be represented by a stress pattern from the fabrication process with amplitudes equivalent to the mean (expected) values.

(3) The direction of the applied imperfection should be such that the lowest resistance is obtained.

(4) For applying equivalent geometric imperfections Table C.2 and Figure C.1 may be used.

Table C.2: Equivalent geometric imperfections

Type of imperfection	Component	Shape	Magnitude
global	member with length ℓ	bow	see EN 1993-1-1, Table 5.1
global	longitudinal stiffener with length a	bow	min (a/400, b/400)
local	panel or subpanel with short span a or b	buckling shape	min (a/200, b/200)
local	stiffener or flange subject to twist	bow twist	1 / 50

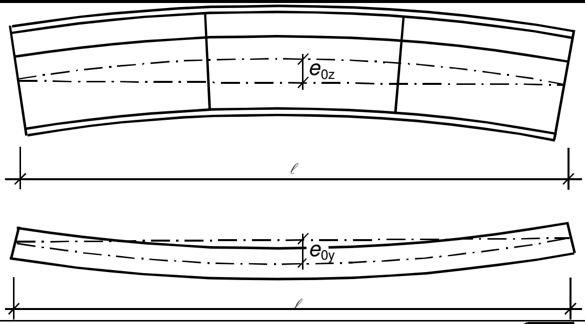
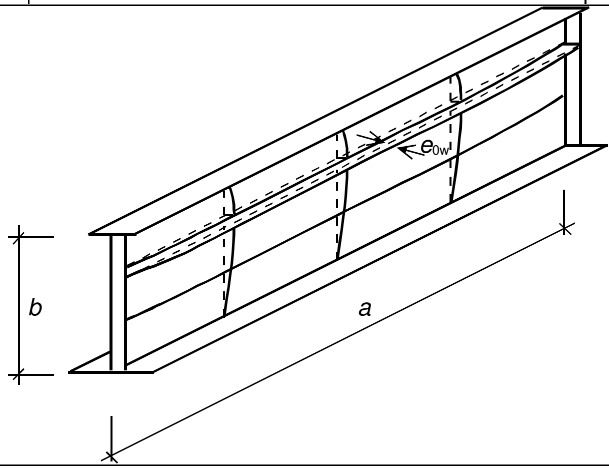
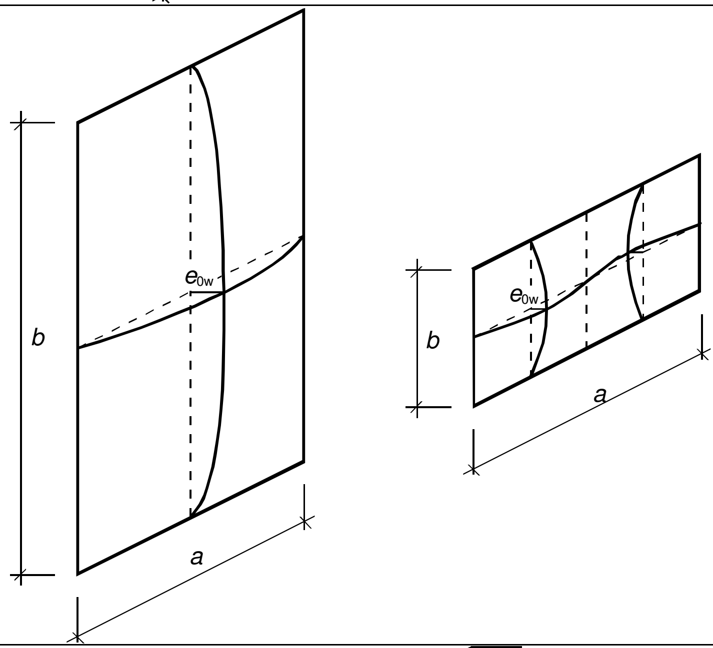
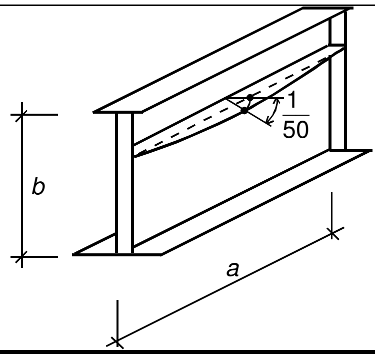
Type of imperfection	Component
global member with length ℓ	
global longitudinal stiffener with length a	
local panel or subpanel	
local stiffener or flange subject to twist	

Figure C.1: Modelling of equivalent geometric imperfections

(5) In combining imperfections a leading imperfection should be chosen and the accompanying imperfections may have their values reduced to 70%.

NOTE 1: Any type of imperfection should be taken as the leading imperfection and the others may be taken as the accompanying imperfections.

NOTE 2: Equivalent geometric imperfections may be substituted by the appropriate fictitious forces acting on the member.

C.6 Material properties

(1) Material properties should be taken as characteristic values.

(2) Depending on the accuracy and the allowable strain required for the analysis the following assumptions for the material behaviour may be used, see Figure C.2:

a) elastic-plastic without strain hardening;

b) elastic-plastic with a nominal plateau slope;

c) elastic-plastic with linear strain hardening;

d) true stress-strain curve modified from the test results as follows:

$$\sigma_{true} = \sigma\left(1+\varepsilon\right)$$
$$\varepsilon_{true} = \ell n\left(1+\varepsilon\right) \qquad \text{(C.1)}$$

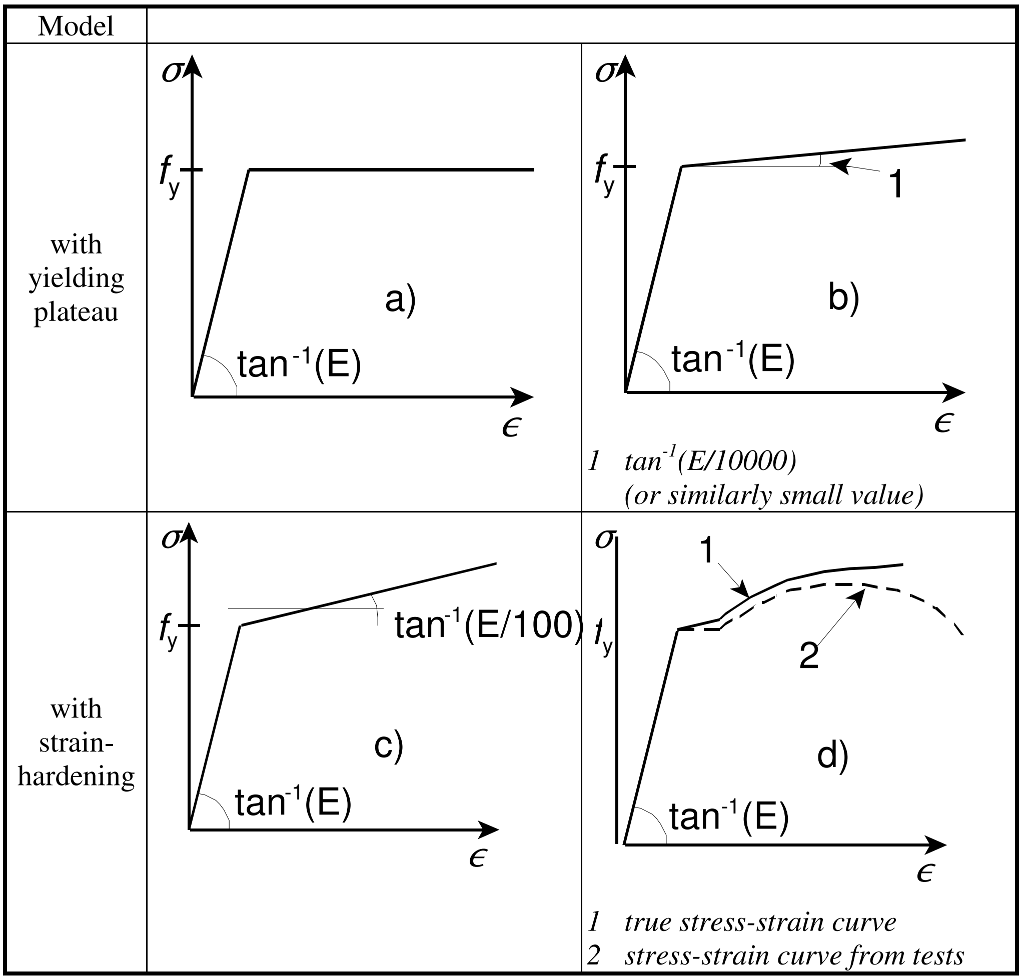


Figure C.2: Modelling of material behaviour

NOTE: For the elastic modulus E the nominal value is relevant.

C.7 Loads

(1) The loads applied to the structures should include relevant load factors and load combination factors. For simplicity a single load multiplier α may be used.

C.8 Limit state criteria

(1) The ultimate limit state criteria should be used as follows:

1. for structures susceptible to buckling:

   attainment of the maximum load.

2. for regions subjected to tensile stresses:

   attainment of a limiting value of the principal membrane strain.

NOTE 1: The National Annex may specify the limiting of principal strain. A value of 5% is recommended.

NOTE 2: Other criteria may be used, e.g. attainment of the yielding criterion or limitation of the yielding zone.

C.9 Partial factors

(1) The load magnification factor α_u to the ultimate limit state should be sufficient to achieve the required reliability.

(2) The magnification factor α_u should consist of two factors as follows:

1. α_1 to cover the model uncertainty of the FE-modelling used. It should be obtained from evaluations of test calibrations, see Annex D to EN 1990;
2. α_2 to cover the scatter of the loading and resistance models. It may be taken as γ_{M1} if instability governs and γ_{M2} if fracture governs.

(3) It should be verified that:

$$\alpha_u > \alpha_1 \alpha_2 \tag{C.2}$$

NOTE: The National Annex may give information on γ_{M1} and γ_{M2}. The use of γ_{M1} and γ_{M2} as specified in the relevant parts of EN 1993 is recommended.

Annex D [informative] – Plate girders with corrugated webs

D.1 General

(1) Annex D covers design rules for I-girders with trapezoidal or sinusoidal corrugated webs, see Figure D.1.

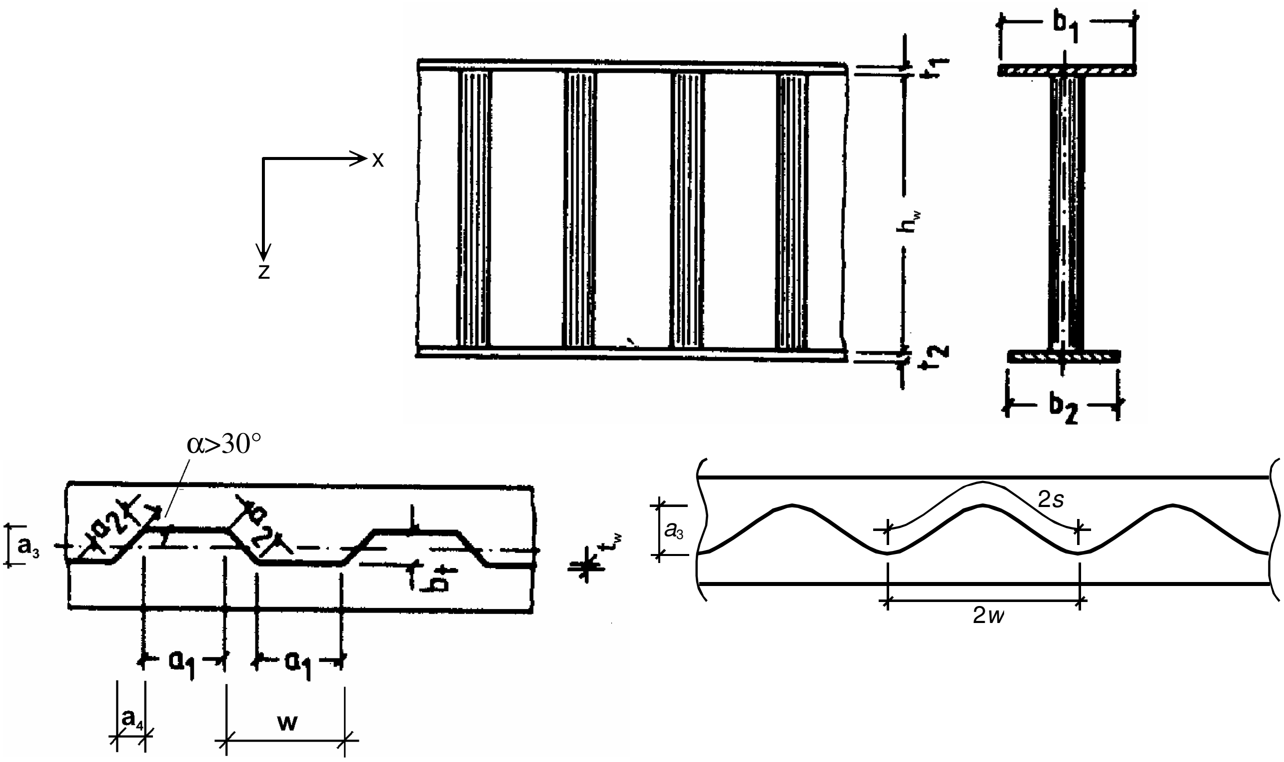


Figure D.1: Geometric notations

D.2 Ultimate limit state

D.2.1 Moment of resistance

(1) The moment of resistance M_{Rd} due to bending should be taken as the minimum of the following:

$$M_{Rd} = \min\left\{ \underbrace{\frac{b_2 t_2 f_{yf,r}}{\gamma_{M0}}\left(h_w + \frac{t_1+t_2}{2}\right)}_{tension\ flange} ; \underbrace{\frac{b_1 t_1 f_{yf,r}}{\gamma_{M0}}\left(h_w + \frac{t_1+t_2}{2}\right)}_{compression\ flange} ; \underbrace{\frac{b_1 t_1 \chi f_{yf}}{\gamma_{M1}}\left(h_w + \frac{t_1+t_2}{2}\right)}_{compression\ flange} \right\} \quad \text{(D.1)}$$

where $f_{yf,r}$ is the value of yield stress reduced due to transverse moments in the flanges

$f_{yf,r} = f_{yf} f_T$

$$f_T = 1 - 0{,}4\sqrt{\frac{\sigma_x(M_z)}{\frac{f_{yf}}{\gamma_{M0}}}}$$

$\sigma_x(M_z)$ is the stress due to the transverse moment in the flange

χ is the reduction factor for out of plane buckling according to 6.3 of EN 1993-1-1

NOTE 1: The transverse moment M_z results from the shear flow in flanges as indicated in Figure D.2.

NOTE 2: For sinusoidally corrugated webs f_T is 1,0.

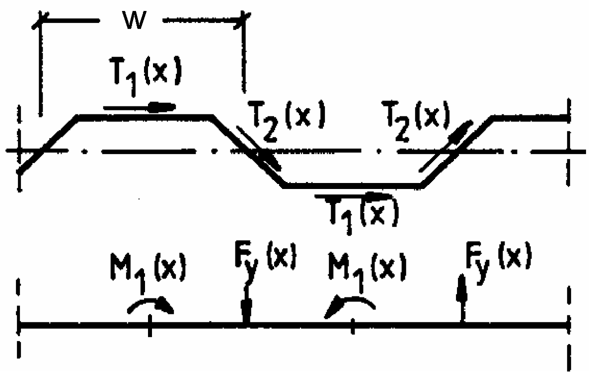


Figure D.2: Transverse actions due to shear flow introduction into the flange

(2) The effective[p] area of the compression flange should be determined from 4.4(1) using the larger value of the slenderness parameter $\overline{\lambda}_p$ defined in 4.4(2). The buckling factor k_σ should be taken as the larger of:

a) $$k_\sigma = 0{,}43 + \left(\frac{\overline{b}}{a}\right)^2 \qquad \text{(D.2)}$$

where $\overline{b}$ is the maximum width of the outstand from the toe of the weld to the free edge

$$a = a_1 + 2a_4$$

b) $$k_\sigma = 0{,}60 \qquad \text{(D.3)}$$

where $\overline{b} = \frac{b_1}{2}$

D.2.2 Shear resistance

(1) The shear resistance V_{Rd} should be taken as:

$$V_{Rd} = \chi_c \frac{f_{yw}}{\gamma_{M1}\sqrt{3}} h_w t_w \qquad \text{(D.4)}$$

where χ_c is the lesser of the values of reduction factors for local buckling $\chi_{c,\ell}$ and global buckling $\chi_{c,g}$ obtained from (2) and (3)

(2) The reduction factor $\chi_{c,\ell}$ for local buckling should be calculated from:

$$\chi_{c,\ell} = \frac{1{,}15}{0{,}9 + \overline{\lambda}_{c,\ell}} \leq 1{,}0 \qquad \text{(D.5)}$$

where $$\overline{\lambda}_{c,\ell} = \sqrt{\frac{f_y}{\tau_{cr,\ell}\sqrt{3}}} \qquad \text{(D.6)}$$

$$\tau_{cr,\ell} = 4{,}83\, E \left[\frac{t_w}{a_{\max}}\right]^2 \qquad \text{(D.7)}$$

$a_{\max}$ should be taken as the greater of a_1 and a_2.

NOTE: For sinusoidally corrugated webs the National Annex may give information on the calculation of $\tau_{cr,\ell}$ and $\chi_{c,\ell}$.
The use of the following equation is recommended:

$$\tau_{cr,\ell} = (5{,}34 + \frac{a_3 s}{h_w t_w}) \frac{\pi^2 E}{12(1-\nu^2)} \left[\frac{t_w}{s}\right]^2$$

where w is the length of one half wave, see Figure D.1,

s is the unfolded length of one half wave, see Figure D.1

(3) The reduction factor $\chi_{c,g}$ for global buckling should be taken as

$$\chi_{c,g} = \frac{1{,}5}{0{,}5 + \bar{\lambda}_{c,g}^2} \le 1{,}0 \quad \text{(D.8)}$$

where $\bar{\lambda}_{c,g} = \sqrt{\frac{f_y}{\tau_{cr,g}\sqrt{3}}}$ (D.9)

$$\tau_{cr,g} = \frac{32{,}4}{t_w\, h_w^2} \sqrt[4]{D_x\, D_z^3} \quad \text{(D.10)}$$

$$D_x = \frac{E\, t_w^3}{12\left(1-\nu^2\right)} \frac{w}{s}$$

$$D_z = \frac{E\, I_z}{w}$$

I_z second moment of area of one corrugation of length w, see Figure D.1

NOTE 1: s and I_z are related to the actual shape of the corrugation.

NOTE 2: Equation (D.10) is valid for plates that are assumed to be hinged at the edges.

D.2.3 Requirements for end stiffeners

(1) Bearing stiffeners should be designed according to section 9.

Annex E [normative] – Alternative methods for determining effective cross sections

E.1 Effective areas for stress levels below the yield strength

(1) As an alternative to the method given in 4.4(2) the following formulae may be applied to determine effective areas at stress levels lower than the yield strength:

a) for internal compression elements:

$$\rho = \frac{1-0{,}055(3+\psi)/\bar{\lambda}_{\mathrm{p,red}}}{\bar{\lambda}_{\mathrm{p,red}}} + 0{,}18\frac{(\bar{\lambda}_{\mathrm{p}} - \bar{\lambda}_{\mathrm{p,red}})}{(\bar{\lambda}_{\mathrm{p}} - 0{,}6)} \quad \text{but } \rho \leq 1{,}0 \tag{E.1}$$

b) for outstand compression elements:

$$\rho = \frac{1-0{,}188/\bar{\lambda}_{\mathrm{p,red}}}{\bar{\lambda}_{\mathrm{p,red}}} + 0{,}18\frac{(\bar{\lambda}_{\mathrm{p}} - \bar{\lambda}_{\mathrm{p,red}})}{(\bar{\lambda}_{\mathrm{p}} - 0{,}6)} \quad \text{but } \rho \leq 1{,}0 \tag{E.2}$$

For notations see 4.4(2) and 4.4(4). For calculation of resistance to global buckling 4.4(5) applies.

E.2 Effective areas for stiffness

(1) For the calculation of effective areas for stiffness the serviceability limit state slenderness $\bar{\lambda}_{p,ser}$ may be calculated from:

$$\bar{\lambda}_{p,ser} = \bar{\lambda}_{p}\sqrt{\frac{\sigma_{com,Ed,ser}}{f_y}} \tag{E.3}$$

where $\sigma_{\mathrm{com,Ed,ser}}$ is defined as the maximum compressive stress (calculated on the basis of the effective cross section) in the relevant element under loads at serviceability limit state.

(2) The second moment of area may be calculated by an interpolation of the gross cross section and the effective cross section for the relevant load combination using the expression:

$$I_{eff} = I_{gr} - \frac{\sigma_{gr}}{\sigma_{com,Ed,ser}}\left(I_{gr} - I_{eff}\left(\sigma_{com,Ed,ser}\right)\right) \tag{E.4}$$

where I_{gr} is the second moment of area of the gross cross section

σ_{gr} is the maximum bending stress at serviceability limit states based on the gross cross section

$I_{\mathrm{eff}}(\sigma_{\mathrm{com,Ed,ser}})$ is the second moment of area of the effective cross section with allowance for local buckling according to E.1 calculated for the maximum stress $\sigma_{\mathrm{com,Ed,ser}} \geq \sigma_{\mathrm{gr}}$ within the span length considered.

(3) The effective second moment of area I_{eff} may be taken as variable along the span according to the most severe locations. Alternatively a uniform value may be used based on the maximum absolute sagging moment under serviceability loading.

(4) The calculations require iterations, but as a conservative approximation they may be carried out as a single calculation at a stress level equal to or higher than $\sigma_{\mathrm{com,Ed,ser}}$.

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BRITISH STANDARD

BS EN 1993-1-8:2005

Incorporating Corrigenda Nos. 1 and 2

Eurocode 3: Design of steel structures —

Part 1-8: Design of joints

The European Standard EN 1993-1-8:2005 has the status of a British Standard

ICS 91.010.30

British Standards

National foreword

This British Standard is the official English language version of EN 1993-1-8:2005, including Corrigendum December 2005. It supersedes DD ENV 1993-1-1:1992, which is withdrawn.

NOTE Corrigendum No. 1 implements a CEN Corrigendum which adds "P" after the clause number and replaces the word "should" with "shall" in the following clauses and subclauses: **2.2**(1) and (3), **2.3**(1), **2.5**(1), **4.1**(2), 6.4.1(1), 7.2.1(1) and (2), 7.3.1(1) and 7.4.2(1).

The structural Eurocodes are divided into packages by grouping Eurocodes for each of the main materials, concrete, steel, composite concrete and steel, timber, masonry and aluminium, this is to enable a common date of withdrawal (DOW) for all the relevant parts that are needed for a particular design. The conflicting national standards will be withdrawn at the end of the coexistence period, after all the EN Eurocodes of a package are available.

Following publication of the EN, there is a period allowed for national calibration during which the national annex is issued, followed by a coexistence period of a maximum 3 years. During the coexistence period Member States are encouraged to adapt their national provisions. Conflicting national standards will be withdrawn by March 2010 at the latest.

BS EN 1993-1-8 will partially supersede BS 449-2, BS 4604-1, BS 4604-2, BS 5400-3 and BS 5950-1, which will be withdrawn by March 2010.

The UK participation in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/31, Structural use of steel, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Where a normative part of this EN allows for a choice to be made at the national level, the range and possible choice will be given in the normative text, and a note will qualify it as a Nationally Determined Parameter (NDP). NDPs can be a specific value for a factor, a specific level or class, a particular method or a particular application rule if several are proposed in the EN.

To enable EN 1993-1-8 to be used in the UK, the NDPs will be published in a National Annex, which will be made available by BSI in due course, after public consultation has taken place.

This British Standard, was published under the authority of the Standards Policy and Strategy Committee on 17 May 2005

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Amendments issued since publication

Amd. No.	Date	Comments
16291 Corrigendum No. 1	June 2006	See note in National foreword
16571 Corrigendum No. 2	September 2006	Revision of national foreword and supersession details

Summary of pages

This document comprises a front cover, an inside front cover, page i, a blank page, the EN title page, pages 2 to 133 and a back cover.

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1993-1-8

May 2005

ICS 91.010.30

Supersedes ENV 1993-1-1:1992
Incorporating Corrigendum
December 2005

English version

Eurocode 3: Design of steel structures - Part 1-8: Design of joints

Eurocode 3: Calcul des structures en acier - Partie 1-8: Calcul des assemblages

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-8: Bemessung von Anschlüssen

This European Standard was approved by CEN on 16 April 2004.

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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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Foreword

This European Standard EN 1993, Eurocode 3: Design of steel structures, 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 November 2005, and conflicting National Standards shall be withdrawn at latest by March 2010.

This Eurocode supersedes ENV 1993-1-1.

According to the CEN-CENELEC Internal Regulations, the National Standard Organizations of the following countries are bound to implement these 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, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Background to the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonization of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonized technical rules for the design of construction works which, in a first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980s.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement[1] between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links *de facto* the Eurocodes with the provisions of all the Council's Directives and/or Commission's Decisions dealing with European standards (*e.g.* the Council Directive 89/106/EEC on construction products - CPD - and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

The Structural Eurocode programme comprises the following standards generally consisting of a number of Parts:

EN 1990	Eurocode 0:	Basis of Structural Design
EN 1991	Eurocode 1:	Actions on structures
EN 1992	Eurocode 2:	Design of concrete structures
EN 1993	Eurocode 3:	Design of steel structures
EN 1994	Eurocode 4:	Design of composite steel and concrete structures
EN 1995	Eurocode 5:	Design of timber structures
EN 1996	Eurocode 6:	Design of masonry structures
EN 1997	Eurocode 7:	Geotechnical design
EN 1998	Eurocode 8:	Design of structures for earthquake resistance
EN 1999	Eurocode 9:	Design of aluminium structures

[1] Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on EUROCODES for the design of building and civil engineering works (BC/CEN/03/89).

Eurocode standards recognize the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level where these continue to vary from State to State.

Status and field of application of eurocodes

The Member States of the EU and EFTA recognize that Eurocodes serve as reference documents for the following purposes :

– as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 – Mechanical resistance and stability – and Essential Requirement N°2 – Safety in case of fire;

– as a basis for specifying contracts for construction works and related engineering services;

– as a framework for drawing up harmonized technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents[2] referred to in Article 12 of the CPD, although they are of a different nature from harmonized product standards[3]. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving full compatibility of these technical specifications with the Eurocodes.

The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

National Standards implementing Eurocodes

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National annex.

The National annex may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, *i.e.* :
– values and/or classes where alternatives are given in the Eurocode,
– values to be used where a symbol only is given in the Eurocode,
– country specific data (geographical, climatic, etc.), *e.g.* snow map,
– the procedure to be used where alternative procedures are given in the Eurocode.
It may contain
– decisions on the application of informative annexes,
– references to non-contradictory complementary information to assist the user to apply the Eurocode.

Links between Eurocodes and harmonized technical specifications (ENs and ETAs) for products

[2] According to Art. 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for harmonized ENs and ETAGs/ETAs.

[3] According to Art. 12 of the CPD the interpretative documents shall :
a) give concrete form to the essential requirements by harmonizing the terminology and the technical bases and indicating classes or levels for each requirement where necessary ;
b) indicate methods of correlating these classes or levels of requirement with the technical specifications, *e.g.* methods of calculation and of proof, technical rules for project design, etc. ;
c) serve as a reference for the establishment of harmonized standards and guidelines for European technical approvals.

The Eurocodes, *de facto*, play a similar role in the field of the ER 1 and a part of ER 2.

There is a need for consistency between the harmonized technical specifications for construction products and the technical rules for works[4]. Furthermore, all the information accompanying the CE Marking of the construction products which refer to Eurocodes should clearly mention which Nationally Determined Parameters have been taken into account.

National annex for EN 1993-1-8

This standard gives alternative procedures, values and recommendations with notes indicating where national choices may have to be made. The National Standard implementing EN 1993-1-8 should have a National Annex containing all Nationally Determined Parameters for the design of steel structures to be constructed in the relevant country.

National choice is allowed in EN 1993-1-8 through:

- 2.2(2)
- 1.2.6 (Group 6: Rivets)
- 3.1.1(3)
- 3.4.2(1)
- 5.2.1(2)
- 6.2.7.2(9)

[4] see Art.3.3 and Art.12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

1 Introduction

1.1 Scope

(1) This part of EN 1993 gives design methods for the design of joints subject to predominantly static loading using steel grades S235, S275, S355 and S460.

1.2 Normative references

This European Standard 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 Standard, only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

1.2.1 Reference Standards, Group 1: Weldable structural steels

EN 10025-1:2004 Hot rolled products of structural steels. General technical delivery conditions

EN 10025-2:2004 Hot rolled products of structural steels. Technical delivery conditions for non-alloy structural steels

EN 10025-3:2004 Hot rolled products of structural steels. Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels

EN 10025-4:2004 Hot rolled products of structural steels. Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels

EN 10025-5:2004 Hot rolled products of structural steels. Technical delivery conditions for structural steels with improved atmospheric corrosion resistance

EN 10025-6:2004 Hot rolled products of structural steels. Technical delivery conditions for flat products of high yield strength structural steels in quenched and tempered condition

1.2.2 Reference Standards, Group 2: Tolerances, dimensions and technical delivery conditions

EN 10029:1991 Hot rolled steel plates 3 mm thick or above - Tolerances on dimensions, shape and mass

EN 10034:1993 Structural steel I- and H-sections - Tolerances on shape and dimensions

EN 10051:1991 Continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels - Tolerances on dimensions and shape

EN 10055:1995 Hot rolled steel equal flange tees with radiused root and toes - Dimensions and tolerances on shape and dimensions

EN 10056-1:1995 Structural steel equal and unequal leg angles - Part 1: Dimensions

EN 10056-2:1993 Structural steel equal and unequal leg angles - Part 2: Tolerances on shape and dimensions

EN 10164:1993 Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions

1.2.3 Reference Standards, Group 3: Structural hollow sections

EN 10219-1:1997 Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery requirements

EN 10219-2:1997	Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 2: Tolerances, dimensions and sectional properties
EN 10210-1:1994	Hot finished structural hollow sections of non-alloy and fine grain structural steels - Part 1: Technical delivery requirements
EN 10210-2:1997	Hot finished structural hollow sections of non-alloy and fine grain structural steels - Part 2: Tolerances, dimensions and sectional properties

1.2.4 Reference Standards, Group 4: Bolts, nuts and washers

EN 14399-1:2002	High strength structural bolting for preloading - Part 1 : General Requirements
EN 14399-2:2002	High strength structural bolting for preloading - Part 2 : Suitability Test for preloading
EN 14399-3:2002	High strength structural bolting for preloading - Part 3 : System HR -Hexagon bolt and nut assemblies
EN 14399-4:2002	High strength structural bolting for preloading - Part 4 : System HV -Hexagon bolt and nut assemblies
EN 14399-5:2002	High strength structural bolting for preloading - Part 5 : Plain washers for system HR
EN 14399-6:2002	High strength structural bolting for preloading - Part 6 : Plain chamfered washers for systems HR and HV
EN ISO 898-1:1999	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs (ISO 898-1:1999)
EN 20898-2:1993	Mechanical properties of fasteners - Part 2: Nuts with special proof load values - Coarse thread (ISO 898-2:1992)
EN ISO 2320:1997	Prevailing torque type steel hexagon nuts - Mechanical and performance requirements (ISO 2320:1997)
EN ISO 4014:2000	Hexagon head bolts - Product grades A and B (ISO 4014:1999)
EN ISO 4016:2000	Hexagon head bolts - Product grade C (ISO 4016:1999)
EN ISO 4017:2000	Hexagon head screws - Product grades A and B (ISO 4017:1999)
EN ISO 4018:2000	Hexagon head screws - Product grade C (ISO 4018:1999)
EN ISO 4032:2000	Hexagon nuts, style 1 - Product grades A and B (ISO 4032:1999)
EN ISO 4033:2000	Hexagon nuts, style 2 - Product grades A and B (ISO 4033:1999)
EN ISO 4034:2000	Hexagon nuts - Product grade C (ISO 4034:1999)
EN ISO 7040:1997	Prevailing torque hexagon nuts (with non-metallic insert), style 1 - Property classes 5, 8 and 10
EN ISO 7042:1997	Prevailing torque all-metal hexagon nuts, style 2 - Property classes 5, 8, 10 and 12
EN ISO 7719:1997	Prevailing torque type all-metal hexagon nuts, style 1 - Property classes 5, 8 and 10
ISO 286- 2:1988	ISO system of limits and fits - Part 2: Tables of standard tolerance grades and limit deviations for hole and shafts
ISO 1891:1979	Bolts, screws, nuts and accessories - Terminology and nomenclature - Trilingual edition
EN ISO 7089:2000	Plain washers- Nominal series- Product grade A
EN ISO 7090:2000	Plain washers, chamfered - Normal series - Product grade A
EN ISO 7091:2000	Plain washers - Normal series - Product grade C
EN ISO 10511:1997	Prevailing torque type hexagon thin nuts (with non-metallic insert)
EN ISO 10512:1997	Prevailing torque type hexagon nuts thin nuts, style 1, with metric fine pitch thread - Property classes 6, 8 and 10
EN ISO 10513:1997	Prevailing torque type all-metal hexagon nuts, style 2, with metric fine pitch thread - Property classes 8, 10 and 12

1.2.5 Reference Standards, Group 5: Welding consumable and welding

EN 12345:1998	Welding-Multilingual terms for welded joints with illustrations. September 1998.
EN ISO 14555:1998	Welding-Arc stud welding of metallic materials. May 1995
EN ISO 13918:1998	Welding-Studs for arc stud welding-January 1997
EN 288-3:1992	Specification and approval of welding procedures for metallic materials. Part 3: Welding procedure tests for arc welding of steels. 1992
EN ISO 5817:2003	Arc-welded joints in steel - Guidance for quality levels for imperfections

1.2.6 Reference Standards, Group 6: Rivets

NOTE: Information may be given in the National Annex.

1.2.7 Reference Standard, Group 7: Execution of steel structures

EN 1090-2	Requirements for the execution of steel structures

1.3 Distinction between Principles and Application Rules

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

1.4 Terms and definitions

(1) The following terms and definitions apply:

1.4.1
basic component (of a joint)
Part of a joint that makes a contribution to one or more of its structural properties.

1.4.2
connection
Location at which two or more elements meet. For design purposes it is the assembly of the basic components required to represent the behaviour during the transfer of the relevant internal forces and moments at the connection.

1.4.3
connected member
Any member that is joined to a supporting member or element.

1.4.4
joint
Zone where two or more members are interconnected. For design purposes it is the assembly of all the basic components required to represent the behaviour during the transfer of the relevant internal forces and moments between the connected members. A beam-to-column joint consists of a web panel and either one connection (single sided joint configuration) or two connections (double sided joint configuration), see Figure 1.1.

1.4.5
joint configuration
Type or layout of the joint or joints in a zone within which the axes of two or more inter-connected members intersect, see Figure 1.2.

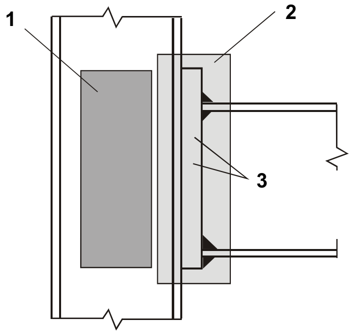
1.4.6
rotational capacity

The angle through which the joint can rotate for a given resistance level without failing.

1.4.7
rotational stiffness
The moment required to produce unit rotation in a joint.

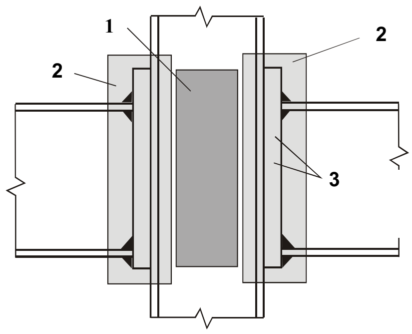
1.4.8
structural properties (of a joint)
Resistance to internal forces and moments in the connected members, rotational stiffness and rotation capacity.

1.4.9
uniplanar joint
In a lattice structure a uniplanar joint connects members that are situated in a single plane.



Joint = web panel in shear + connection

a) Single-sided joint configuration

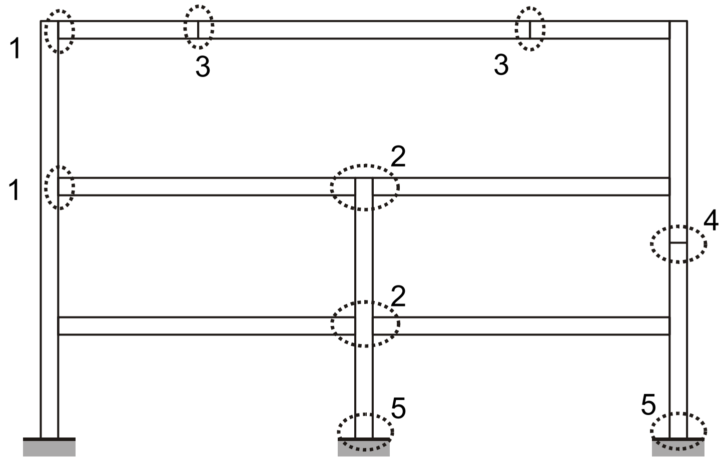


Left joint = web panel in shear + left connection
Right joint = web panel in shear + right connection

b) Double-sided joint configuration

1 web panel in shear
2 connection
3 components (e.g. bolts, endplate)

Figure 1.1: Parts of a beam-to-column joint configuration



1 Single-sided beam-to-column joint configuration;

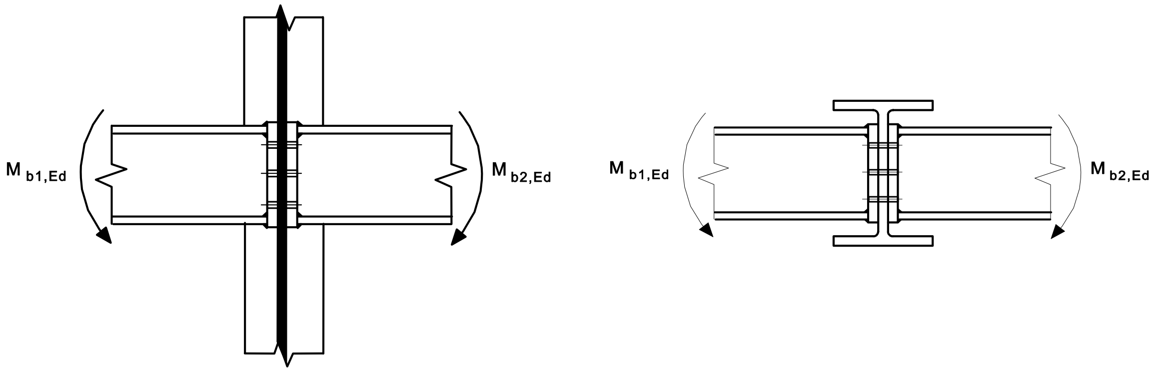
2 Double-sided beam-to-column joint configuration;

3 Beam splice;

4 Column splice;

5 Column base.

a) Major-axis joint configurations



Double-sided beam-to-column joint configuration

Double-sided beam-to-beam joint configuration

b) Minor-axis joint configurations (to be used only for balanced moments $M_{b1,Ed} = M_{b2,Ed}$)

Figure 1.2: Joint configurations

1.5 Symbols

(1) The following symbols are used in this Standard:

d is the nominal bolt diameter, the diameter of the pin or the diameter of the fastener;

d_0 is the hole diameter for a bolt, a rivet or a pin ;

$d_{o,t}$ is the hole size for the tension face, generally the hole diameter, but for a slotted holes perpendicular to the tension face the slot length should be used;

$d_{o,v}$ is the hole size for the shear face, generally the hole diameter, but for slotted holes parallel to the shear face the slot length should be used;

d_c is the clear depth of the column web;

d_m is the mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller;

$f_{H,Rd}$ is the design value of the Hertz pressure;

f_{ur} is the specified ultimate tensile strength of the rivet;

e_1 is the end distance from the centre of a fastener hole to the adjacent end of any part, measured in the direction of load transfer, see Figure 3.1;

e_2 is the edge distance from the centre of a fastener hole to the adjacent edge of any part, measured at right angles to the direction of load transfer, see Figure 3.1;

e_3 is the distance from the axis of a slotted hole to the adjacent end or edge of any part, see Figure 3.1;

e_4 is the distance from the centre of the end radius of a slotted hole to the adjacent end or edge of any part, see Figure 3.1;

ℓ_{eff} is the effective length of fillet weld;

n is the number of the friction surfaces or the number of fastener holes on the shear face;

p_1 is the spacing between centres of fasteners in a line in the direction of load transfer, see Figure 3.1;

$p_{1,0}$ is the spacing between centres of fasteners in an outer line in the direction of load transfer, see Figure 3.1;

$p_{1,i}$ is the spacing between centres of fasteners in an inner line in the direction of load transfer, see Figure 3.1;

p_2 is the spacing measured perpendicular to the load transfer direction between adjacent lines of fasteners, see Figure 3.1;

r is the bolt row number;

NOTE: In a bolted connection with more than one bolt-row in tension, the bolt-rows are numbered starting from the bolt-row furthest from the centre of compression.

s_s is the length of stiff bearing;

t_a is the thickness of the angle cleat;

t_{fc} is the thickness of the column flange;

t_p is the thickness of the plate under the bolt or the nut;

t_w is the thickness of the web or bracket;

t_{wc} is the thickness of the column web;

A is the gross cross-section area of bolt;

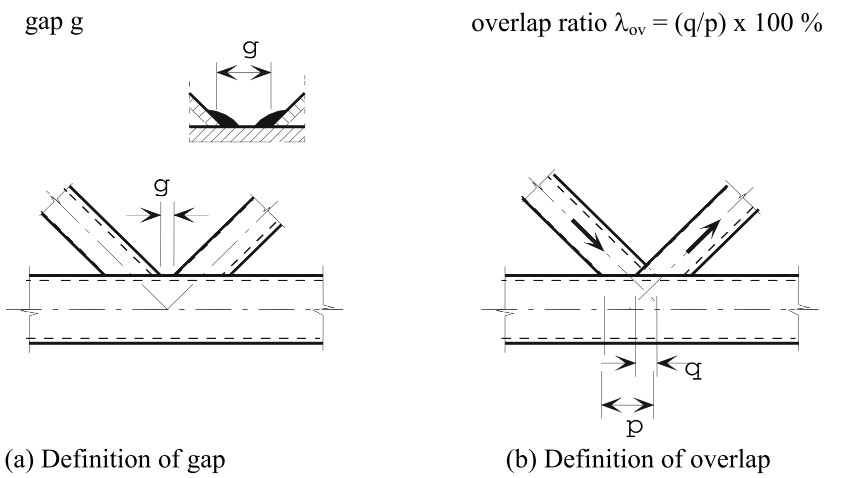
A_0 is the area of the rivet hole;

A_{vc} is the shear area of the column, see EN 1993-1-1;

A_s is the tensile stress area of the bolt or of the anchor bolt;

$A_{v,eff}$ is the effective shear area;
$B_{p,Rd}$ is the design punching shear resistance of the bolt head and the nut
E is the elastic modulus;
$F_{p,Cd}$ is the design preload force;
$F_{t,Ed}$ is the design tensile force per bolt for the ultimate limit state;
$F_{t,Rd}$ is the design tension resistance per bolt;
$F_{T,Rd}$ is the tension resistance of an equivalent T-stub flange;
$F_{v,Rd}$ is the design shear resistance per bolt;
$F_{b,Rd}$ is the design bearing resistance per bolt;
$F_{s,Rd,ser}$ is the design slip resistance per bolt at the serviceability limit state;
$F_{s,Rd}$ is the design slip resistance per bolt at the ultimate limit state;
$F_{v,Ed,ser}$ is the design shear force per bolt for the serviceability limit state;
$F_{v,Ed}$ is the design shear force per bolt for the ultimate limit state;
$M_{j,Rd}$ is the design moment resistance of a joint;
S_j is the rotational stiffness of a joint;
$S_{j,ini}$ is the initial rotational stiffness of a joint;
$V_{wp,Rd}$ is the plastic shear resistance of a column web panel;
z is the lever arm;
μ is the slip factor;
ϕ is the rotation of a joint.

(2) The following standard abbreviations for hollow sections are used in section 7:
CHS for "circular hollow section";
RHS for "rectangular hollow section", which in this context includes square hollow sections.



(a) Definition of gap (b) Definition of overlap

Figure 1.3: Gap and overlap joints

(3) The following symbols are used in section 7:
A_i is the cross-sectional area of member i (i = 0, 1, 2 or 3);
A_v is the shear area of the chord;
$A_{v,eff}$ is the effective shear area of the chord;

L is the system length of a member;

$M_{ip,i,Rd}$ is the design value of the resistance of the joint, expressed in terms of the in-plane internal moment in member i (i = 0, 1, 2 or 3);

$M_{ip,i,Ed}$ is the design value of the in-plane internal moment in member i (i = 0, 1, 2 or 3);

$M_{op,i,Rd}$ is the design value of the resistance of the joint, expressed in terms of the out-of-plane internal moment in member i (i = 0, 1, 2 or 3);

$M_{op,i,Ed}$ is the design value of the out-of-plane internal moment in member i (i = 0, 1, 2 or 3);

$N_{i,Rd}$ is the design value of the resistance of the joint, expressed in terms of the internal axial force in member i (i = 0, 1, 2 or 3);

$N_{i,Ed}$ is the design value of the internal axial force in member i (i = 0, 1, 2 or 3);

$W_{e\ell,i}$ is the elastic section modulus of member i (i = 0, 1, 2 or 3);

$W_{p\ell,i}$ is the plastic section modulus of member i (i = 0, 1, 2 or 3);

b_i is the overall out-of-plane width of RHS member i (i = 0, 1, 2 or 3);

b_{eff} is the effective width for a brace member to chord connection;

$b_{e,ov}$ is the effective width for an overlapping brace to overlapped brace connection;

$b_{e,p}$ is the effective width for punching shear;

b_p is the width of a plate;

b_w is the effective width for the web of the chord;

d_i is the overall diameter of CHS member i (i = 0, 1, 2 or 3);

d_w is the depth of the web of an I or H section chord member;

e is the eccentricity of a joint;

f_b is the buckling strength of the chord side wall;

f_{yi} is the yield strength of member i (i = 0, 1, 2 or 3);

f_{y0} is the yield strength of a chord member;

g is the gap between the brace members in a K or N joint (negative values of g represent an overlap q); the gap g is measured along the length of the connecting face of the chord, between the toes of the adjacent brace members, see Figure 1.3(a);

h_i is the overall in-plane depth of the cross-section of member i (i = 0, 1, 2 or 3);

k is a factor defined in the relevant table, with subscript g, m, n or p;

ℓ is the buckling length of a member;

p is the length of the projected contact area of the overlapping brace member onto the face of the chord, in the absence of the overlapped brace member, see Figure 1.3(b);

q is the length of overlap, measured at the face of the chord, between the brace members in a K or N joint, see Figure 1.3(b);

r is the root radius of an I or H section or the corner radius of a rectangular hollow section;

t_f is the flange thickness of an I or H section;

t_i is the wall thickness of member i (i = 0, 1, 2 or 3);

t_p is the thickness of a plate;

t_w is the web thickness of an I or H section;

α is a factor defined in the relevant table;

θ_i is the included angle between brace member i and the chord (i = 1, 2 or 3);

κ is a factor defined where it occurs;

μ is a factor defined in the relevant table;

φ is the angle between the planes in a multiplanar joint.

(4) The integer subscripts used in section 7 are defined as follows:

i is an integer subscript used to designate a member of a joint, $i = 0$ denoting a chord and $i = 1$, 2 or 3 the brace members. In joints with two brace members, $i = 1$ normally denotes the compression brace and $i = 2$ the tension brace, see Figure 1.4(b). For a single brace $i = 1$ whether it is subject to compression or tension, see Figure 1.4(a);

i and j are integer subscripts used in overlap type joints, i to denote the overlapping brace member and j to denote the overlapped brace member, see Figure 1.4(c).

(5) The stress ratios used in section 7 are defined as follows:

n is the ratio $(\sigma_{0,\mathrm{Ed}}/f_{y0})/\gamma_{M5}$ (used for RHS chords);

n_p is the ratio $(\sigma_{p,\mathrm{Ed}}/f_{y0})/\gamma_{M5}$ (used for CHS chords);

$\sigma_{0,\mathrm{Ed}}$ is the maximum compressive stress in the chord at a joint;

$\sigma_{p,\mathrm{Ed}}$ is the value of $\sigma_{0,\mathrm{Ed}}$ excluding the stress due to the components parallel to the chord axis of the axial forces in the braces at that joint, see Figure 1.4.

(6) The geometric ratios used in section 7 are defined as follows:

β is the ratio of the mean diameter or width of the brace members, to that of the chord:

- for T, Y and X joints:

$$\frac{d_1}{d_0} \; ; \; \frac{d_1}{b_0} \text{ or } \frac{b_1}{b_0}$$

- for K and N joints:

$$\frac{d_1 + d_2}{2\,d_0} \; ; \; \frac{d_1 + d_2}{2\,b_0} \text{ or } \frac{b_1 + b_2 + h_1 + h_2}{4\,b_0}$$

- for KT joints:

$$\frac{d_1 + d_2 + d_3}{3\,d_0} \; ; \; \frac{d_1 + d_2 + d_3}{3\,b_0} \text{ or } \frac{b_1 + b_2 + b_3 + h_1 + h_2 + h_3}{6\,b_0}$$

β_p is the ratio b_i/b_p;

γ is the ratio of the chord width or diameter to twice its wall thickness:

$$\frac{d_0}{2\,t_0} \; ; \; \frac{b_0}{2\,t_0} \text{ or } \frac{b_0}{2\,t_f}$$

η is the ratio of the brace member depth to the chord diameter or width:

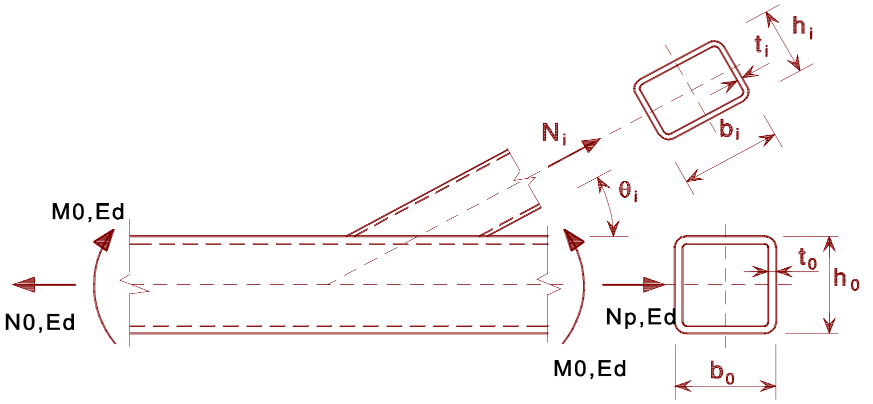
$$\frac{h_i}{d_0} \text{ or } \frac{h_i}{b_0}$$

η_p is the ratio h_i/b_p;

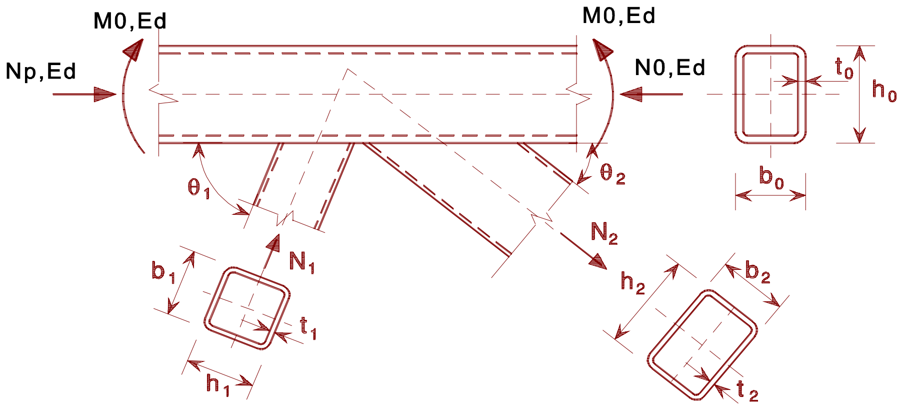
λ_{ov} is the overlap ratio, expressed as a percentage ($\lambda_{ov} = (q/p) \times 100\%$) as shown in figure 1.3(b).

(7) Other symbols are specified in appropriate clauses when they are used.

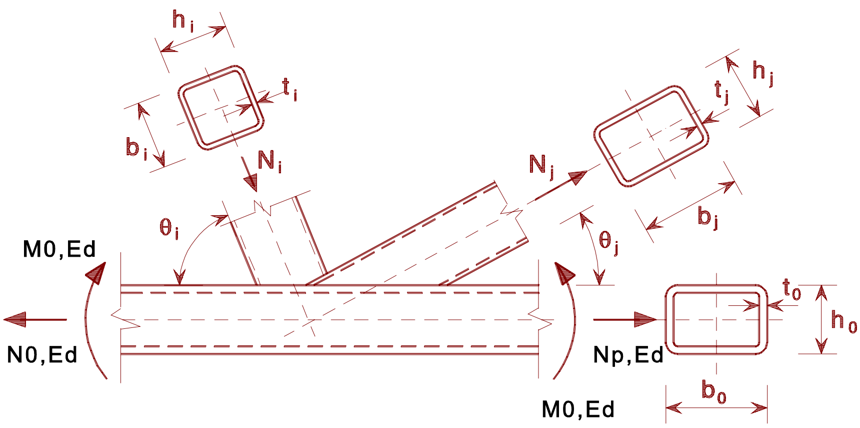
NOTE: Symbols for circular sections are given in Table 7.2.



a) Joint with single brace member



b) Gap joint with two brace members



c) Overlap joint with two brace members

Figure 1.4: Dimensions and other parameters at a hollow section lattice girder joint

2 Basis of design

2.1 Assumptions

(1) The design methods given in this part of EN 1993 assume that the standard of construction is as specified in the execution standards given in 1.2 and that the construction materials and products used are those specified in EN 1993 or in the relevant material and product specifications.

2.2 General requirements

(1)P All joints shall have a design resistance such that the structure is capable of satisfying all the basic design requirements given in this Standard and in EN 1993-1-1.

(2) The partial safety factors γ_M for joints are given in Table 2.1.

Table 2.1: Partial safety factors for joints

Resistance of members and cross-sections	γ_{M0} , γ_{M1} and γ_{M2} see EN 1993-1-1
Resistance of bolts	γ_{M2}
Resistance of rivets	
Resistance of pins	
Resistance of welds	
Resistance of plates in bearing	
Slip resistance - at ultimate limit state (Category C) - at serviceability limit state (Category B)	 γ_{M3} $\gamma_{M3,ser}$
Bearing resistance of an injection bolt	γ_{M4}
Resistance of joints in hollow section lattice girder	γ_{M5}
Resistance of pins at serviceability limit state	$\gamma_{M6,ser}$
Preload of high strength bolts	γ_{M7}
Resistance of concrete	γ_c see EN 1992

NOTE: Numerical values for γ_M may be defined in the National Annex. Recommended values are as follows: $\gamma_{M2} = 1,25$; $\gamma_{M3} = 1,25$ and $\gamma_{M3,ser} = 1,1$; $\gamma_{M4} = 1,0$; $\gamma_{M5} = 1,0$; $\gamma_{M6,ser} = 1,0$; $\gamma_{M7} = 1,1$.

(3)P Joints subject to fatigue shall also satisfy the principles given in EN 1993-1-9.

2.3 Applied forces and moments

(1)P The forces and moments applied to joints at the ultimate limit state shall be determined according to the principles in EN 1993-1-1.

2.4 Resistance of joints

(1) The resistance of a joint should be determined on the basis of the resistances of its basic components.

(2) Linear-elastic or elastic-plastic analysis may be used in the design of joints.

(3) Where fasteners with different stiffnesses are used to carry a shear load the fasteners with the highest stiffness should be designed to carry the design load. An exception to this design method is given in 3.9.3.

2.5 Design assumptions

(1)P Joints shall be designed on the basis of a realistic assumption of the distribution of internal forces and moments. The following assumptions shall be used to determine the distribution of forces:

(a) the internal forces and moments assumed in the analysis are in equilibrium with the forces and moments applied to the joints,

(b) each element in the joint is capable of resisting the internal forces and moments,

(c) the deformations implied by this distribution do not exceed the deformation capacity of the fasteners or welds and the connected parts,

(d) the assumed distribution of internal forces shall be realistic with regard to relative stiffnesses within the joint,

(e) the deformations assumed in any design model based on elastic-plastic analysis are based on rigid body rotations and/or in-plane deformations which are physically possible, and

(f) any model used is in compliance with the evaluation of test results (see EN 1990).

(2) The application rules given in this part satisfy 2.5(1).

2.6 Joints loaded in shear subject to impact, vibration and/or load reversal

(1) Where a joint loaded in shear is subject to impact or significant vibration one of the following jointing methods should be used:

- welding
- bolts with locking devices
- preloaded bolts
- injection bolts
- other types of bolt which effectively prevent movement of the connected parts
- rivets.

(2) Where slip is not acceptable in a joint (because it is subject to reversal of shear load or for any other reason), preloaded bolts in a Category B or C connection (see 3.4), fit bolts (see 3.6.1), rivets or welding should be used.

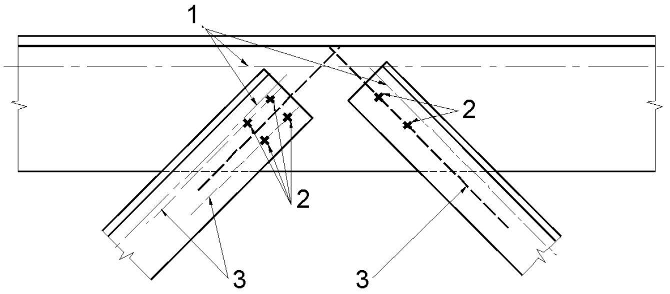
(3) For wind and/or stability bracings, bolts in Category A connections (see 3.4) may be used.

2.7 Eccentricity at intersections

(1) Where there is eccentricity at intersections, the joints and members should be designed for the resulting moments and forces, except in the case of particular types of structures where it has been demonstrated that it is not necessary, see 5.1.5.

(2) In the case of joints of angles or tees attached by either a single line of bolts or two lines of bolts any possible eccentricity should be taken into account in accordance with 2.7(1). In-plane and out-of-plane eccentricities should be determined by considering the relative positions of the centroidal axis of the member and of the setting out line in the plane of the connection (see Figure 2.1). For a single angle in tension connected by bolts on one leg the simplified design method given in 3.10.3 may be used.

NOTE: The effect of eccentricity on angles used as web members in compression is given in EN 1993-1-1, Annex BB 1.2.



1 Centroidal axes
2 Fasteners
3 Setting out lines

Figure 2.1: Setting out lines

3 Connections made with bolts, rivets or pins

3.1 Bolts, nuts and washers

3.1.1 General

(1) All bolts, nuts and washers should comply with 1.2.4 Reference Standards: Group 4.

(2) The rules in this Standard are valid for the bolt classes given in Table 3.1.

(3) The yield strength f_{yb} and the ultimate tensile strength f_{ub} for bolt classes 4.6, 4.8, 5.6, 5.8, 6.8, 8.8 and 10.9 are given in Table 3.1. These values should be adopted as characteristic values in design calculations.

Table 3.1: Nominal values of the yield strength f_{yb} and the ultimate tensile strength f_{ub} for bolts

Bolt class	4.6	4.8	5.6	5.8	6.8	8.8	10.9
f_{yb} (N/mm^2)	240	320	300	400	480	640	900
f_{ub} (N/mm^2)	400	400	500	500	600	800	1000

NOTE: The National Annex may exclude certain bolt classes.

3.1.2 Preloaded bolts

(1) Only bolt assemblies of classes 8.8 and 10.9 conforming to the requirements given in 1.2.4 Reference Standards: Group 4 for High Strength Structural Bolting for preloading with controlled tightening in accordance with the requirements in 1.2.7 Reference Standards: Group 7 may be used as preloaded bolts.

3.2 Rivets

(1) The material properties, dimensions and tolerances of steel rivets should comply with the requirements given in 1.2.6 Reference Standards: Group 6.

3.3 Anchor bolts

(1) The following materials may be used for anchor bolts:

- Steel grades conforming to 1.2.1 Reference Standards: Group 1;
- Steel grades conforming to 1.2.4 Reference Standards: Group 4;
- Steel grades used for reinforcing bars conforming to EN 10080;

provided that the nominal yield strength does not exceed 640 N/mm^2 when the anchor bolts are required to act in shear and not more than 900 N/mm^2 otherwise.

3.4 Categories of bolted connections

3.4.1 Shear connections

(1) Bolted connections loaded in shear should be designed as one of the following:

a) **Category A: Bearing type**
In this category bolts from class 4.6 up to and including class 10.9 should be used. No preloading and special provisions for contact surfaces are required. The design ultimate shear load should not exceed the design shear resistance, obtained from 3.6, nor the design bearing resistance, obtained from 3.6 and 3.7.

b) **Category B: Slip-resistant at serviceability limit state**
In this category preloaded bolts in accordance with 3.1.2(1) should be used. Slip should not occur at the serviceability limit state. The design serviceability shear load should not exceed the design slip resistance, obtained from 3.9. The design ultimate shear load should not exceed the design shear resistance, obtained from 3.6, nor the design bearing resistance, obtained from 3.6 and 3.7.

c) **Category C: Slip-resistant at ultimate limit state**
In this category preloaded bolts in accordance with 3.1.2(1) should be used. Slip should not occur at the ultimate limit state. The design ultimate shear load should not exceed the design slip resistance, obtained from 3.9, nor the design bearing resistance, obtained from 3.6 and 3.7. In addition for a connection in tension, the design plastic resistance of the net cross-section at bolt holes $N_{net,Rd}$, (see 6.2 of EN 1993-1-1), should be checked, at the ultimate limit state.

The design checks for these connections are summarized in Table 3.2.

3.4.2 Tension connections

(1) Bolted connection loaded in tension should be designed as one of the following:

a) **Category D: non-preloaded**
In this category bolts from class 4.6 up to and including class 10.9 should be used. No preloading is required. This category should not be used where the connections are frequently subjected to variations of tensile loading. However, they may be used in connections designed to resist normal wind loads.

b) **Category E: preloaded**
In this category preloaded 8.8 and 10.9 bolts with controlled tightening in conformity with 1.2.7 Reference Standards: Group 7 should be used.

The design checks for these connections are summarized in Table 3.2.

Table 3.2: Categories of bolted connections

Category	Criteria	Remarks
Shear connections		
A bearing type	$F_{v,Ed} \leq F_{v,Rd}$ $F_{v,Ed} \leq F_{b,Rd}$	No preloading required. Bolt classes from 4.6 to 10.9 may be used.
B slip-resistant at serviceability	$F_{v,Ed.ser} \leq F_{s,Rd,ser}$ $F_{v,Ed} \leq F_{v,Rd}$ $F_{v,Ed} \leq F_{b,Rd}$	Preloaded 8.8 or 10.9 bolts should be used. For slip resistance at serviceability see 3.9.
C slip-resistant at ultimate	$F_{v,Ed} \leq F_{s,Rd}$ $F_{v,Ed} \leq F_{b,Rd}$ $F_{v,Ed} \leq N_{net,Rd}$	Preloaded 8.8 or 10.9 bolts should be used. For slip resistance at ultimate see 3.9. $N_{net,Rd}$ see 3.4.1(1) c).
Tension connections		
D non-preloaded	$F_{t,Ed} \leq F_{t,Rd}$ $F_{t,Ed} \leq B_{p,Rd}$	No preloading required. Bolt classes from 4.6 to 10.9 may be used. $B_{p,Rd}$ see Table 3.4.
E preloaded	$F_{t,Ed} \leq F_{t,Rd}$ $F_{t,Ed} \leq B_{p,Rd}$	Preloaded 8.8 or 10.9 bolts should be used. $B_{p,Rd}$ see Table 3.4.
The design tensile force $F_{t,Ed}$ should include any force due to prying action, see 3.11. Bolts subjected to both shear force and tensile force should also satisfy the criteria given in Table 3.4.		

NOTE: If preload is not explicitly used in the design calculations for slip resistances but is required for execution purposes or as a quality measure (e.g. for durability) then the level of preload can be specified in the National Annex.

3.5 Positioning of holes for bolts and rivets

(1) Minimum and maximum spacing and end and edge distances for bolts and rivets are given in Table 3.3.

(2) Minimum and maximum spacing, end and edge distances for structures subjected to fatigue, see EN 1993-1-9.

Table 3.3: Minimum and maximum spacing, end and edge distances

Distances and spacings, see Figure 3.1	Minimum	Maximum[1) 2) 3)]		
		Structures made from steels conforming to EN 10025 except steels conforming to EN 10025-5		Structures made from steels conforming to EN 10025-5
		Steel exposed to the weather or other corrosive influences	Steel not exposed to the weather or other corrosive influences	Steel used unprotected
End distance e_1	$1{,}2d_0$	$4t + 40$ mm		The larger of $8t$ or 125 mm
Edge distance e_2	$1{,}2d_0$	$4t + 40$ mm		The larger of $8t$ or 125 mm
Distance e_3 in slotted holes	$1{,}5d_0$ [4)]			
Distance e_4 in slotted holes	$1{,}5d_0$ [4)]			
Spacing p_1	$2{,}2d_0$	The smaller of $14t$ or 200 mm	The smaller of $14t$ or 200 mm	The smaller of $14t_{min}$ or 175 mm
Spacing $p_{1,0}$		The smaller of $14t$ or 200 mm		
Spacing $p_{1,i}$		The smaller of $28t$ or 400 mm		
Spacing p_2 [5)]	$2{,}4d_0$	The smaller of $14t$ or 200 mm	The smaller of $14t$ or 200 mm	The smaller of $14t_{min}$ or 175 mm

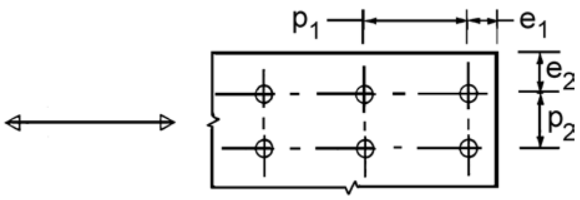
1) Maximum values for spacings, edge and end distances are unlimited, except in the following cases:
- for compression members in order to avoid local buckling and to prevent corrosion in exposed members and;
- for exposed tension members to prevent corrosion.

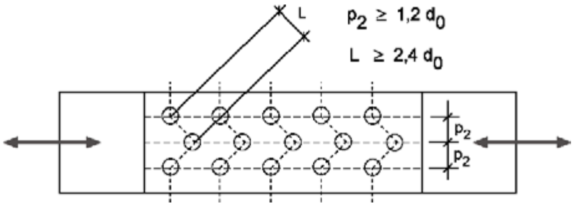
2) The local buckling resistance of the plate in compression between the fasteners should be calculated according to EN 1993-1-1 using $0{,}6\ p_1$ as buckling length. Local buckling between the fasteners need not to be checked if p_1/t is smaller than $9\ \varepsilon$. The edge distance should not exceed the local buckling requirements for an outstand element in the compression members, see EN 1993-1-1. The end distance is not affected by this requirement.

3) t is the thickness of the thinner outer connected part.

4) The dimensional limits for slotted holes are given in 1.2.7 Reference Standards: Group 7.

5) For staggered rows of fasteners a minimum line spacing of $p_2 = 1{,}2d_0$ may be used, provided that the minimum distance, L, between any two fasteners is greater or equal than $2{,}4d_0$, see Figure 3.1b).

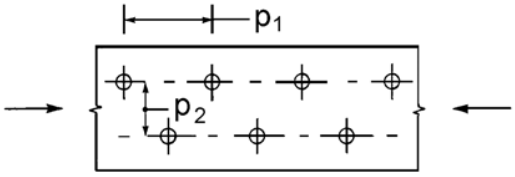


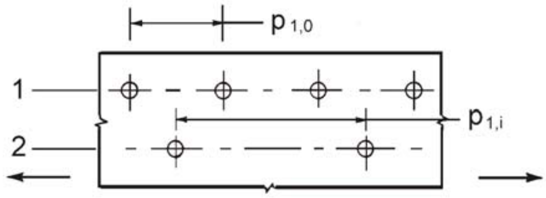


Staggered Rows of fasteners

a) Symbols for spacing of fasteners

b) Symbols for staggered spacing





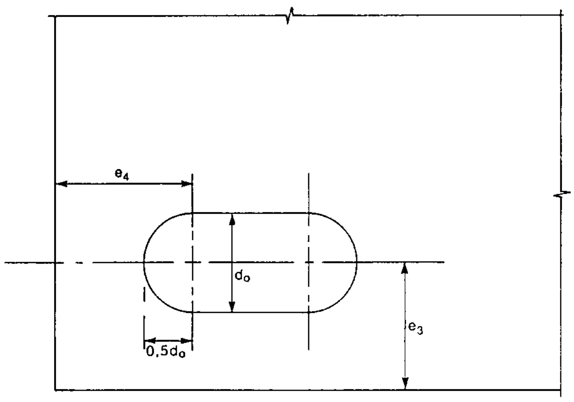
$p_1 \leq 14$ t and ≤ 200 mm $p_2 \leq 14$ t and ≤ 200 mm

$p_{1,0} \leq 14$ t and ≤ 200 mm $p_{1,i} \leq 28$ t and ≤ 400 mm

1 outer row *2 inner row*

c) Staggered spacing in compression members

d) Staggered spacing in tension members



e) End and edge distances for slotted holes

Figure 3.1: Symbols for end and edge distances and spacing of fasteners

3.6 Design resistance of individual fasteners

3.6.1 Bolts and rivets

(1) The design resistance for an individual fastener subjected to shear and/or tension is given in Table 3.4.

(2) For preloaded bolts in accordance with 3.1.2(1) the design preload, $F_{p,Cd}$,to be used in design calculations should be taken as:

$$F_{p,Cd} = 0{,}7 f_{ub} A_s / \gamma_{M7} \qquad \ldots (3.1)$$

NOTE: Where the preload is not used in design calculations see note to Table 3.2.

(3) The design resistances for tension and for shear through the threaded portion of a bolt given in Table 3.4 should only be used for bolts manufactured in conformity with 1.2.4 Reference Standard: Group 4.

For bolts with cut threads, such as anchor bolts or tie rods fabricated from round steel bars where the threads comply with EN 1090, the relevant values from Table 3.4 should be used. For bolts with cut threads where the threads do not comply with EN 1090 the relevant values from Table 3.4 should be multiplied by a factor of 0,85.

(4) The design shear resistance $F_{v,Rd}$ given in Table 3.4 should only be used where the bolts are used in holes with nominal clearances not exceeding those for normal holes as specified in 1.2.7 Reference Standards: Group 7.

(5) M12 and M14 bolts may also be used in 2 mm clearance holes provided that the design resistance of the bolt group based on bearing is greater or equal to the design resistance of the bolt group based on bolt shear. In addition for class 4.8, 5.8, 6.8, 8.8 and 10.9 bolts the design shear resistance $F_{v,Rd}$ should be taken as 0,85 times the value given in Table 3.4.

(6) Fit bolts should be designed using the method for bolts in normal holes.

(7) The thread of a fit bolt should not be included in the shear plane.

(8) The length of the threaded portion of a fit bolt included in the bearing length should not exceed 1/3 of the thickness of the plate, see Figure 3.2.

(9) The hole tolerance used for fit bolts should be in accordance with 1.2.7 Reference Standards: Group 7.

(10) In single lap joints with only one bolt row, see Figure 3.3, the bolts should be provided with washers under both the head and the nut. The design bearing resistance $F_{b,Rd}$ for each bolt should be limited to:

$$F_{b,Rd} \leq 1{,}5\, f_u\, d\, t \,/\, \gamma_{M2} \qquad \text{... (3.2)}$$

NOTE: Single rivets should not be used in single lap joints.

(11) In the case of class 8.8 or 10.9 bolts, hardened washers should be used for single lap joints with only one bolt or one row of bolts.

(12) Where bolts or rivets transmitting load in shear and bearing pass through packing of total thickness t_p greater than one-third of the nominal diameter d, see Figure 3.4, the design shear resistance $F_{v,Rd}$ calculated as specified in Table 3.4, should be multiplying by a reduction factor β_p given by:

$$\beta_p = \frac{9d}{8d + 3t_p} \quad \text{but } \beta_p \leq 1 \qquad \text{... (3.3)}$$

(13) For double shear connections with packing on both sides of the splice, t_p should be taken as the thickness of the thicker packing.

(14) Riveted connections should be designed to transfer shear forces. If tension is present the design tensile force $F_{t.Ed}$ should not exceed the design tension resistance $F_{t,Rd}$ given in Table 3.4.

(15) For grade S 235 steel the "as driven" value of f_{ur} may be taken as 400 N/mm^2.

(16) As a general rule, the grip length of a rivet should not exceed 4,5d for hammer riveting and 6,5d for press riveting.

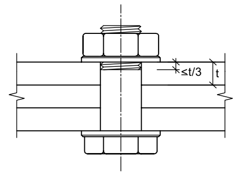


Figure 3.2: Threaded portion of the shank in the bearing length for fit bolts

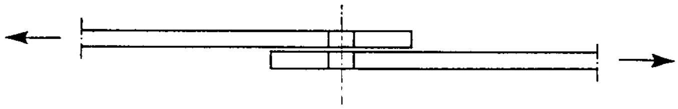


Figure 3.3: Single lap joint with one row of bolts

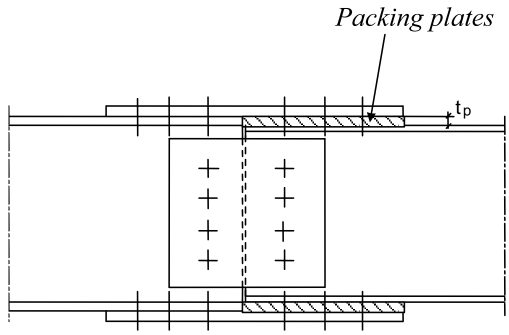


Figure 3.4: Fasteners through packings

Table 3.4: Design resistance for individual fasteners subjected to shear and/or tension

Failure mode	Bolts	Rivets
Shear resistance per shear plane	$F_{v,Rd} = \dfrac{\alpha_v \; f_{ub} \; A}{\gamma_{M2}}$ - where the shear plane passes through the threaded portion of the bolt (A is the tensile stress area of the bolt A_s): - for classes 4.6, 5.6 and 8.8: $\alpha_v = 0,6$ - for classes 4.8, 5.8, 6.8 and 10.9: $\alpha_v = 0,5$ - where the shear plane passes through the unthreaded portion of the bolt (A is the gross cross section of the bolt): $\alpha_v = 0,6$	$F_{v,Rd} = \dfrac{0,6 \; f_{ur} \; A_0}{\gamma_{M2}}$
Bearing resistance [1), 2), 3)]	$F_{b,Rd} = \dfrac{k_1 \, a_b \, f_u \, d \, t}{\gamma_{M2}}$ where α_b is the smallest of α_d ; $\dfrac{f_{ub}}{f_u}$ or 1,0; in the direction of load transfer: - for end bolts: $\alpha_d = \dfrac{e_1}{3d_0}$; for inner bolts: $\alpha_d = \dfrac{p_1}{3d_0} - \dfrac{1}{4}$ perpendicular to the direction of load transfer: - for edge bolts: k_1 is the smallest of $2,8\dfrac{e_2}{d_0} - 1,7$ or 2,5 - for inner bolts: k_1 is the smallest of $1,4\dfrac{p_2}{d_0} - 1,7$ or 2,5	
Tension resistance [2)]	$F_{t,Rd} = \dfrac{k_2 \; f_{ub} \; A_s}{\gamma_{M2}}$ where $k_2 = 0,63$ for countersunk bolt, otherwise $k_2 = 0,9$.	$F_{t,Rd} = \dfrac{0,6 \; f_{ur} \; A_0}{\gamma_{M2}}$
Punching shear resistance	$B_{p,Rd} = 0,6 \, \pi \, d_m \, t_p \, f_u \, / \, \gamma_{M2}$	No check needed
Combined shear and tension	$\dfrac{F_{v,Ed}}{F_{v,Rd}} + \dfrac{F_{t,Ed}}{1,4 \, F_{t,Rd}} \leq 1,0$	

1) The bearing resistance $F_{b,Rd}$ for bolts

- in oversized holes is 0,8 times the bearing resistance for bolts in normal holes.
- in slotted holes, where the longitudinal axis of the slotted hole is perpendicular to the direction of the force transfer, is 0,6 times the bearing resistance for bolts in round, normal holes.

2) For countersunk bolt:

- the bearing resistance $F_{b,Rd}$ should be based on a plate thickness t equal to the thickness of the connected plate minus half the depth of the countersinking.
- for the determination of the tension resistance $F_{t,Rd}$ the angle and depth of countersinking should conform with 1.2.4 Reference Standards: Group 4, otherwise the tension resistance $F_{t,Rd}$ should be adjusted accordingly.

3) When the load on a bolt is not parallel to the edge, the bearing resistance may be verified separately for the bolt load components parallel and normal to the end.

3.6.2 Injection bolts

3.6.2.1 General

(1) Injection bolts may be used as an alternative to ordinary bolts and rivets for category A, B and C connections specified in 3.4.

(2) Fabrication and erection details for injection bolts are given in 1.2.7 Reference Standards: Group 7.

3.6.2.2 Design resistance

(1) The design method given in 3.6.2.2(2) to 3.6.2.2(6) should be used for connections with injection bolts of class 8.8 or 10.9. Bolt assemblies should conform with the requirements given in 1.2.4 Reference Standards: Group 4, but see 3.6.2.2(3) for when preloaded bolts are used.

(2) The design ultimate shear load of any bolt in a Category A connection should not exceed the smaller of the following: the design shear resistance of the bolt as obtained from 3.6 and 3.7; the design bearing resistance of the resin as obtained from 3.6.2.2(5).

(3) Preloaded injection bolts should be used for category B and C connections, for which preloaded bolt assemblies in accordance with 3.1.2(1) should be used.

(4) The design serviceability shear load of any bolt in a category B connection and the design ultimate shear load of any bolt in a category C connection should not exceed the design slip resistance of the bolt as obtained from 3.9 at the relevant limit state plus the design bearing resistance of the resin as obtained from 3.6.2.2(5) at the relevant limit state. In addition the design ultimate shear load of a bolt in a category B or C connection should not exceed either the design shear resistance of the bolt as obtained from 3.6, nor the design bearing resistance of the bolt as obtained from 3.6 and 3.7.

(5) The design bearing resistance of the resin, $F_{b,Rd.resin}$, may be determined according to the following equation:

$$F_{b,Rd,resin} = \frac{k_t\ k_s\ d\ t_{b,resin}\ \beta\ f_{b,resin}}{\gamma_{M4}} \qquad \text{... (3.4)}$$

where:

$F_{b,Rd,resin}$ is the bearing strength of an injection bolt

β is a coefficient depending of the thickness ratio of the connected plates as given in Table 3.5 and Figure 3.5

$f_{b,resin}$ is the bearing strength of the resin to be determined according to the 1.2.7 Reference Standards: Group 7.

$t_{b,\ resin}$ is the effective bearing thickness of the resin, given in Table 3.5

k_t is 1,0 for serviceability limit state (long duration)
is 1,2 for ultimate limit state

k_s is taken as 1,0 for holes with normal clearances or (1,0 - 0,1 m), for oversized holes

m is the difference (in mm) between the normal and oversized hole dimensions. In the case of short slotted holes as specified in 1.2.7 Reference Standards: Group 7, m = 0, 5 · (the difference (in mm) between the hole length and width).

(6) When calculating the bearing resistance of a bolt with a clamping length exceeding 3d, a value of not more than 3d should be taken to determine the effective bearing thickness $t_{b,resin}$ (see Figure 3.6).

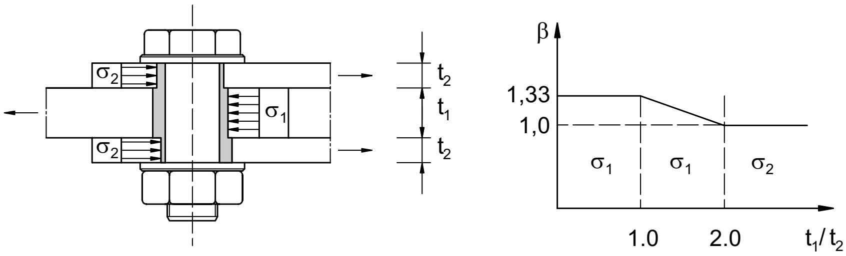


Figure 3.5: Factor *ß* as a function of the thickness ratio of the connected plates

Table 3.5: Values of *ß* and $t_{b,resin}$

t_1 / t_2	$ß$	$t_{b,resin}$
$\geq 2{,}0$ $1{,}0 < t_1 / t_2 < 2{,}0$ $\leq 1{,}0$	1,0 $1{,}66 - 0{,}33\ (t_1 / t_2)$ 1,33	$2\ t_2 \leq 1{,}5\ d$ $t_1 \leq 1{,}5\ d$ $t_1 \leq 1{,}5\ d$

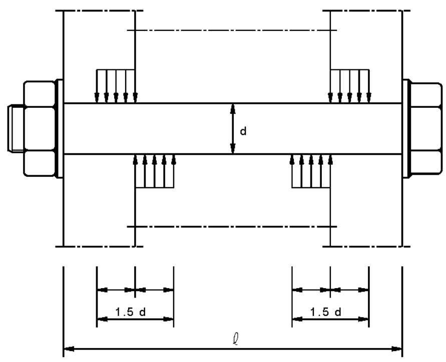


Figure 3.6: Limiting effective length for long injection bolts

3.7 Group of fasteners

(1) The design resistance of a group of fasteners may be taken as the sum of the design bearing resistances $F_{b,Rd}$ of the individual fasteners provided that the design shear resistance $F_{v,Rd}$ of each individual fastener is greater than or equal to the design bearing resistance $F_{b,Rd}$. Otherwise the design resistance of a group of fasteners should be taken as the number of fasteners multiplied by the smallest design resistance of any of the individual fasteners.

3.8 Long joints

(1) Where the distance L_j between the centres of the end fasteners in a joint, measured in the direction of force transfer (see Figure 3.7), is more than 15 d, the design shear resistance $F_{v,Rd}$ of all the fasteners calculated according to Table 3.4 should be reduced by multiplying it by a reduction factor β_{Lf}, given by:

$$\beta_{Lf} = 1 - \frac{L_j - 15d}{200d} \qquad \text{... (3.5)}$$

but $\beta_{Lf} \leq 1,0$ and $\beta_{Lf} \geq 0,75$

(2) The provision in 3.8(1) does not apply where there is a uniform distribution of force transfer over the length of the joint, e.g. the transfer of shear force between the web and the flange of a section.

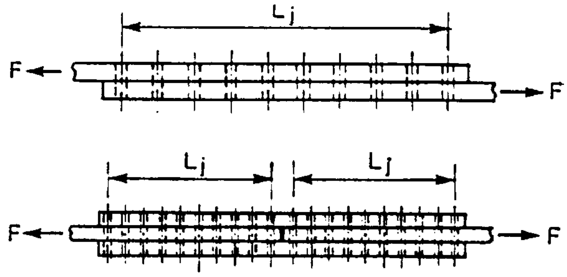


Figure 3.7: Long joints

3.9 Slip-resistant connections using 8.8 or 10.9 bolts

3.9.1 Design Slip resistance

(1) The design slip resistance of a preloaded class 8.8 or 10.9 bolt should be taken as:

$$F_{s,Rd} = \frac{k_s\ n\ \mu}{\gamma_{M3}} F_{p,C} \qquad \text{... (3.6)}$$

where:

k_s is given in Table 3.6

n is the number of the friction surfaces

μ is the slip factor obtained either by specific tests for the friction surface in accordance with 1.2.7 Reference Standards: Group 7 or when relevant as given in Table 3.7.

(2) For class 8.8 and 10.9 bolts conforming with 1.2.4 Reference Standards: Group 4, with controlled tightening in conformity with 1.2.7 Reference Standards: Group 7, the preloading force $F_{p,C}$ to be used in equation (3.6) should be taken as:

$$F_{p,C} = 0,7\, f_{ub}\, A_s \qquad \text{... (3.7)}$$

Table 3.6: Values of k_s

Description	k_s
Bolts in normal holes.	1,0
Bolts in either oversized holes or short slotted holes with the axis of the slot perpendicular to the direction of load transfer.	0,85
Bolts in long slotted holes with the axis of the slot perpendicular to the direction of load transfer.	0,7
Bolts in short slotted holes with the axis of the slot parallel to the direction of load transfer.	0,76
Bolts in long slotted holes with the axis of the slot parallel to the direction of load transfer.	0,63

Table 3.7: Slip factor, μ, for pre-loaded bolts

Class of friction surfaces (see 1.2.7 Reference Standard: Group 7)	Slip factor μ
A	0,5
B	0,4
C	0,3
D	0,2

NOTE 1: The requirements for testing and inspection are given in 1.2.7 Reference Standards: Group 7.

NOTE 2: The classification of any other surface treatment should be based on test specimens representative of the surfaces used in the structure using the procedure set out in 1.2.7 Reference Standards: Group 7.

NOTE 3: The definitions of the class of friction surface are given in 1.2.7 Reference Standards: Group 7.

NOTE 4: With painted surface treatments a loss of pre-load may occur over time.

3.9.2 Combined tension and shear

(1) If a slip-resistant connection is subjected to an applied tensile force, $F_{t,Ed}$ or $F_{t,Ed,ser}$, in addition to the shear force, $F_{v,Ed}$ or $F_{v,Ed,ser}$, tending to produce slip, the design slip resistance per bolt should be taken as follows:

for a category B connection: $$F_{s,Rd,ser} = \frac{k_s\ n\ \mu\ (F_{p,C} - 0{,}8 F_{t,Ed,ser})}{\gamma_{M3,ser}} \quad \text{... (3.8a)}$$

for a category C connection: $$F_{s,Rd} = \frac{k_s\ n\ \mu\ (F_{p,C} - 0{,}8 F_{t,Ed})}{\gamma_{M3}} \quad \text{... (3.8b)}$$

(2) If, in a moment connection, a contact force on the compression side counterbalances the applied tensile force no reduction in slip resistance is required.

3.9.3 Hybrid connections

(1) As an exception to 2.4(3) , preloaded class 8.8 and 10.9 bolts in connections designed as slip-resistant at the ultimate limit state (Category C in 3.4) may be assumed to share load with welds, provided that the final tightening of the bolts is carried out after the welding is complete.

3.10 Deductions for fastener holes

3.10.1 General

(1) Deduction for holes in the member design should be made according to EN 1993-1-1.

3.10.2 Design for block tearing

(1) Block tearing consists of failure in shear at the row of bolts along the shear face of the hole group accompanied by tensile rupture along the line of bolt holes on the tension face of the bolt group. Figure 3.8 shows block tearing.

(2) For a symmetric bolt group subject to concentric loading the design block tearing resistance, $V_{\mathrm{eff,1,Rd}}$ is given by:

$$V_{\mathrm{eff,1,Rd}} = f_u A_{nt} / \gamma_{M2} + (1 / \sqrt{3}) f_y A_{nv} / \gamma_{M0} \qquad \text{... (3.9)}$$

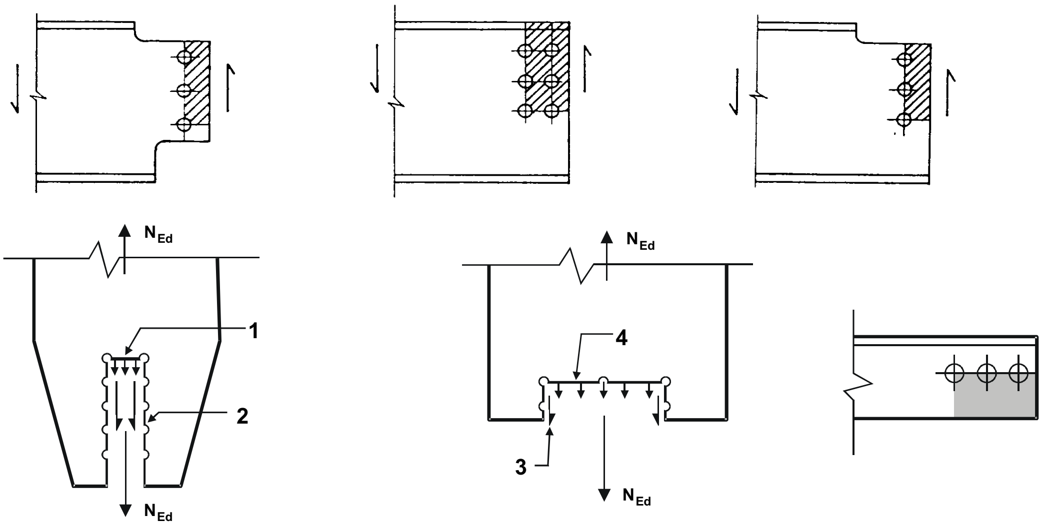
where:

A_{nt} is net area subjected to tension;

A_{nv} is net area subjected to shear.

(3) For a bolt group subject to eccentric loading the design block shear tearing resistance $V_{\mathrm{eff,2,Rd}}$ is given by:

$$V_{\mathrm{eff,2,Rd}} = 0{,}5\, f_u A_{nt} / \gamma_{M2} + (1 / \sqrt{3}) f_y A_{nv} / \gamma_{M0} \qquad \text{... (3.10)}$$



1 small tension force
2 large shear force
3 small shear force
4 large tension force

Figure 3.8: Block tearing

3.10.3 Angles connected by one leg and other unsymmetrically connected members in tension

(1) The eccentricity in joints, see 2.7(1), and the effects of the spacing and edge distances of the bolts, should be taken into account in determining the design resistance of:

- unsymmetrical members;
- symmetrical members that are connected unsymmetrically, such as angles connected by one leg.

(2) A single angle in tension connected by a single row of bolts in one leg, see Figure 3.9, may be treated as concentrically loaded over an effective net section for which the design ultimate resistance should be determined as follows:

with 1 bolt: $$N_{u,Rd} = \frac{2{,}0(e_2 - 0{,}5d_0)t\ f_u}{\gamma_{M2}} \quad \text{... (3.11)}$$

with 2 bolts: $$N_{u,Rd} = \frac{\beta_2\ A_{net}\ f_u}{\gamma_{M2}} \quad \text{... (3.12)}$$

with 3 or more bolts: $$N_{u,Rd} = \frac{\beta_3\ A_{net}\ f_u}{\gamma_{M2}} \quad \text{... (3.13)}$$

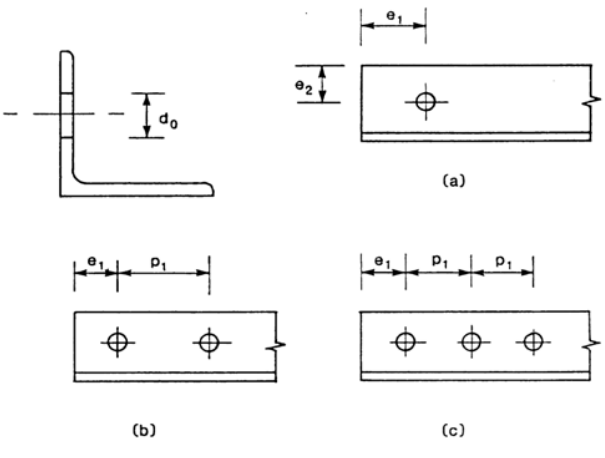
where:

β_2 and β_3 are reduction factors dependent on the pitch p_1 as given in Table 3.8. For intermediate values of p_1 the value of β may be determined by linear interpolation;

A_{net} is the net area of the angle. For an unequal-leg angle connected by its smaller leg, A_{net} should be taken as equal to the net section area of an equivalent equal-leg angle of leg size equal to that of the smaller leg.

Table 3.8: Reduction factors β_2 and β_3

Pitch	p_1	$\leq 2{,}5\ d_o$	$\geq 5{,}0\ d_o$
2 bolts	β_2	0,4	0,7
3 bolts or more	β_3	0,5	0,7



a) 1 bolt

b) 2 bolts

c) 3 bolts

Figure 3.9: Angles connected by one leg

3.10.4 Lug angles

(1) The Lug angle shown in Figure 3.10 connects angle members and their fasteners to a gusset or other supporting part and should be designed to transmit a force 1,2 times the force in the outstand of the angle connected.

(2) The fasteners connecting the lug angle to the outstand of the angle member should be designed to transmit a force 1,4 times the force in the outstand of the angle member.

(3) Lug angles connecting a channel or a similar member should be designed to transmit a force 1,1 times the force in the channel flanges to which they are attached.

(4) The fasteners connecting the lug angle to the channel or similar member should be designed to transmit a force 1,2 times the force in the channel flange which they connect.

(5) In no case should less than two bolts or rivets be used to attach a lug angle to a gusset or other supporting part.

(6) The connection of a lug angle to a gusset plate or other supporting part should terminate at the end of the member connected. The connection of the lug angle to the member should run from the end of the member to a point beyond the direct connection of the member to the gusset or other supporting part.

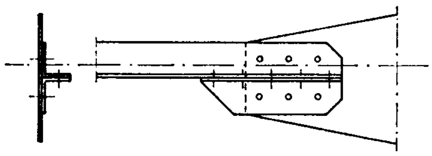


Figure 3.10: Lug angles

3.11 Prying forces

(1) Where fasteners are required to carry an applied tensile force, they should be designed to resist the additional force due to prying action, where this can occur.

NOTE: The rules given in 6.2.4 implicitly account for prying forces.

3.12 Distribution of forces between fasteners at the ultimate limit state

(1) When a moment is applied to a joint, the distribution of internal forces may be either linear (i.e. proportional to the distance from the centre of rotation) or plastic, (i.e. any distribution that is in equilibrium is acceptable provided that the resistances of the components are not exceeded and the ductility of the components is sufficient).

(2) The elastic linear distribution of internal forces should be used for the following:

- when bolts are used creating a category C slip-resistant connection,
- in shear connections where the design shear resistance $F_{v,Rd}$ of a fastener is less than the design bearing resistance $F_{b,Rd}$,
- where connections are subjected to impact, vibration or load reversal (except wind loads).

(3) When a joint is loaded by a concentric shear only, the load may be assumed to be uniformly distributed amongst the fasteners, provided that the size and the class of fasteners is the same.

3.13 Connections made with pins

3.13.1 General

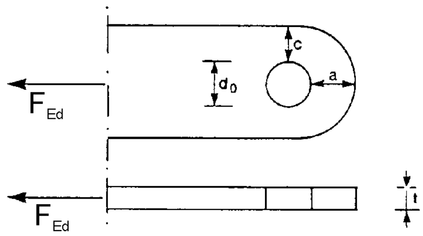
(1) Wherever there is a risk of pins becoming loose, they should be secured.

(2) Pin connections in which no rotation is required may be designed as single bolted connections, provided that the length of the pin is less than 3 times the diameter of the pin, see 3.6.1. For all other cases the method given in 3.13.2 should be followed.

(3) In pin-connected members the geometry of the unstiffened element that contains a hole for the pin should satisfy the dimensional requirements given in Table 3.9.

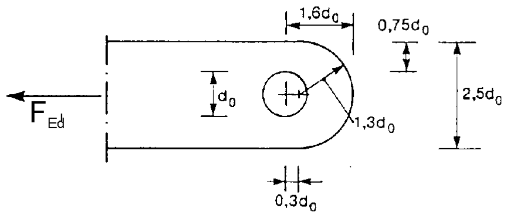
Table 3.9: Geometrical requirements for pin ended members

Type A: Given thickness t



$$a \geq \frac{F_{Ed}\gamma_{M0}}{2\,t\,f_y} + \frac{2\,d_0}{3} \quad : \quad c \geq \frac{F_{Ed}\gamma_{M0}}{2\,t\,f_y} + \frac{d_0}{3}$$

Type B: Given geometry



$$t \geq 0{,}7\sqrt{\frac{F_{Ed}\gamma_{M0}}{f_y}} \quad : \quad d_0 \leq 2{,}5\,t$$

(4) Pin connected members should be arranged such to avoid eccentricity and should be of sufficient size to distribute the load from the area of the member with the pin hole into the member away from the pin.

3.13.2 Design of pins

(1) The design requirements for solid circular pins are given in Table 3.10.

(2) The moments in a pin should be calculated on the basis that the connected parts form simple supports. It should be generally assumed that the reactions between the pin and the connected parts are uniformly distributed along the length in contact on each part as indicated in Figure 3.11.

(3) If the pin is intended to be replaceable, in addition to the provisions given in 3.13.1 to 3.13.2, the contact bearing stress should satisfy:

$$\sigma_{h,Ed} \leq f_{h,Rd} \qquad \text{... (3.14)}$$

where:

$$\sigma_{h,Ed} = 0,591 \sqrt{\frac{E\, F_{Ed,ser}\ (d_0 - d)}{d^2\ t}} \qquad \text{... (3.15)}$$

$$f_{h,Ed} = 2,5\, f_y/\gamma_{M6,ser} \qquad \text{... (3.16)}$$

where:

d is the diameter of the pin;

d_0 is the diameter of the pin hole;

$F_{Ed,ser}$ is the design value of the force to be transferred in bearing, under the characteristic load combination for serviceability limit states.

Table 3.10: Design criteria for pin connections

Failure mode	Design requirements
Shear resistance of the pin	$F_{v,Rd} = 0,6\, A\, f_{up}/\gamma_{M2} \geq F_{v,Ed}$
Bearing resistance of the plate and the pin	$F_{b,Rd} = 1,5\, t\, d\, f_y/\gamma_{M0} \geq F_{b,Ed}$
If the pin is intended to be replaceable this requirement should also be satisfied.	$F_{b,Rd,ser} = 0,6\, t\, d\, f_y/\gamma_{M6,ser} \geq F_{b,Ed,ser}$
Bending resistance of the pin	$M_{Rd} = 1,5\, W_{e\ell}\, f_{yp}/\gamma_{M0} \geq M_{Ed}$
If the pin is intended to be replaceable this requirement should also be satisfied.	$M_{Rd,ser} = 0,8\, W_{e\ell}\, f_{yp}/\gamma_{M6,ser} \geq M_{Ed,ser}$
Combined shear and bending resistance of the pin	$\left[\frac{M_{Ed}}{M_{Rd}}\right]^2 + \left[\frac{F_{v,Ed}}{F_{v,Rd}}\right]^2 \leq 1$

d is the diameter of the pin;

f_y is the lower of the design strengths of the pin and the connected part;

f_{up} is the ultimate tensile strength of the pin;

f_{yp} is the yield strength of the pin;

t is the thickness of the connected part;

A is the cross-sectional area of a pin.

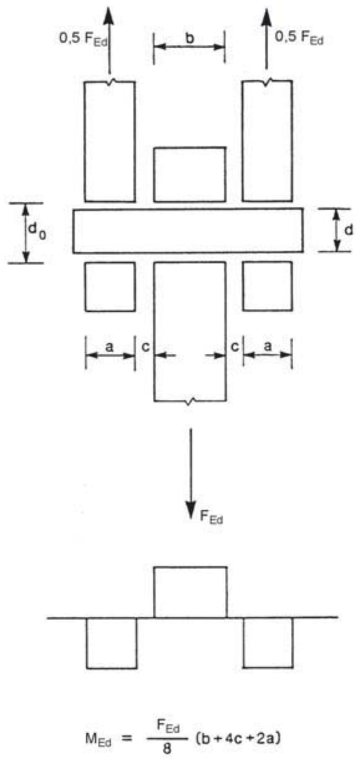


Figure 3.11: Bending moment in a pin

4 Welded connections

4.1 General

(1) The provisions in this section apply to weldable structural steels conforming to EN 1993-1-1 and to material thicknesses of 4 mm and over. The provisions also apply to joints in which the mechanical properties of the weld metal are compatible with those of the parent metal, see 4.2.

For welds in thinner material reference should be made to EN 1993 part 1.3 and for welds in structural hollow sections in material thicknesses of 2,5 mm and over guidance is given section 7 of this Standard.

For stud welding reference should be made to EN 1994-1-1.

NOTE: Further guidance on stud welding can be found in EN ISO 14555 and EN ISO 13918.

(2)P Welds subject to fatigue shall also satisfy the principles given in EN 1993-1-9.

(3) Quality level C according to EN ISO 25817 is usually required, if not otherwise specified. The frequency of inspection of welds should be specified in accordance with the rules in 1.2.7 Reference Standards: Group 7. The quality level of welds should be chosen according to EN ISO 25817. For the quality level of welds used in fatigue loaded structures, see EN 1993-1-9.

(4) Lamellar tearing should be avoided.

(5) Guidance on lamellar tearing is given in EN 1993-1-10.

4.2 Welding consumables

(1) All welding consumables should conform to the relevant standards specified in 1.2.5 Reference Standards; Group 5.

(2) The specified yield strength, ultimate tensile strength, elongation at failure and minimum Charpy V-notch energy value of the filler metal, should be equivalent to, or better than that specified for the parent material.

NOTE: Generally it is safe to use electrodes that are overmatched with regard to the steel grades being used.

4.3 Geometry and dimensions

4.3.1 Type of weld

(1) This Standard covers the design of fillet welds, fillet welds all round, butt welds, plug welds and flare groove welds. Butt welds may be either full penetration butt welds or partial penetration butt welds. Both fillet welds all round and plug welds may be either in circular holes or in elongated holes.

(2) The most common types of joints and welds are illustrated in EN 12345.

4.3.2 Fillet welds

4.3.2.1 General

(1) Fillet welds may be used for connecting parts where the fusion faces form an angle of between 60° and 120°.

(2) Angles smaller than 60° are also permitted. However, in such cases the weld should be considered to be a partial penetration butt weld.

(3) For angles greater than 120° the resistance of fillet welds should be determined by testing in accordance with EN 1990 Annex D: Design by testing.

(4) Fillet welds finishing at the ends or sides of parts should be returned continuously, full size, around the corner for a distance of at least twice the leg length of the weld, unless access or the configuration of the joint renders this impracticable.

NOTE: In the case of intermittent welds this rule applies only to the last intermittent fillet weld at corners.

(5) End returns should be indicated on the drawings.

(6) For eccentricity of single-sided fillet welds, see 4.12.

4.3.2.2 Intermittent fillet welds

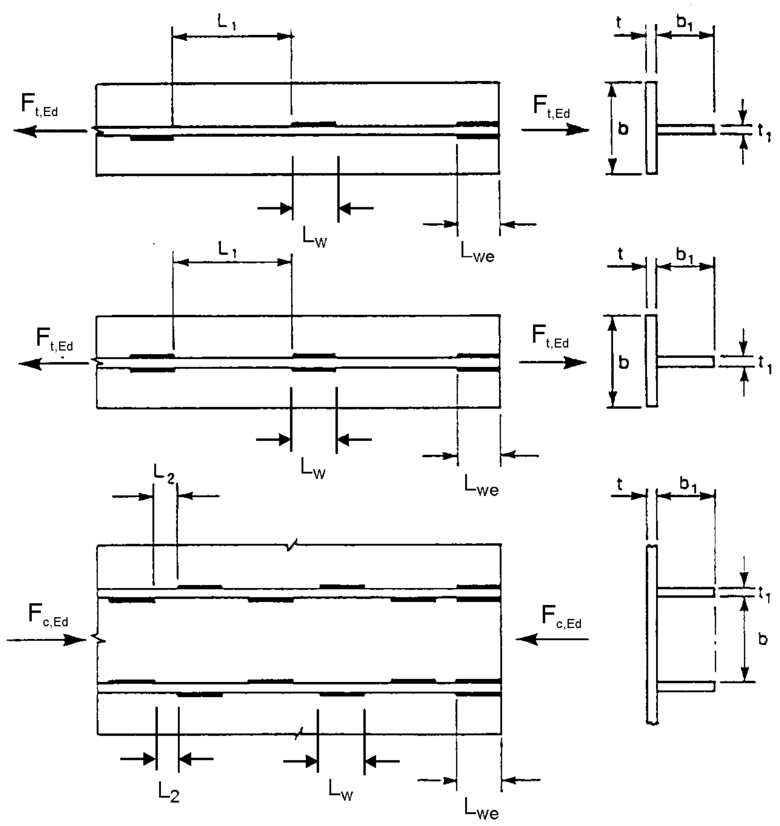
(1) Intermittent fillet welds should not be used in corrosive conditions.

(2) In an intermittent fillet weld, the gaps (L_1 or L_2) between the ends of each length of weld L_w should fulfil the requirement given in Figure 4.1.

(3) In an intermittent fillet weld, the gap (L_1 or L_2) should be taken as the smaller of the distances between the ends of the welds on opposite sides and the distance between the ends of the welds on the same side.

(4) In any run of intermittent fillet weld there should always be a length of weld at each end of the part connected.

(5) In a built-up member in which plates are connected by means of intermittent fillet welds, a continuous fillet weld should be provided on each side of the plate for a length at each end equal to at least three-quarters of the width of the narrower plate concerned (see Figure 4.1).



The smaller of $L_{we} \geq 0{,}75\, b$ and $0{,}75\, b_1$

For build-up members in tension:
The smallest of $L_1 \leq 16\, t$ and $16\, t_1$ and 200 mm

For build-up members in compression or shear:
The smallest of $L_2 \leq 12\, t$ and $12\, t_1$ and $0{,}25\, b$ and 200 mm

Figure 4.1: Intermittent fillet welds

4.3.3 Fillet welds all round

(1) Fillet welds all round, comprising fillet welds in circular or elongated holes, may be used only to transmit shear or to prevent the buckling or separation of lapped parts.

(2) The diameter of a circular hole, or width of an elongated hole, for a fillet weld all round should not be less than four times the thickness of the part containing it.

(3) The ends of elongated holes should be semi-circular, except for those ends which extend to the edge of the part concerned.

(4) The centre to centre spacing of fillet welds all round should not exceed the value necessary to prevent local buckling, see Table 3.3.

4.3.4 Butt welds

(1) A full penetration butt weld is defined as a weld that has complete penetration and fusion of weld and parent metal throughout the thickness of the joint.

(2) A partial penetration butt weld is defined as a weld that has joint penetration which is less than the full thickness of the parent material.

(3) Intermittent butt welds should not be used.

(4) For eccentricity in single-sided partial penetration butt welds, see 4.12.

4.3.5 Plug welds

(1) Plug welds may be used:

- to transmit shear,
- to prevent the buckling or separation of lapped parts, and
- to inter-connect the components of built-up members

but should not be used to resist externally applied tension.

(2) The diameter of a circular hole, or width of an elongated hole, for a plug weld should be at least 8 mm more than the thickness of the part containing it.

(3) The ends of elongated holes should either be semi-circular or else should have corners which are rounded to a radius of not less than the thickness of the part containing the slot, except for those ends which extend to the edge of the part concerned.

(4) The thickness of a plug weld in parent material up to 16 mm thick should be equal to the thickness of the parent material. The thickness of a plug weld in parent material over 16 mm thick should be at least half the thickness of the parent material and not less than 16 mm.

(5) The centre to centre spacing of plug welds should not exceed the value necessary to prevent local buckling, see Table 3.3.

4.3.6 Flare groove welds

(1) For solid bars the design effective throat thickness of flare groove welds, when fitted flush to the surface of the solid section of the bars, is defined in Figure 4.2. The definition of the design throat thickness of flare groove welds in rectangular hollow sections is given in 7.3.1(7).

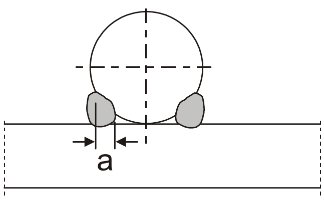


Figure 4.2: Effective throat thickness of flare groove welds in solid sections

4.4 Welds with packings

(1) In the case of welds with packing, the packing should be trimmed flush with the edge of the part that is to be welded.

(2) Where two parts connected by welding are separated by packing having a thickness less than the leg length of weld necessary to transmit the force, the required leg length should be increased by the thickness of the packing.

(3) Where two parts connected by welding are separated by packing having a thickness equal to, or greater than, the leg length of weld necessary to transmit the force, each of the parts should be connected to the packing by a weld capable of transmitting the design force.

4.5 Design resistance of a fillet weld

4.5.1 Length of welds

(1) The effective length of a fillet weld l should be taken as the length over which the fillet is full-size. This maybe taken as the overall length of the weld reduced by twice the effective throat thickness a. Provided that the weld is full size throughout its length including starts and terminations, no reduction in effective length need be made for either the start or the termination of the weld.

(2) A fillet weld with an effective length less than 30 mm or less than 6 times its throat thickness, whichever is larger, should not be designed to carry load.

4.5.2 Effective throat thickness

(1) The effective throat thickness, a, of a fillet weld should be taken as the height of the largest triangle (with equal or unequal legs) that can be inscribed within the fusion faces and the weld surface, measured perpendicular to the outer side of this triangle, see Figure 4.3.

(2) The effective throat thickness of a fillet weld should not be less than 3 mm.

(3) In determining the design resistance of a deep penetration fillet weld, account may be taken of its additional throat thickness, see Figure 4.4, provided that preliminary tests show that the required penetration can consistently be achieved.

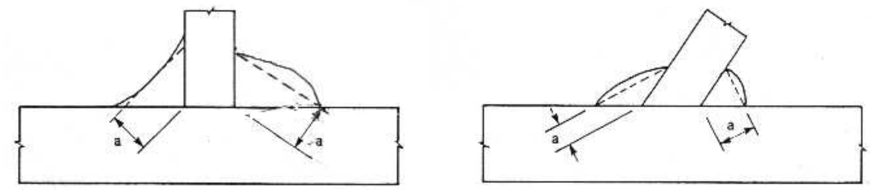


Figure 4.3: Throat thickness of a fillet weld

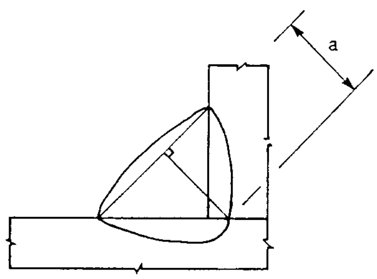


Figure 4.4: Throat thickness of a deep penetration fillet weld

4.5.3 Design Resistance of fillet welds

4.5.3.1 General

(1) The design resistance of a fillet weld should be determined using either the Directional method given in 4.5.3.2 or the Simplified method given in 4.5.3.3.

4.5.3.2 Directional method

(1) In this method, the forces transmitted by a unit length of weld are resolved into components parallel and transverse to the longitudinal axis of the weld and normal and transverse to the plane of its throat.

(2) The design throat area A_w should be taken as $A_w = \sum a \, \ell_{eff}$.

(3) The location of the design throat area should be assumed to be concentrated in the root.

(4) A uniform distribution of stress is assumed on the throat section of the weld, leading to the normal stresses and shear stresses shown in Figure 4.5, as follows:

- $\sigma_\perp$ is the normal stress perpendicular to the throat
- $\sigma_\parallel$ is the normal stress parallel to the axis of the weld
- $\tau_\perp$ is the shear stress (in the plane of the throat) perpendicular to the axis of the weld
- $\tau_\parallel$ is the shear stress (in the plane of the throat) parallel to the axis of the weld.

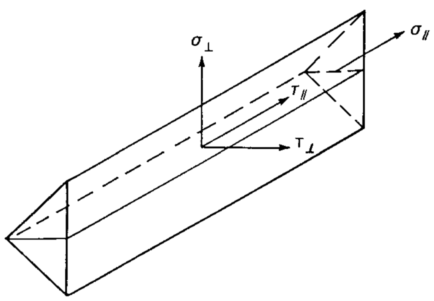


Figure 4.5: Stresses on the throat section of a fillet weld

(5) The normal stress $\sigma_\parallel$ parallel to the axis is not considered when verifying the design resistance of the weld.

(6) The design resistance of the fillet weld will be sufficient if the following are both satisfied:

$$[\sigma_\perp^2 + 3\,(\tau_\perp^2 + \tau_\parallel^2)]^{0,5} \leq f_u / (\beta_w \, \gamma_{M2}) \quad \text{and} \quad \sigma_\perp \leq 0.9 f_u / \gamma_{M2} \qquad \text{... (4.1)}$$

where:

f_u is the nominal ultimate tensile strength of the weaker part joined;

β_w is the appropriate correlation factor taken from Table 4.1.

(7) Welds between parts with different material strength grades should be designed using the properties of the material with the lower strength grade.

Table 4.1: Correlation factor β_w for fillet welds

Standard and steel grade			Correlation factor β_w
EN 10025	**EN 10210**	**EN 10219**	
S 235 S 235 W	S 235 H	S 235 H	0,8
S 275 S 275 N/NL S 275 M/ML	S 275 H S 275 NH/NLH	S 275 H S 275 NH/NLH S 275 MH/MLH	0,85
S 355 S 355 N/NL S 355 M/ML S 355 W	S 355 H S 355 NH/NLH	S 355 H S 355 NH/NLH S 355 MH/MLH	0,9
S 420 N/NL S 420 M/ML		S 420 MH/MLH	1,0
S 460 N/NL S 460 M/ML S 460 Q/QL/QL1	S 460 NH/NLH	S 460 NH/NLH S 460 MH/MLH	1,0

4.5.3.3 Simplified method for design resistance of fillet weld

(1) Alternatively to 4.5.3.2 the design resistance of a fillet weld may be assumed to be adequate if, at every point along its length, the resultant of all the forces per unit length transmitted by the weld satisfy the following criterion:

$$F_{w,Ed} \leq F_{w,Rd} \qquad \text{... (4.2)}$$

where:

$F_{w,Ed}$ is the design value of the weld force per unit length;

$F_{w,Rd}$ is the design weld resistance per unit length.

(2) Independent of the orientation of the weld throat plane to the applied force, the design resistance per unit length $F_{w,Rd}$ should be determined from:

$$F_{w,Rd} = f_{vw.d}\, a \qquad \text{... (4.3)}$$

where:

$f_{vw.d}$ is the design shear strength of the weld.

(3) The design shear strength $f_{vw.d}$ of the weld should be determined from:

$$f_{vw.d} = \frac{f_u / \sqrt{3}}{\beta_w \gamma_{M2}} \qquad \text{... (4.4)}$$

where:

f_u and β_w are defined in 4.5.3.2(6).

4.6 Design resistance of fillet welds all round

(1) The design resistance of a fillet weld all round should be determined using one of the methods given in 4.5.

4.7 Design resistance of butt welds

4.7.1 Full penetration butt welds

(1) The design resistance of a full penetration butt weld should be taken as equal to the design resistance of the weaker of the parts connected, provided that the weld is made with a suitable consumable which will produce all-weld tensile specimens having both a minimum yield strength and a minimum tensile strength not less than those specified for the parent metal.

4.7.2 Partial penetration butt welds

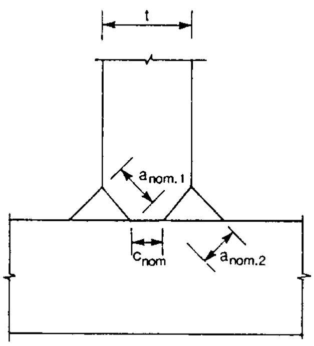
(1) The design resistance of a partial penetration butt weld should be determined using the method for a deep penetration fillet weld given in 4.5.2(3).

(2) The throat thickness of a partial penetration butt weld should not be greater than the depth of penetration that can be consistently achieved, see 4.5.2(3).

4.7.3 T-butt joints

(1) The design resistance of a T-butt joint, consisting of a pair of partial penetration butt welds reinforced by superimposed fillet welds, may be determined as for a full penetration butt weld (see 4.7.1) if the total nominal throat thickness, exclusive of the unwelded gap, is not less than the thickness t of the part forming the stem of the tee joint, provided that the unwelded gap is not more than (t / 5) or 3 mm, whichever is less, see Figure 4.6(a).

(2) The design resistance of a T-butt joint which does not meet the requirements given in 4.7.3(1) should be determined using the method for a fillet weld or a deep penetration fillet weld given in 4.5 depending on the amount of penetration. The throat thickness should be determined in conformity with the provisions for fillet welds (see 4.5.2) or partial penetration butt welds (see 4.7.2) as relevant.



$a_{\text{nom},1} + a_{\text{nom},2} \geq t$

c_{nom} should be the smaller of t/5 and 3 mm

Figure 4.6: Effective full penetration of T-butt welds

4.8 Design resistance of plug welds

(1) The design resistance $F_{w,Rd}$ of a plug weld (see 4.3.3) should be taken as:

$$F_{w,Rd} = f_{vw,d}\, A_w, \qquad \text{... (4.5)}$$

where

$f_{vw.d}$ is the design shear strength of a weld given in 4.5.3.3(3);

A_w is the design throat area and should be taken as the area of the hole.

4.9 Distribution of forces

(1) The distribution of forces in a welded connection may be calculated on the assumption of either elastic or plastic behaviour in conformity with 2.4 and 2.5.

(2) It is acceptable to assume a simplified load distribution within the welds.

(3) Residual stresses and stresses not subjected to transfer of load need not be included when checking the resistance of a weld. This applies specifically to the normal stress parallel to the axis of a weld.

(4) Welded joints should be designed to have adequate deformation capacity. However, ductility of the welds should not be relied upon.

(5) In joints where plastic hinges may form, the welds should be designed to provide at least the same design resistance as the weakest of the connected parts.

(6) In other joints where deformation capacity for joint rotation is required due to the possibility of excessive straining, the welds require sufficient strength not to rupture before general yielding in the adjacent parent material.

(7) If the design resistance of an intermittent weld is determined by using the total length ℓ_{tot}, the weld shear force per unit length $F_{w,Ed}$ should be multiplied by the factor $(e+\ell)/\ell$, see Figure 4.7.

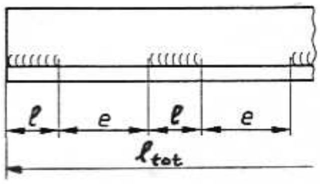


Figure 4.7: Calculation of weld forces for intermittent welds

4.10 Connections to unstiffened flanges

(1) Where a transverse plate (or beam flange) is welded to a supporting unstiffened flange of an I, H or other section, see Figure 4.8, and provided that the condition given in 4.10(3) is met, the applied force perpendicular to the unstiffened flange should not exceed any of the relevant design resistances as follows:

- that of the web of the supporting member of I or H sections as given in 6.2.6.2 or 6.2.6.3 as appropriate;
- those for a transverse plate on a RHS member as given in Table 7.13;
- that of the supporting flange as given by formula (6.20) in 6.2.6.4.3(1) calculated assuming the applied force is concentrated over an effective width, b_{eff}, of the flange as given in 4.10(2) or 4.10(4) as relevant.

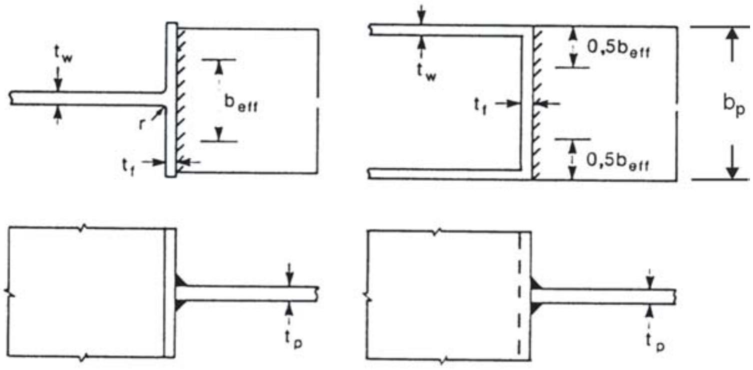


Figure 4.8: Effective width of an unstiffened T-joint

(2) For an unstiffened I or H section the effective width b_{eff} should be obtained from:

$$b_{eff} = t_w + 2s + 7kt_f \quad \text{... (4.6a)}$$

where:

$$k = (t_f / t_p)(f_{y,f} / f_{y,p}) \text{ but } k \leq 1 \quad \text{... (4.6b)}$$

$f_{y,f}$ is the yield strength of the flange of the I or H section;

$f_{y,p}$ is the yield strength of the plate welded to the I or H section.

The dimension s should be obtained from:

– for a rolled I or H section: $s = r$ ... (4.6c)

– for a welded I or H section: $s = \sqrt{2}\ a$ ... (4.6d)

(3) For an unstiffened flange of an I or H section , the following criterion should be satisfied:

$$b_{eff} \geq (f_{y,p} / f_{u,p}) b_p \quad \text{... (4.7)}$$

where:

$f_{u,p}$ is the ultimate strength of the plate welded to the I or H section;

b_p is the width of the plate welded to the I or H section.

Otherwise the joint should be stiffened.

(4) For other sections such as box sections or channel sections where the width of the connected plate is similar to the width of the flange, the effective width b_{eff} should be obtained from:

$$b_{eff} = 2t_w + 5t_f \quad \text{but} \quad b_{eff} \leq 2t_w + 5\,k\,t_f \quad \text{... (4.8)}$$

NOTE: For hollow sections, see Table 7.13.

(5) Even if $b_{eff} \leq b_p$, the welds connecting the plate to the flange need to be designed to transmit the design resistance of the plate $b_P\, t_P f_{y,P} / \gamma_{M0}$ assuming a uniform stress distribution.

4.11 Long joints

(1) In lap joints the design resistance of a fillet weld should be reduced by multiplying it by a reduction factor β_{Lw} to allow for the effects of non-uniform distribution of stress along its length.

(2) The provisions given in 4.11 do not apply when the stress distribution along the weld corresponds to the stress distribution in the adjacent base metal, as, for example, in the case of a weld connecting the flange and the web of a plate girder.

(3) In lap joints longer than 150a the reduction factor β_{Lw} should be taken as $\beta_{Lw.1}$ given by:

$$\beta_{Lw.1} = 1{,}2 - 0{,}2L_j/(150a) \quad \text{but} \quad \beta_{Lw.1} \leq 1{,}0 \qquad \text{... (4.9)}$$

where:

L_j is the overall length of the lap in the direction of the force transfer.

(4) For fillet welds longer than 1,7 metres connecting transverse stiffeners in plated members, the reduction factor β_{Lw} may be taken as $\beta_{Lw.2}$ given by:

$$\beta_{Lw.2} = 1{,}1 - L_w/17 \quad \text{but} \quad \beta_{Lw.2} \leq 1{,}0 \quad \text{and} \quad \beta_{Lw.2} \geq 0{,}6 \qquad \text{... (4.10)}$$

where:

L_w is the length of the weld (in metres).

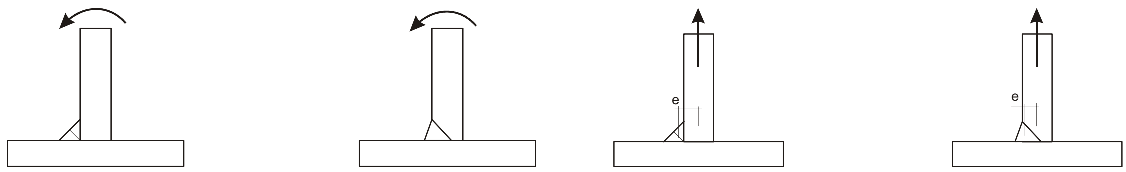
4.12 Eccentrically loaded single fillet or single-sided partial penetration butt welds

(1) Local eccentricity should be avoided whenever it is possible.

(2) Local eccentricity (relative to the line of action of the force to be resisted) should be taken into account in the following cases:

- Where a bending moment transmitted about the longitudinal axis of the weld produces tension at the root of the weld, see Figure 4.9(a);
- Where a tensile force transmitted perpendicular to the longitudinal axis of the weld produces a bending moment, resulting in a tension force at the root of the weld, see Figure 4.9(b).

(3) Local eccentricity need not be taken into account if a weld is used as part of a weld group around the perimeter of a structural hollow section.



(a) Bending moment produces tension at the root of the weld

(b) Tensile force produces tension at the root of the weld

Figure 4.9: Single fillet welds and single-sided partial penetration butt welds

4.13 Angles connected by one leg

(1) In angles connected by one leg, the eccentricity of welded lap joint end connections may be allowed for by adopting an effective cross-sectional area and then treating the member as concentrically loaded.

(2) For an equal-leg angle, or an unequal-leg angle connected by its larger leg, the effective area may be taken as equal to the gross area.

(3) For an unequal-leg angle connected by its smaller leg, the effective area should be taken as equal to the gross cross-sectional area of an equivalent equal-leg angle of leg size equal to that of the smaller leg, when determining the design resistance of the cross-section, see EN 1993-1-1. However when determining the design buckling resistance of a compression member, see EN 1993-1-1, the actual gross cross-sectional area should be used.

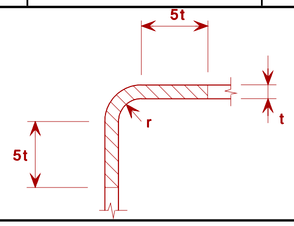
4.14 Welding in cold-formed zones

(1) Welding may be carried out within a length 5t either side of a cold-formed zone, see Table 4.2, provided that one of the following conditions is fulfilled:

- the cold-formed zones are normalized after cold-forming but before welding;
- the *r*/*t*-ratio satisfy the relevant value obtained from Table 4.2.

Table 4.2: Conditions for welding cold-formed zones and adjacent material

r/t	Strain due to cold forming (%)	Maximum thickness (mm)		
		Generally		Fully killed Aluminium-killed steel (Al ≥ 0,02 %)
		Predominantly static loading	Where fatigue predominates	
≥ 25	≤ 2	any	any	any
≥ 10	≤ 5	any	16	any
≥ 3,0	≤ 14	24	12	24
≥ 2,0	≤ 20	12	10	12
≥ 1,5	≤ 25	8	8	10
≥ 1,0	≤ 33	4	4	6



APPENDICES

NA.2.2 Nationally determined parameters for buildings

NA.2.2.1 *Clause A.1.2.1 (1)*

a) All effects of actions that can exist simultaneously should be considered together in combination of actions.

b) With regard to Note 2 of Clause A.1.2.1 (1) of EN 1990 no modifications are allowed through the National Annex for A1.2.1 (2) and (3).

NA.2.2.2 *Clause A.1.2.2*

Table NA.A1.1 provides values for the symbols of Table A1.1 of EN 1990.

Table NA.A1.1 – Values of Ψ factors for buildings

Action	Ψ_0	Ψ_1	Ψ_2
Imposed loads in buildings, category (see EN 1991-1.1)			
Category A: domestic, residential areas	0,7	0,5	0,3
Category B: office areas	0,7	0,5	0,3
Category C: congregation areas	0,7	0,7	0,6
Category D: shopping areas	0,7	0,7	0,6
Category E: storage areas	1,0	0,9	0,8
Category F: traffic area, vehicle weight $\leq$ 30 kN	0,7	0,7	0,6
Category G: traffic area, 30 kN < vehicle weight $\leq$ 160 kN	0,7	0,5	0,3
Category H: roofs[a]	0,7	0	0
Snow loads on buildings (see EN 1991-3)			
— for sites located at altitude H > 1 000 m a.s.l.	0,70	0,50	0,20
— for sites located at altitude H $\leq$ 1 000 m a.s.l.	0,50	0,20	0
Wind loads on buildings (see EN 1991-1-4)	0,5	0,2	0
Temperature (non-fire) in buildings (see EN 1991-1-5)	0,6	0,5	0

[a] See also EN 1991-1-1: Clause 3.3.2 (1)

NA.2.2.3 *Clause A.1.3*

NA.2.2.3.1 *Values for the symbols γ of Table A1.2 (A)*

Table NA.A1.2 (A) provides the values for the symbols γ of Table A1.2 (A). The values chosen are:

$\gamma_{Gj,sup} = 1,10$

$\gamma_{Gj,inf} = 0,90$

$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)

$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)

NOTE For Ψ values see Table A1.1 (BS).

Table NA.A1.2 (A) – Design values of actions (EQU) (Set A)

Persistent and transient design situations	Permanent actions		Leading variable action[a]	Accompanying variable actions	
	Unfavourable	Favourable		Main (if any)	Others
(Eq. 6.10)	1,10 $G_{kj,sup}$	0,90 $G_{kj,inf}$	1,5 $Q_{k,1}$ (0 when favourable)		$1,5\Psi_{0,i}Q_{k,i}$ (0 when favourable)

[a] Variable actions are those considered in Table NA.A1.1.

In cases where the verification of static equilibrium also involves the resistance of structural members, as an alternative to two separate verifications based on Tables NA.A1.2 (A) and A1.2 (B), a combined verification, based on Table NA.A1.2 (A), should be adopted, with the following set of values.

$\gamma_{Gj,sup} = 1,35$

$\gamma_{Gj,inf} = 1,15$

$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)

$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)

provided that applying $\gamma_{Gj,inf} = 1,00$ both to the favourable part and to the unfavourable part of permanent actions does not give a more unfavourable effect.

NA.2.2.3.2 *Values for the symbols γ and ξ of Table A1.2 (B)*

Table NA.A1.2 (B) provides the values for the symbols γ and ξ of Table A1.2 (B). The values chosen are:

$\gamma_{Gj,sup} = 1,35$

$\gamma_{Gj,inf} = 1,00$

$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)

$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)

$\xi = 0,925$

NOTE For Ψ values see Table NA.A1.1.

Table NA.A1.2 (B) – Design values of actions (STR/GEO) (Set B)

Persistent and transient design situations	Permanent actions		Leading variable action	Accompanying variable actions[a]		Persistent and transient design situations	Permanent actions		Leading variable action[a]	Accompanying variable actions[a]	
	Unfavourable	Favourable		Main (if any)	Others		Unfavourable	Favourable	Action	Main	Others
(Eq. 6.10)	$1{,}35G_{kj,sup}$	$1{,}00G_{kj,inf}$	$1{,}5Q_{k,1}$		$1{,}5\psi_{0,1}Q_{k,i}$	(Eq. 6.10a)	$1{,}35G_{kj,sup}$	$1{,}00G_{kj,inf}$		$1{,}5\psi_{0,1}Q_{k,1}$	$1{,}5\psi_{0,1}Q_{k,i}$
						(Eq. 6.10b)	$0{,}925*1{,}35G_{kj,sup}$	$1{,}00G_{kj,inf}$	$1{,}5Q_{k,1}$		$1{,}5\psi_{0,1}Q_{k,i}$

NOTE 1 Either expression 6.10, or expression 6.10a together with and 6.10b may be made, as desired.

NOTE 2 The characteristic values of all permanent actions from one source are multiplied by $\gamma_{G,sup}$ if the total resulting action effect is unfavourable and $\gamma_{G,inf}$ if the total resulting action effect is favourable. For example, all actions originating from the self weight of the structure may be considered as coming from one source; this also applies if different materials are involved.

NOTE 3 For particular verifications, the values for γ_G and γ_Q may be subdivided into γ_g and γ_q and the model uncertainty factor γ_{sd}. A value of γ_{sd} in the range 1,05 to 1,15 can be used in most common cases and can be modified in the National Annex.

NOTE 4 When variable actions are favourable Q_k should be taken as 0.

[a] Variable actions are those considered in Table NA.A1.1.

3.4 Section properties

3.4.1 Gross cross-section

Gross cross-section properties should be determined from the specified shape and nominal dimensions of the member or element. Holes for bolts should not be deducted, but due allowance should be made for larger openings. Material used solely in splices or as battens should not be included.

3.4.2 Net area

The net area of a cross-section or an element of a cross-section should be taken as its gross area, less the deductions for bolt holes given in **3.4.4**.

3.4.3 Effective net area

The effective net area a_e of each element of a cross-section with bolt holes should be determined from:

$$a_e = K_e a_n \quad \text{but} \quad a_e \leq a_g$$

in which the effective net area coefficient K_e is given by:

— for grade S 275: $K_e = 1.2$

— for grade S 355: $K_e = 1.1$

— for grade S 460: $K_e = 1.0$

— for other steel grades: $K_e = (U_s/1.2)/p_y$

where

a_g is the gross area of the element;

a_n is the net area of the element;

p_y is the design strength;

U_s is the specified minimum tensile strength.

3.4.4 Deductions for bolt holes

3.4.4.1 *Hole area*

In deducting for bolt holes (including countersunk holes), the sectional area of the hole in the plane of its own axis should be deducted, not that of the bolt.

3.4.4.2 *Holes not staggered*

Provided that the bolt holes are not staggered, the area to be deducted should be the sum of the sectional areas of the bolt holes in a cross-section perpendicular to the member axis or direction of direct stress.

3.4.4.3 *Staggered holes*

Where the bolt holes are staggered, the area to be deducted should be the greater of:

a) the deduction for non-staggered holes given in **3.4.4.2**;

b) the sum of the sectional areas of a chain of holes lying on any diagonal or zig-zag line extending progressively across the member or element, see Figure 3, less an allowance of $0.25s^2t/g$ for each gauge space g that it traverses diagonally, where:

g is the gauge spacing perpendicular to the member axis or direction of direct stress, between the centres of two consecutive holes in the chain, see Figure 3;

s is the staggered pitch, i.e. the spacing parallel to the member axis or direction of direct stress, between the centres of the same two holes, see Figure 3;

t is the thickness of the holed material.

For sections such as angles with holes in both legs, the gauge spacing g should be taken as the sum of the back marks to each hole, less the leg thickness, see Figure 4.

4.5.9 Connection of web stiffeners to flanges

4.5.9.1 *Stiffeners in compression*

Web stiffeners required to resist compression should either be fitted against the loaded flange or connected to it by continuous welds, fitted bolts or preloaded bolts designed to be non-slip under factored loads, see **6.4.2**.

The stiffener should be fitted against, or connected to, both flanges where any of the following apply:

a) a load is applied directly over a support;

b) the stiffener forms the end stiffener of a stiffened web;

c) the stiffener acts as a torsion stiffener.

4.5.9.2 *Stiffeners in tension*

Web stiffeners required to resist tension should be connected to the flange transmitting the load or reaction by continuous welds, fitted bolts or preloaded bolts designed to be non-slip under factored loads, see **6.4.2**. This connection should be designed to resist the lesser of the applied load or reaction or the capacity of the stiffener, see **4.5.2.2**.

4.5.10 Length of web stiffeners

Bearing stiffeners or tension stiffeners that do not also have other functions, see **4.5.1.1**, may be curtailed where the capacity P_{us} of the unstiffened web beyond the end of the stiffener is not less than the proportion of the applied load or reaction carried by the stiffener. The capacity P_{us} of the unstiffened web at this point should be obtained from:

$$P_{us} = (b_1 + w)tp_{yw}$$

where

b_1 is the stiff bearing length, see **4.5.1.3**;

w is the length obtained by dispersion at 45° to the level at which the stiffener terminates.

The length of a stiffener that does not extend right across the web should also be such that the local shear stress in the web due to the force transmitted by the stiffener does not exceed $0.6p_{yw}$.

4.6 Tension members

4.6.1 Tension capacity

The tension capacity P_t of a member should generally be obtained from:

$$P_t = p_y A_e$$

in which A_e is the sum of the effective net areas a_e of all the elements of the cross-section, determined from **3.4.3**, but not more than 1.2 times the total net area A_n.

4.6.2 Members with eccentric connections

If members are connected eccentric to their axes, the resulting moments should generally be allowed for in accordance with **4.8.2**. However, angles, channels or T-sections with eccentric end connections may be treated as axially loaded by using the reduced tension capacity given in **4.6.3**.

4.6.3 Simple tension members

4.6.3.1 *Single angle, channel or T-section members*

For a simple tie, designed as axially loaded, consisting of a single angle connected through one leg only, a single channel connected only through the web or a T-section connected only through the flange, the tension capacity should be obtained as follows:

— for bolted connections: $P_t = p_y(A_e - 0.5a_2)$

— for welded connections: $P_t = p_y(A_g - 0.3a_2)$

in which:

$$a_2 = A_g - a_1$$

where

A_g is the gross cross-sectional area, see **3.4.1**;

a_1 is the gross area of the connected element, taken as the product of its thickness and the overall leg width for an angle, the overall depth for a channel or the flange width for a T-section.

4.6.3.2 ***Double angle, channel or T-section members***

For a simple tie, designed as axially loaded, consisting of two angles connected through one leg only, two channels connected only through the web or two T-sections connected only through the flange, the tension capacity should be obtained as follows:

a) if the tie is connected to both sides of a gusset or section and the components are interconnected by bolts or welds and held apart and longitudinally parallel by battens or solid packing pieces in at least two locations within their length, the tension capacity per component should be obtained from:

— for bolted connections: $P_t = p_y(A_e - 0.25a_2)$

— for welded connections: $P_t = p_y(A_g - 0.15a_2)$

b) if the components are both connected to the same side of a gusset or member, or not interconnected as given in a), the tension capacity per component should be taken as given in **4.6.3.1**.

In case a) the outermost interconnection should be within a distance from each end of ten times the smaller leg length for angle components, or ten times the smaller overall dimension for channels or T-sections.

4.6.3.3 ***Other simple ties***

A simple tie consisting of a single angle connected through both legs by lug angles or otherwise, a single channel connected by both flanges or a T-section connected only through the stem (or both the flange and the stem), should be designed as axially loaded. The tension capacity should be based on the effective net area from **3.4.3**.

4.6.3.4 ***Continuous ties***

The internal bays of continuous ties should be designed as axially loaded. The tension capacity should be based on the effective net area from **3.4.3**.

4.6.4 Laced or battened ties

For laced or battened ties, the lacing or battening systems should be designed to resist the greater of:

a) the axial forces, moments and shear forces induced by eccentric loads, applied moments or transverse forces, including self-weight and wind resistance;

b) the axial forces, moments and shear forces induced by a transverse shear on the complete member at any point in its length equal to 1 % of the axial force in the member, taken as shared equally between all transverse lacing or battening systems in parallel planes.

4.7 Compression members

4.7.1 General

4.7.1.1 ***Segment length***

The segment length L of a compression member in any plane should be taken as the length between the points at which it is restrained against buckling in that plane.

4.7.1.2 ***Restraints***

A restraint should have sufficient strength and stiffness to inhibit movement of the restrained point in position or direction as appropriate. Positional restraints should be connected to an appropriate shear diaphragm or system of triangulated bracing.

Positional restraints to compression members forming the flanges of lattice girders should satisfy the recommendations for lateral restraint of beams specified in **4.3.2**. All other positional restraints to compression members should be capable of resisting a force of not less than 1.0 % of the axial force in the member and transferring it to the adjacent points of positional restraint.

3.6.4 Equal-leg angle sections

For class 4 slender hot rolled equal-leg angle sections, the method given in **3.6.3** may be used. Alternatively, the effective cross-sectional area A_{eff} and effective section modulus Z_{eff} about a given axis may conservatively be obtained using:

$$\frac{A_{eff}}{A} = \frac{12\varepsilon}{b/t}$$

$$\frac{Z_{eff}}{Z} = \frac{15\varepsilon}{b/t}$$

where

b is the leg length;

t is the thickness.

3.6.5 Alternative method

As an alternative to the methods detailed in **3.6.2**, **3.6.3** and **3.6.4**, a reduced design strength p_{yr} may be calculated at which the cross-section would be class 3 semi-compact. The reduced design strength p_{yr} should then be used in place of p_y in the checks on section capacity and member buckling resistance given in **4.2**, **4.3**, **4.4**, **4.7** and **4.8**. The value of this reduced design strength p_{yr} may be obtained from:

$$p_{yr} = (\beta_3/\beta)^2 p_y$$

in which β is the value of b/T, b/t, D/t or d/t that exceeds the limiting value β_3 given in Table 11 or Table 12 for a class 3 semi-compact section.

NOTE Unless the class 3 semi-compact limit is exceeded by only a small margin, the use of this alternative method can be rather conservative.

3.6.6 Circular hollow sections

Provided that the overall diameter D does not exceed $240t\varepsilon^2$ the effective cross-sectional area A_{eff} and effective section modulus Z_{eff} of a class 4 slender circular hollow section of thickness t may be determined from:

$$\frac{A_{eff}}{A} = \left[\left(\frac{80}{D/t}\right)\left(\frac{275}{p_y}\right)\right]^{0.5}$$

$$\frac{Z_{eff}}{Z} = \left[\left(\frac{140}{D/t}\right)\left(\frac{275}{p_y}\right)\right]^{0.25}$$

Bracing systems that supply positional restraint to more than one member should be designed to resist the sum of the restraint forces from each member that they restrain, reduced by the factor k_r obtained from:

$$k_r = (0.2 + 1/N_r)^{0.5}$$

in which N_r is the number of parallel members restrained.

4.7.2 Slenderness

The slenderness λ of a compression member should generally be taken as its effective length L_E divided by its radius of gyration r about the relevant axis, except as given in **4.7.9**, **4.7.10** or **4.7.13**.

In the case of a single-angle strut with lateral restraints to its two legs alternately, the slenderness for buckling about every axis should be increased by 20 %.

4.7.3 Effective lengths

Except for angles, channels or T-sections designed in accordance with **4.7.10** the effective length L_E of a compression member should be determined from the segment length L centre-to-centre of restraints or intersections with restraining members in the relevant plane as follows.

a) Generally, in accordance with Table 22, depending on the conditions of restraint in the relevant plane, members carrying more than 90 % of their reduced plastic moment capacity M_r in the presence of axial force (see **I.2**) being taken as incapable of providing directional restraint.

b) For continuous columns in multistorey buildings of simple design, in accordance with Table 22, depending on the conditions of restraint in the relevant plane, directional restraint being based on connection stiffness as well as member stiffness.

c) For compression members in trusses, lattice girders or bracing systems, in accordance with Table 22, depending on the conditions of restraint in the relevant plane.

d) For columns in single storey buildings of simple design, see **D.1**.

e) For columns supporting internal platform floors of simple design, see **D.2**.

f) For columns forming part of a continuous structure, see Annex E.

Table 22 — Nominal effective length L_E for a compression member[a]

<table>
<tr><td colspan="4">a) non-sway mode</td></tr>
<tr><td colspan="3">Restraint (in the plane under consideration) by other parts of the structure</td><td>L_E</td></tr>
<tr><td rowspan="4">Effectively held in position at both ends</td><td colspan="2">Effectively restrained in direction at both ends</td><td>0.7L</td></tr>
<tr><td colspan="2">Partially restrained in direction at both ends</td><td>0.85L</td></tr>
<tr><td colspan="2">Restrained in direction at one end</td><td>0.85L</td></tr>
<tr><td colspan="2">Not restrained in direction at either end</td><td>1.0L</td></tr>
<tr><td colspan="4">b) sway mode</td></tr>
<tr><td>One end</td><td colspan="2">Other end</td><td>L_E</td></tr>
<tr><td rowspan="3">Effectively held in position and restrained in direction</td><td rowspan="3">Not held in position</td><td>Effectively restrained in direction</td><td>1.2L</td></tr>
<tr><td>Partially restrained in direction</td><td>1.5L</td></tr>
<tr><td>Not restrained in direction</td><td>2.0L</td></tr>
<tr><td colspan="4">[a] Excluding angle, channel or T-section struts designed in accordance with 4.7.10.</td></tr>
</table>

4.7.4 Compression resistance

The compression resistance P_c of a member should be obtained from the following:

a) for class 1 plastic, class 2 compact or class 3 semi-compact cross-sections:

$$P_c = A_g p_c$$

b) for class 4 slender cross-sections:

$$P_c = A_{eff} p_{cs}$$

Table 25 — Angle, channel and T-section struts

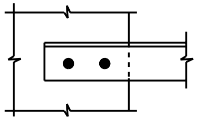
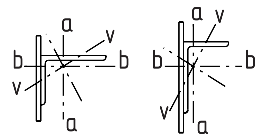
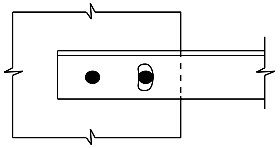
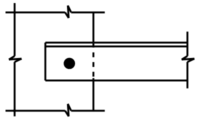
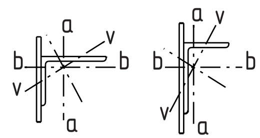
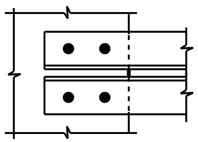
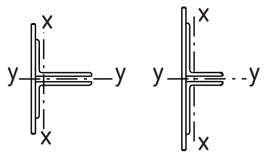
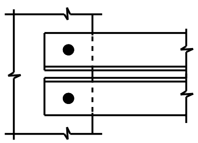
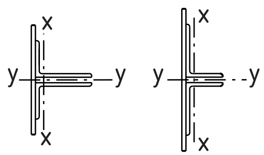
Clause	Connection	Sections and axes	Slenderness ratios (see notes 1 and 2)
4.7.10.2a)			v-v axis: $0.85L_v/r_v$ but $\geq 0.7L_v/r_v + 15$ a-a axis: $1.0L_a/r_a$ but $\geq 0.7L_a/r_a + 30$ b-b axis: $0.85L_b/r_b$ but $\geq 0.7L_b/r_b + 30$
4.7.10.2b) **4.7.10.2**c)	 (kidney-shaped slot)  (see note 3)		v-v axis: $1.0L_v/r_v$ but $\geq 0.7L_v/r_v + 15$ a-a axis: $1.0L_a/r_a$ but $\geq 0.7L_a/r_a + 30$ b-b axis: $1.0L_b/r_b$ but $\geq 0.7L_b/r_b + 30$ (see note 3)
4.7.10.3a)	 (see note 4)		x-x axis: $1.0L_x/r_x$ but $\geq 0.7L_x/r_x + 30$ y-y axis: $[(0.85L_y/r_y)^2 + \lambda_c^2]^{0.5}$ but $\geq 1.4\lambda_c$ (see note 5)
4.7.10.3b)	 (see note 4)		x-x axis: $1.0L_x/r_x$ but $\geq 0.7L_x/r_x + 30$ y-y axis: $[(L_y/r_y)^2 + \lambda_c^2]^{0.5}$ but $\geq 1.4\lambda_c$ (see note 5)

Table 25 — Angle, channel and T-section struts (*continued*)

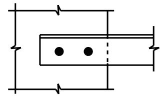
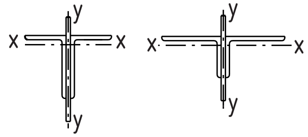
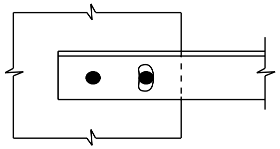
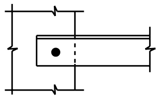
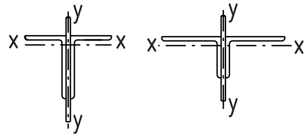
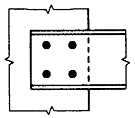
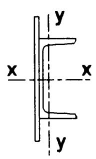
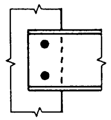
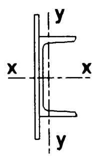
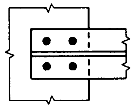
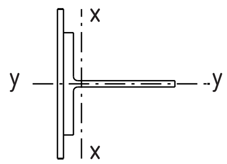
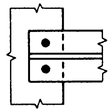
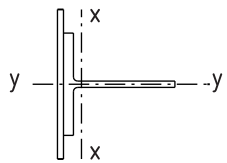
Clause	Connection	Sections and axes	Slenderness ratios (see notes 1 and 2)
4.7.10.3c)	 (see note 4)		x-x axis: $0.85L_x/r_x$ but $\geq 0.7L_x/r_x + 30$ y-y axis: $[(L_y/r_y)^2 + \lambda_c^2]^{0.5}$ but $\geq 1.4\lambda_c$ (see note 5)
4.7.10.3d) **4.7.10.3**e)	  (kidney-shaped slot) (see notes 3 and 4)		x-x axis: $1.0L_x/r_x$ but $\geq 0.7L_x/r_x + 30$ y-y axis: $[(L_y/r_y)^2 + \lambda_c^2]^{0.5}$ but $\geq 1.4\lambda_c$ (see notes 3 and 5)
4.7.10.4a)			x-x axis: $0.85L_x/r_x$ y-y axis: $1.0L_y/r_y$ but $\geq 0.7L_y/r_y + 30$
4.7.10.4b)			x-x axis $1.0L_x/r_x$ y-y axis $1.0L_y/r_y$ but $\geq 0.7L_y/r_y + 30$

Table 25 — Angle, channel and T-section struts (*continued*)

Clause	Connection	Sections and axes	Slenderness ratios (see notes 1 and 2)
4.7.10.5a)			x-x axis: $1.0L_x/r_x$ but $\geq 0.7L_x/r_x + 30$ y-y axis: $0.85L_y/r_y$
4.7.10.5b)			x-x axis: $1.0L_x/r_x$ but $\geq 0.7L_x/r_x + 30$ y-y axis $1.0L_y/r_y$

NOTE 1 The length L is taken between the intersections of the centroidal axes or the intersections of the setting out lines of the bolts, irrespective of whether the strut is connected to a gusset or directly to another member.

NOTE 2 Intermediate restraints reduce the value of L for buckling about the relevant axes. For single angle members, L_v is taken between lateral restraints, perpendicular to either a-a or b-b.

NOTE 3 For single or double angles connected by one bolt, the compression resistance is also reduced to 80 % of that for an axially loaded member, see **4.7.10.2**b) or **4.7.10.3**d).

NOTE 4 Double angles are either battened (see **4.7.12**) or interconnected back-to-back (see **4.7.13**). Battens or interconnecting bolts are also needed at the ends of members.

NOTE 5 $\lambda_c = L_v/r_v$ with L_v measured between interconnecting bolts for back-to-back struts, or between end welds or end bolts of adjacent battens for battened angle struts.

Annex D (normative)
Effective lengths of columns in simple structures

D.1 Columns for single storey buildings

D.1.1 *Typical cases*

The effective lengths of columns for single storey buildings of simple design, see **2.1.2.2**, should be determined by reference to the typical cases illustrated in Figure D.1 to Figure D.5, provided that the following conditions apply.

a) In the plane of the diagram the columns act as cantilevers tied together by the roof trusses, but in this plane the tops of the columns are not otherwise held in position or restrained in direction.

b) Perpendicular to the plane of the diagram, the tops of the columns are effectively held in position by members connecting them to a braced bay, or by other suitable means. In the case of Figure D.3 to Figure D.5 the braced bay also holds the columns in position at crane girder level.

c) The bases of the columns are effectively held in position and restrained in direction in both planes.

d) The foundations are capable of providing restraint commensurate with that provided by the base.

D.1.2 *Variations*

Where the conditions differ from those detailed in **D.1.1**, the following modifications should be made to the effective lengths shown in Figure D.1 to Figure D.5.

a) If, in the plane of the diagram, the tops of the columns are effectively held in position by horizontal bracing or other suitable means, the effective lengths in this plane should be obtained from Table 22a).

b) If, in the plane of the diagram, the roof truss or other roof member is connected to the columns by a connection capable of transmitting appreciable moment, the effective length of the stanchion in this plane should be determined in accordance with Annex E.

c) If, perpendicular to the plane of the diagram, one flange only of the stanchion is restrained at intervals by sheeting rails, then for buckling out-of-plane the method given in Annex G should be used.

d) If, perpendicular to the plane of the diagram, the base of the column is not effectively restrained in direction, the effective lengths $0.85L$ or $0.85L_1$ in Figure D.1 to Figure D.5 should be increased to $1.0L$ or $1.0L_1$ respectively.

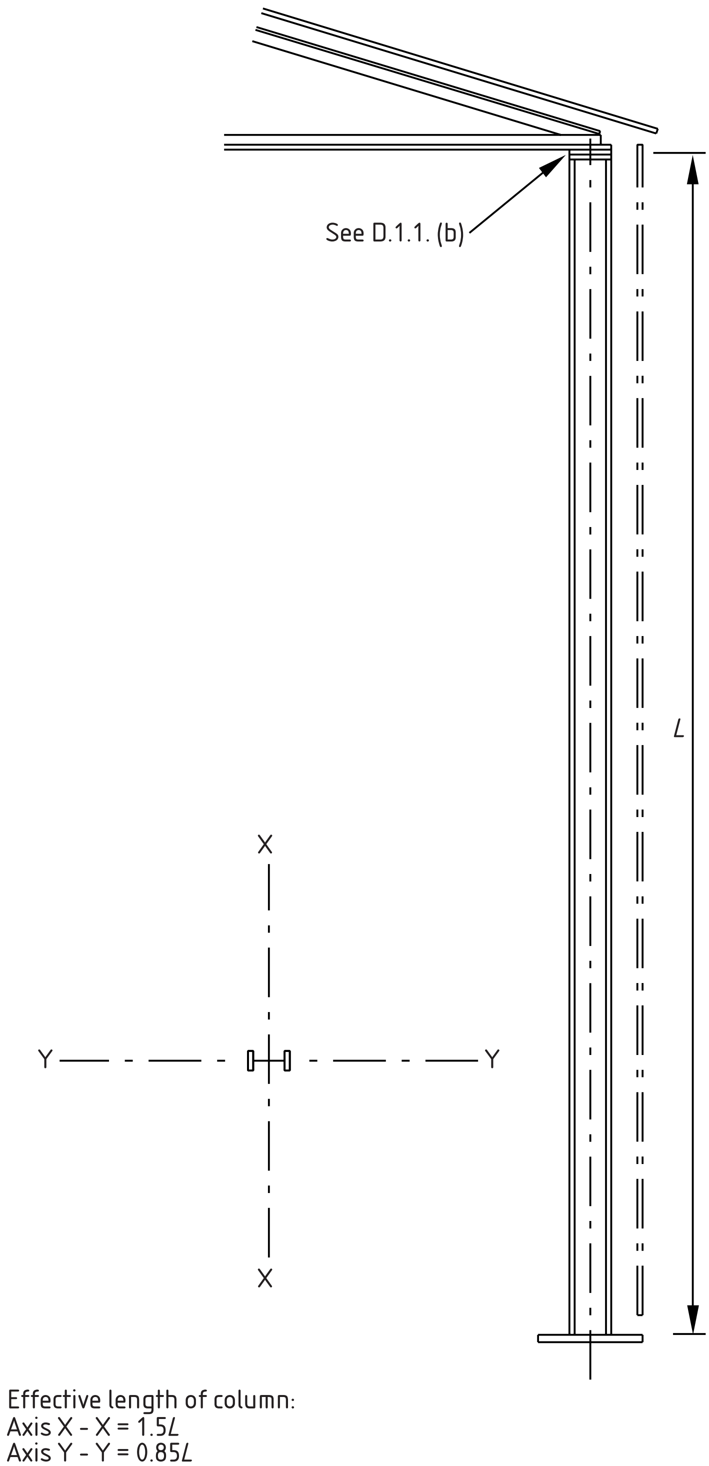


Figure D.1 — Side column without intermediate lateral restraint

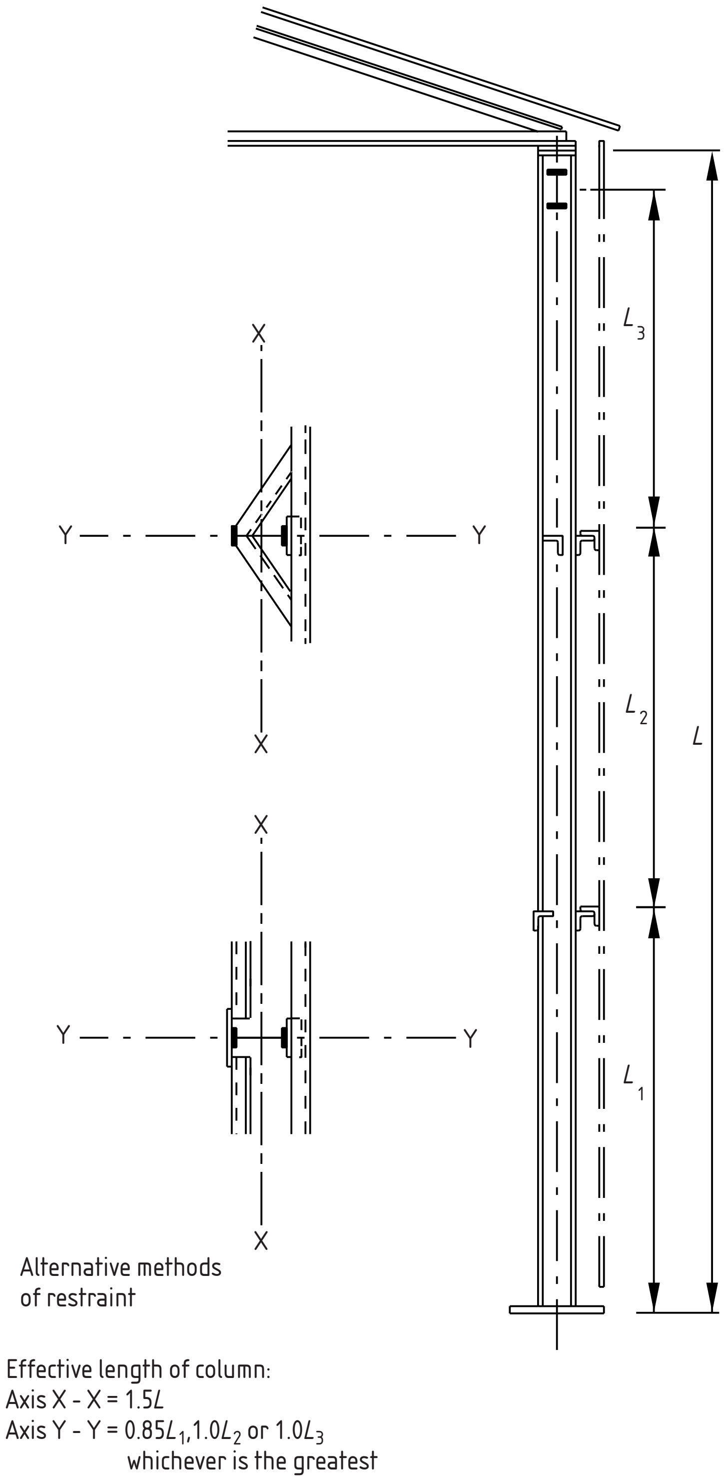


Figure D.2 — Side column with intermediate lateral restraint to both flanges

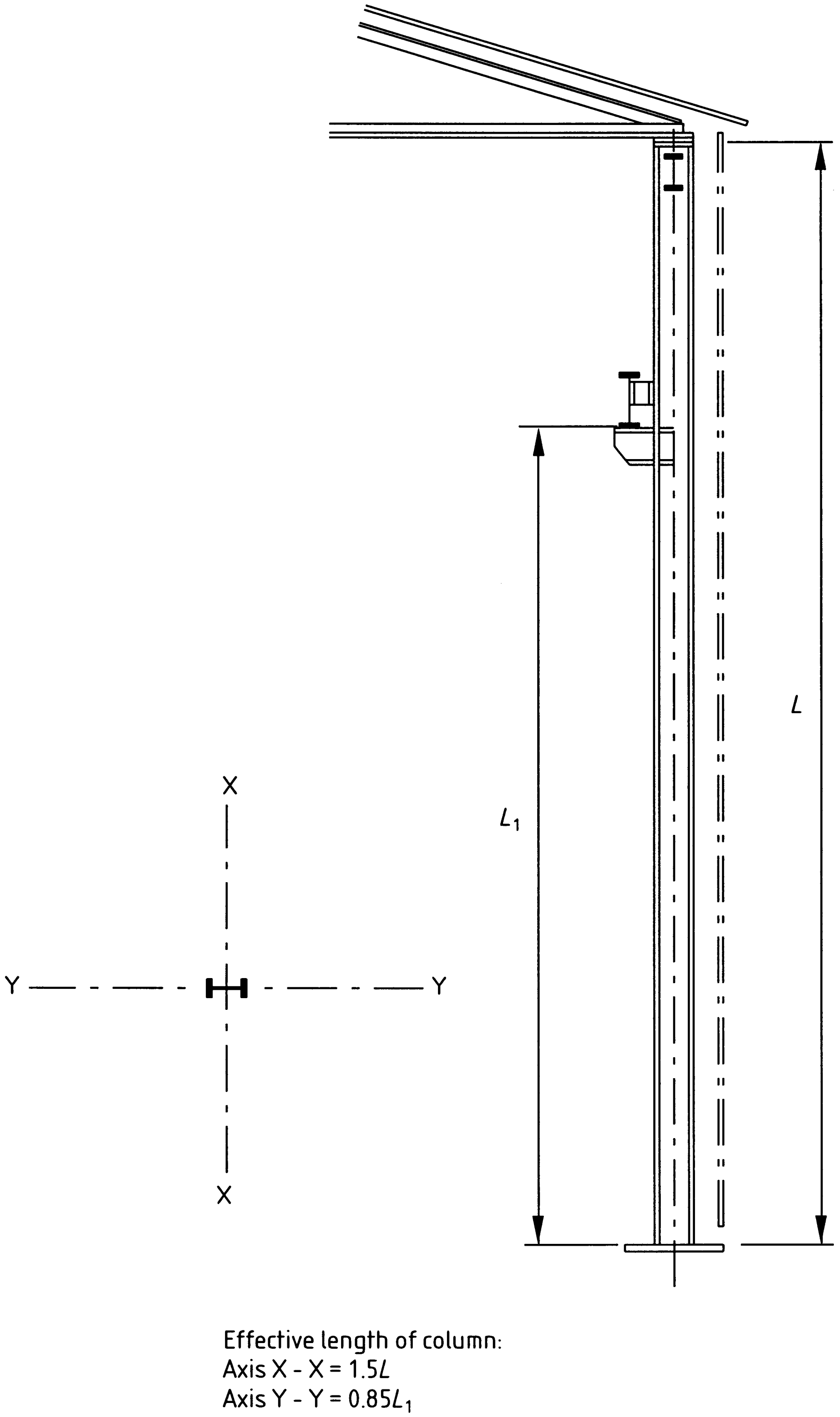


Figure D.3 — Simple side column with crane gantry beams

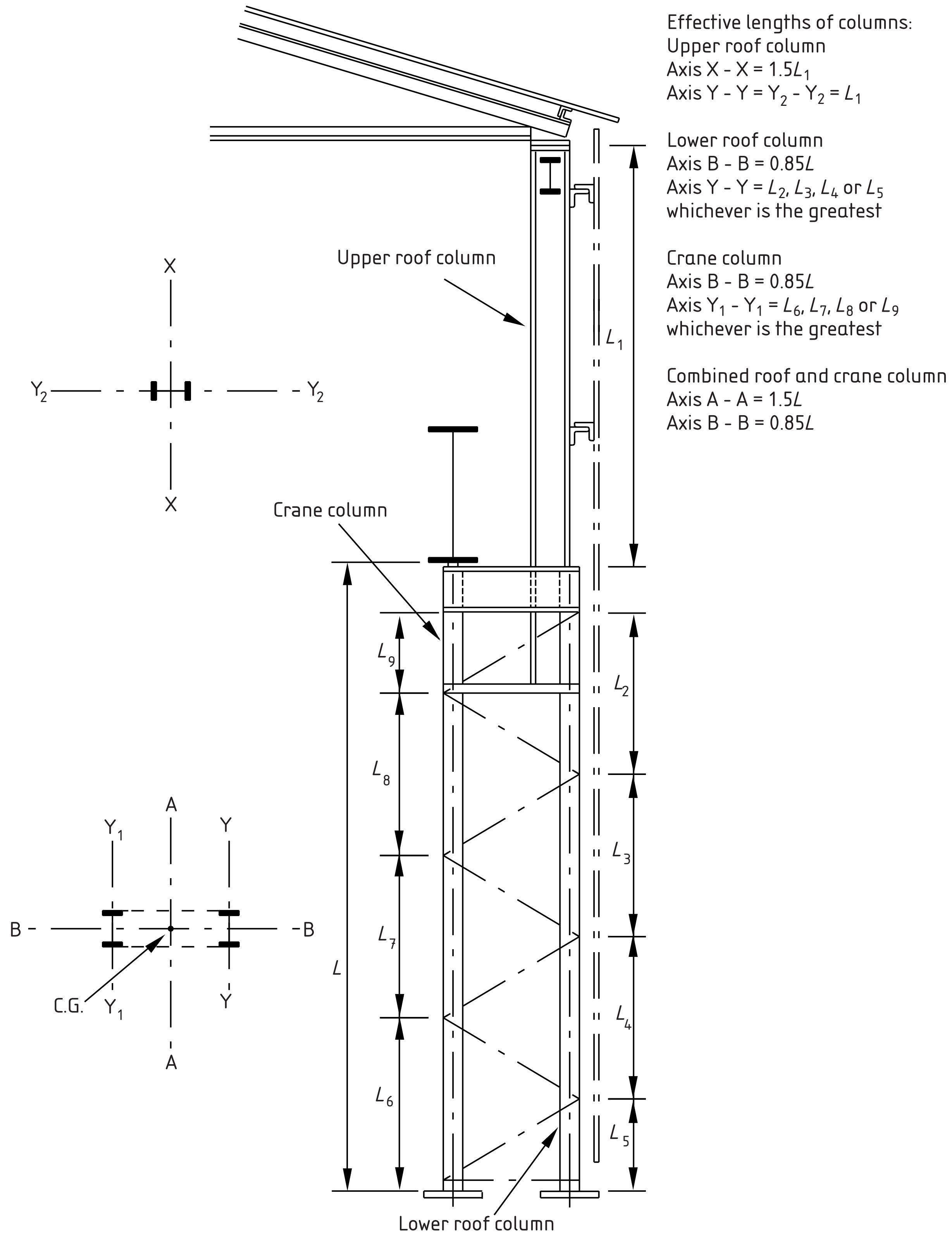


Figure D.4 — Compound side column with crane gantry beams

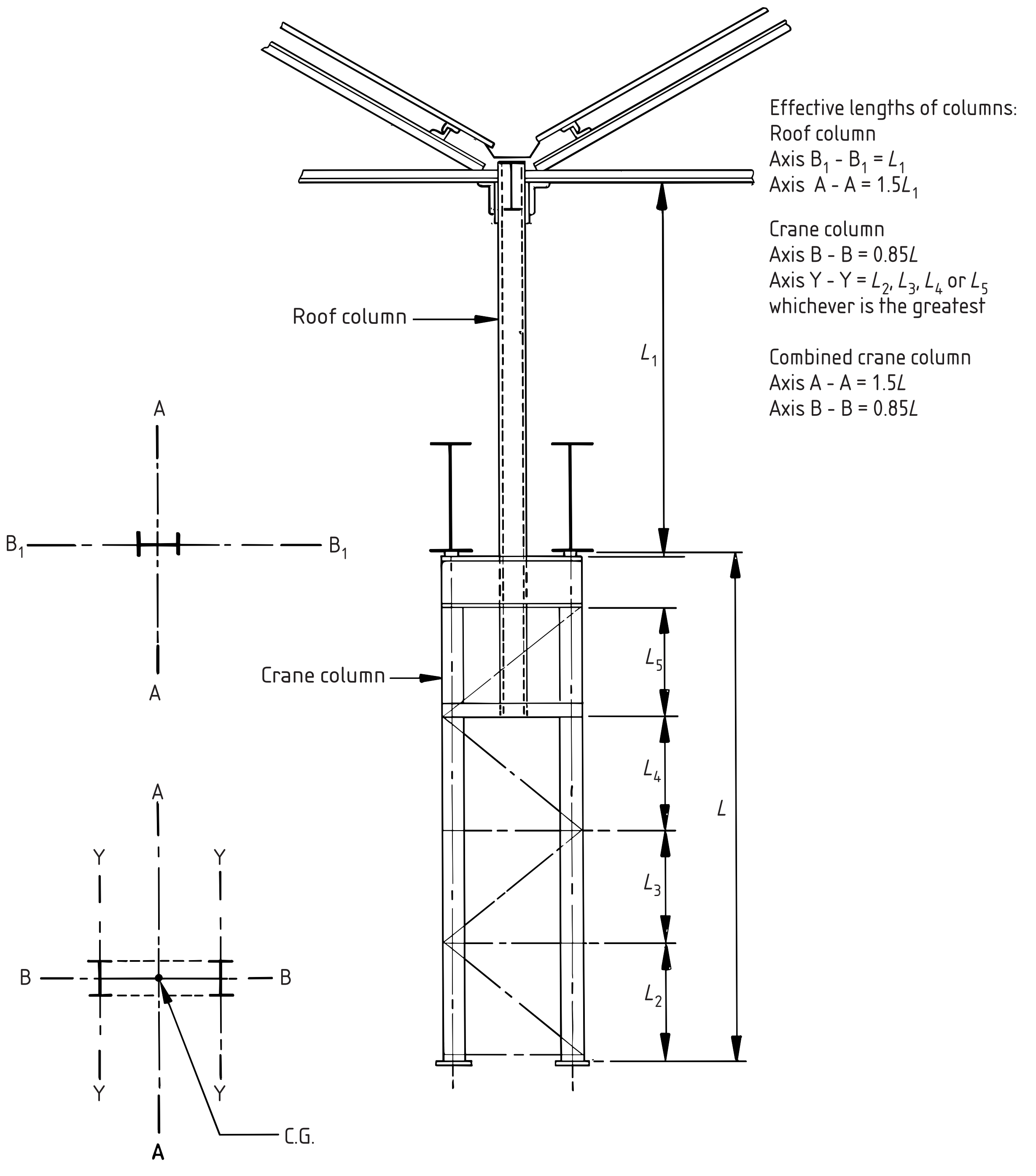


Figure D.5 — Compound valley column with crane gantry beams

D.2 Columns supporting internal platform floors

The effective lengths of columns supporting internal platform floors of simple design, see **2.1.2.2**, should be determined from Table D.1, depending on the conditions of directional restraint at the head and the base of the column in the relevant plane, and on whether the platform is braced against sway in that plane by some appropriate means other than the strength and stiffness of the columns themselves.

For columns that are unbraced in the relevant plane, where at least five columns act together to resist sway, the reduced effective lengths given in case c) of Table D.1 may be used, except for columns supporting storage loads.

In assessing the conditions of fixity, no greater directional restraint should be assumed than can reliably be provided at the head of a column by the cap-plate, the beams and the connection details, or at the base of a column by the baseplate, the base slab and the connection between them.

Table D.1 — Effective lengths of columns for internal platform floors

Case	Directional restraint at base of column	Directional restraint at head of column			
		Effectively restrained	Partially restrained	Nominally pinned	Truly pinned
a) Braced column	Effectively restrained	0.70L	0.80L	0.85L	0.90L
	Partially restrained	0.80L	0.85L	0.90L	0.95L
	Nominally pinned	0.85L	0.90L	0.95L	1.00L
	Truly pinned	0.90L	0.95L	1.00L	Avoid
b) Unbraced column Except as in case c)	Effectively restrained	1.50L	2.00L	2.50L	3.00L
	Partially restrained	2.00L	2.50L	3.00L	4.00L[a]
	Nominally pinned	2.50L	3.00L	Avoid	Avoid
	Truly pinned	3.00L	Avoid	Avoid	Avoid
c) Unbraced column	Effectively restrained	1.20L	1.50L	2.00L	2.50L
Five or more columns tied together	Partially restrained	1.50L	2.00L	2.50L	3.00L[a]
	Nominally pinned	2.00L	2.50L	Avoid	Avoid
No storage loads	Truly pinned	2.50L	Avoid	Avoid	Avoid

[a] For buckling about major axis only. To be avoided for buckling about minor axis.

Annex E (normative) Effective lengths of compression members in continuous structures

E.1 General

The effective length L_E for in-plane buckling of a column or other compression member in a continuous structure with moment-resisting joints, should be determined using the methods given in this annex.

Generally, the effective length ratio L_E/L should be obtained from Figure E.1 for the non-sway mode or Figure E.2 for the sway mode, as appropriate.

Distribution factors for columns in multi-storey buildings may be determined using the limited frame method given in **E.2**. The stiffening effect of infill wall panels may be taken into account as given in **E.3**.

Distribution factors for other compression members should be determined by reference to **E.4**.

In structures in which frames with moment-resisting joints provide sway resistance to simple columns (or other columns that do not contribute to the sway resistance in that plane), the in-plane effective lengths of the columns contributing to the sway resistance should be increased as detailed in **E.5**.

Alternatively, the effective length may be derived from the elastic critical load factor, taking account of the vertical loads supported by the whole structure, see **E.6**.

A1 NOTE Recommendations for the necessary stiffness of the moment-resisting joints are given in **6.1.5**. A1

E.2 Columns in multi-storey buildings

E.2.1 *Limited frame method*

For columns in multi-storey beam-and-column framed buildings with full continuity at moment-resisting joints and concrete or composite floor and roof slabs, the effective length L_E for in-plane buckling of a column-length may be determined on the basis of the limited frame shown in Figure E.3. The distribution factors k_1 and k_2 for the ends of the column-length should be obtained from:

$$k = \frac{\text{Total stiffness of the columns at the joint}}{\text{Total stiffness of all the members at the joint}}$$

If any member shown in Figure E.3 is not present in the actual structure, or is not rigidly connected to the column-length being designed, its stiffness should be taken as zero in determining distribution factors.

If the moment at one end of the column-length being designed exceeds 90 % of its reduced plastic moment capacity M_r in the presence of axial force, the distribution factor k for that end of the column-length should be taken as unity.

E.2.2 *Beam stiffness*

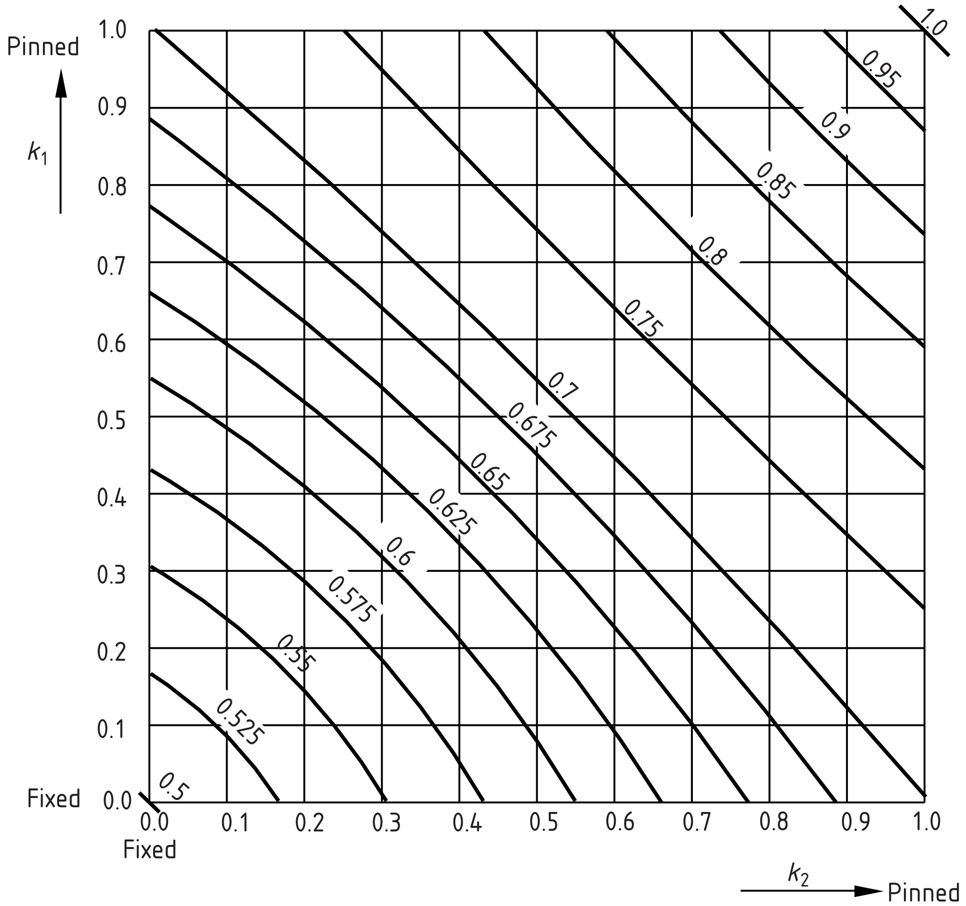
The stiffness coefficient K_b for a beam directly supporting a concrete or composite floor slab should normally be taken as I/L for both the sway mode and the non-sway mode, provided that the beam does not carry axial force, other than that due to sharing wind loads or notional horizontal loads between columns.

The stiffness coefficient K_b for any other beam should be obtained:

— from Table E.1 for other beams in buildings with concrete or composite floor slabs;

— by reference to **E.4.1** for beams in other rectilinear frames.

For beams with axial forces, reference should be made to **E.4.2**. If a beam has semi-rigid connections, its effective stiffness coefficient should be reduced accordingly.



NOTE This figure shows values of L_E/L that satisfy:

$$k_1 = \frac{1 - Ak_2}{A - Bk_2}$$

in which:

$$A = 1 - \frac{1}{4}\left[\frac{\alpha^2}{1 - \alpha\cot\alpha} + \alpha\cot\alpha\right]$$

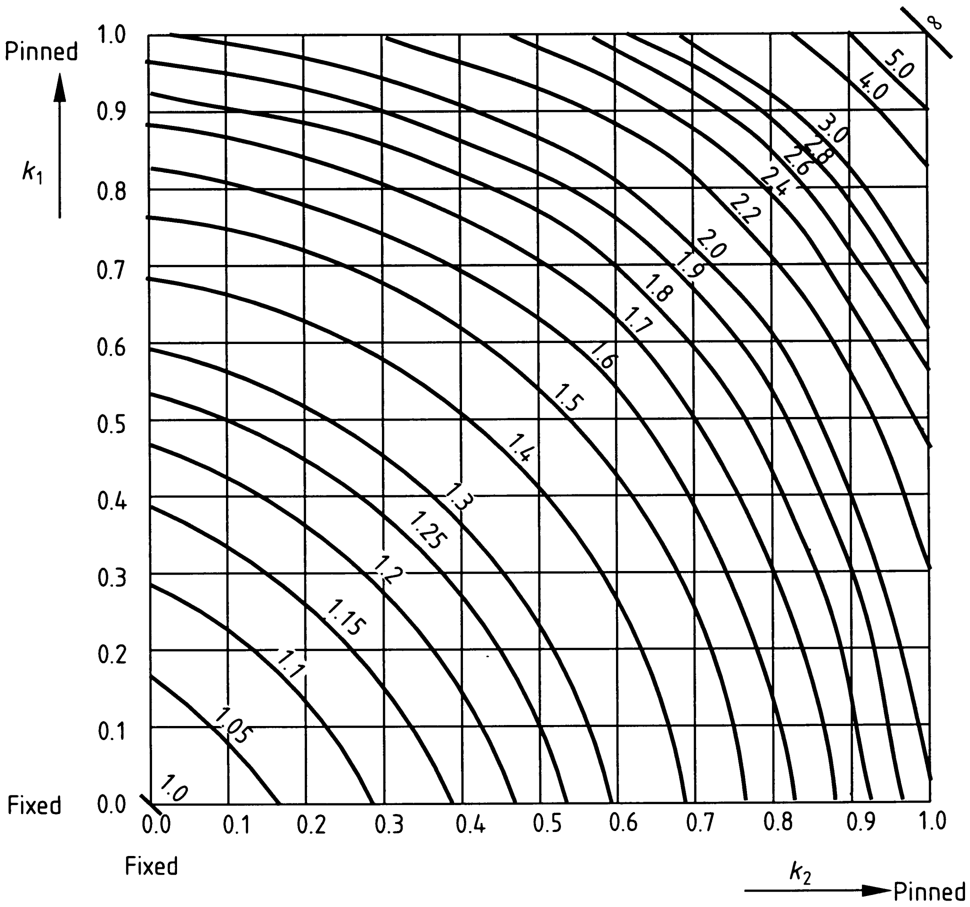
$$B = A^2 - \frac{1}{16}\left[\frac{\alpha^2}{1 - \alpha\cot\alpha} - \alpha\cot\alpha\right]^2$$

$$\alpha = \frac{\pi/2}{L_E/L}\text{[radians]}$$

A conservative value of L_E/L for given values of k_1 and k_2 may be obtained from:

$$L_E/L \approx 0.5 + 0.14(k_1 + k_2) + 0.055(k_1 + k_2)^2$$

Figure E.1 — Effective length ratio L_E/L for the non-sway buckling mode



NOTE This figure shows values of L_E/L that satisfy:

$$k_1 = \frac{1 - Ak_2}{A - Bk_2}$$

in which:

$$A = 1 - 0.25\alpha(\cot\alpha - \tan\alpha)$$

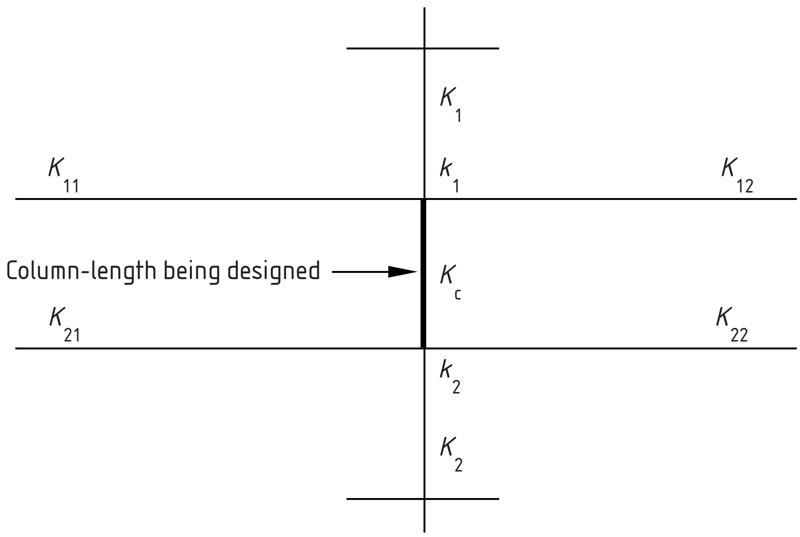
$$B = A^2 - [0.25\alpha(\cot\alpha + \tan\alpha)]^2$$

$$\alpha = \frac{\pi/2}{L_E/L}[\text{radians}]$$

A conservative value of L_E/L for given values of k_1 and k_2 may be obtained from:

$$L_E/L \approx \left[\frac{1 - 0.2(k_1 + k_2) - 0.12k_1k_2}{1 - 0.8(k_1 + k_2) + 0.6k_1k_2}\right]^{0.5}$$

Figure E.2 — Effective length ratio L_E/L for the sway buckling mode



Distribution factors:

$$k_1 = \frac{K_c + K_1}{K_c + K_1 + K_{11} + K_{12}}$$

$$k_2 = \frac{K_c + K_2}{K_c + K_2 + K_{21} + K_{22}}$$

where

K_1 and K_2 are the values of K_c for the adjacent column-lengths;

K_{11}, K_{12}, K_{21} and K_{22} are the values of K_b for the adjacent beams.

Figure E.3 — Distribution factors for continuous columns

Table E.1 — Stiffness coefficients K_b of beams in buildings with floor slabs

Loading conditions for the beam	Non-sway mode	Sway mode
Beams directly supporting concrete or composite floor or roof slabs	$1.0I/L$	$1.0I/L$
Other beams with direct loads	$0.75I/L$	$1.0I/L$
Beams with end moments only	$0.5I/L$	$1.5I/L$

Wherever a peak moment in a beam exceeds 90 % of its reduced plastic moment capacity M_r in the presence of axial force, it should be treated as pinned at that point. If such a point occurs only at the far end of the beam the value of K_b should be taken as $0.75I/L$ (or the value from Table E.1, if less), otherwise K_b should be taken as zero.

In a structure designed using plastic analysis, a beam should be taken as having a stiffness coefficient K_b of zero unless it has been designed to remain elastic.

E.2.3 ***Base stiffness***

The base stiffness should be determined by reference to **5.1.3**. In determining the distribution factor k at the foot of a column, the base stiffness should be treated as a beam stiffness, not a column stiffness.

E.2.4 ***Column stiffness***

The stiffness coefficient K_c of an adjacent column-length above or below the column-length being designed should be taken as I/L. [A1) *Text deleted* (A1]

2.3 Simplified determination of slenderness

The basic definition of non-dimensional beam slenderness $\bar{\lambda}_{\text{LT}}$ (Equation (2.18)) requires the explicit calculation of M_{cr}, given, for the most general case, by Equation (2.14). Use of this equation will generally lead to the most accurate assessment of lateral torsional buckling resistance and hence the most economic design. There are, however, a number of simplifications that can be made in the determination of $\bar{\lambda}_{\text{LT}}$ that will greatly expedite the calculation process, often with little loss of economy. These simplifications are described in NCCI SN002 [7] and are summarised below. A number of the simplifications relate specifically to doubly-symmetric I sections.

As an alternative to Equation (2.18), the non-dimensional beam slenderness $\bar{\lambda}_{\text{LT}}$ may be taken as:

$$\bar{\lambda}_{\text{LT}} = \frac{1}{\sqrt{C_1}} UVD\bar{\lambda}_z \sqrt{\beta_w} \qquad (2.21)$$

C_1 is a factor that allows for the shape of the bending moment diagram and is discussed in Section 2.4. It may be conservatively taken as equal to 1.0.

U is a parameter that depends on section geometry, given by:

$$U = \sqrt{\frac{W_{\text{pl,y}}\, g}{A}\sqrt{\frac{I_z}{I_w}}} \qquad (2.22)$$

where all symbols are as previously defined.

For UKB and UKC sections, values of U range between about 0.84 and 0.90; $U = 0.9$ is therefore a suitable conservative upper bound for such sections. The parameter g is defined in Section 2.2.1.

V is a parameter related to slenderness, and is given in full by:

$$V = \frac{1}{\sqrt[4]{\left(\frac{k}{k_w}\right)^2 + \frac{\lambda_z^2}{\frac{\pi^2 E}{G}\frac{A}{I_T}\frac{I_w}{I_z}} + (C_2 z_g)^2 \frac{I_z}{I_w}}} \qquad (2.23)$$

the symbols for which are defined in Section 2.2.1.
For doubly-symmetric hot-rolled UKB and UKC sections, and for cases where the loading is not destabilizing, V may be conservatively simplified to:

$$V = \frac{1}{\sqrt[4]{1 + \frac{1}{20}\left(\frac{\lambda_z}{h/t_f}\right)^2}} \qquad (2.24)$$

For all sections symmetric about the major axis and not subjected to destabilizing loading, V may be conservatively taken as equal to 1.0.

D is a destabilizing parameter to allow for destabilizing loads (i.e. loads applied above the shear centre of the beam, where the load can move with the beam as it buckles), given by:

$$D = \frac{1}{\sqrt{1 - V^2 C_2 z_g \sqrt{\frac{I_z}{I_w}}}} \quad (2.25)$$

Destabilizing loads are discussed in Section 2.5. For non-destabilizing loads, $D = 1.0$.

$\bar{\lambda}_z$ is the minor axis non-dimensional slenderness of the member, given by $\bar{\lambda}_z = \lambda_z / \lambda_1$, in which $\lambda_z = kL / i_z$, where k is an effective length parameter, values of which are given in Section 3 of this guide.

β_w is a parameter that allows for the classification of the cross-section; for Class 1 and 2 sections, $\beta_w = 1$ while for Class 3 sections $\beta_w = W_{el,y} / W_{pl,y}$.

For a hot-rolled doubly-symmetric I or H section with lateral restraints to the compression flange at both ends of the segment under consideration and with no destabilizing loads, the non-dimensional beam slenderness $\bar{\lambda}_{LT}$ may be conservatively obtained from Table 2.3. Table 2.3 has been derived on the basis of Equation (2.21) with the conservative assumptions of $C_1 = 1.0$, $U = 0.9$, $V = 1.0$, $D = 1.0$ and $\sqrt{\beta_w} = 1.0$.

Table 2.3 $\bar{\lambda}_{LT}$ for different steel grades

S235	S275	S355
$\bar{\lambda}_{LT} = \frac{L / i_z}{104}$	$\bar{\lambda}_{LT} = \frac{L / i_z}{96}$	$\bar{\lambda}_{LT} = \frac{L / i_z}{85}$

Note that the simplified method described in this Section can lead to more favourable results if in-plane curvature prior to buckling is accounted for in the calculation of the parameter U (through the parameter g described in Section 2.2.1). The slenderness would be less than that derived from Equation (2.18) using a simplified value of M_{cr} that neglects this beneficial effect.

2.4 Equivalent uniform moment factors C_1

The distribution of bending moments along the length of a beam influences the value of the elastic critical moment. Allowance for the variation of bending moments on the elastic buckling moment M_{cr} or slenderness $\bar{\lambda}_{LT}$ of a beam may be made by means of the equivalent uniform moment factor C_1 (see Equations (2.14) and (2.21)). Uniform bending moment is the most severe scenario, for which $C_1 = 1$. Taking $C_1 = 1$ is also conservative for other patterns of moment, but may become overly conservative when the bending moment distribution varies significantly from uniform.

Recommended values of C_1 and $1/\sqrt{C_1}$ are given in Table 2.4 and Table 2.5. These values are taken from P362 [12]. Similar values are also available elsewhere including

NCCI: Elastic critical moment for lateral torsional buckling

This NCCI gives the expression of the elastic critical moment for doubly symmetric cross-sections. Values of the factors involved in the calculation are given for common cases. For a beam under a uniformly distributed load with end moments or a concentrated load at mid-span with end moments, the values for the factors are given in graphs.

Contents

1. General

For doubly symmetric cross-sections, the elastic critical moment M_{cr} may be calculated by the method given in paragraph 2.

For cases not covered by the method given in paragraph 2, the elastic critical moment may be determined by a buckling analysis of the beam provided that the calculation accounts for all the parameters liable to affect the value of M_{cr} :

- geometry of the cross-section
- warping rigidity
- position of the transverse loading with regard to the shear centre
- restraint conditions

The ***LTBeam*** software is specific software for the calculation of the critical moment M_{cr}. It may be downloaded free of charge from the following web site:

http://www.cticm.com

2. Method for doubly symmetric sections

The method given hereafter only applies to uniform straight members for which the cross-section is symmetric about the bending plane.

The conditions of restraint at each end are at least :

- restrained against lateral movement
- restrained against rotation about the longitudinal axis

The elastic critical moment may be calculated from the following formula derived from the buckling theory :

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{(kL)^2} \left\{ \sqrt{\left(\frac{k}{k_w}\right)^2 \frac{I_w}{I_z} + \frac{(kL)^2 GI_t}{\pi^2 EI_z} + (C_2 z_g)^2} - C_2 z_g \right\} \quad \textbf{(1)}$$

where

E is the Young modulus (E = 210000 N/mm^2)

G is the shear modulus (G = 80770 N/mm^2)

I_z is the second moment of area about the weak axis

I_t is the torsion constant

I_w is the warping constant

L is the beam length between points which have lateral restraint

k and k_w are effective length factors

z_g is the distance between the point of load application and the shear centre.

Note : for doubly symmetric sections, the shear centre coincides with the centroid.

C_1 and C_2 are coefficients depending on the loading and end restraint conditions (see §3).

The factor k refers to end rotation on plan. It is analogous to the ratio of the buckling length to the system length for a compression member. k should be taken as not less than 1,0 unless less than 1,0 can be justified.

The factor k_w refers to end warping. Unless special provision for warping fixity is made, k_w should be taken as 1,0.

In the general case z_g is positive for loads acting towards the shear centre from their point of application (Figure 2.1).

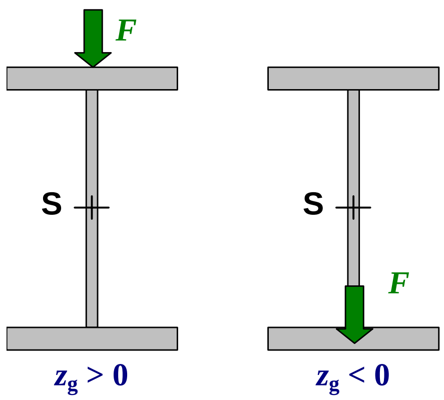


Figure 2.1 Point of application of the transverse load

In the common case of normal support conditions at the ends (fork supports), k and k_w are taken equal to 1.

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{L^2} \left\{ \sqrt{\frac{I_w}{I_z} + \frac{L^2 GI_t}{\pi^2 EI_z} + (C_2 z_g)^2} - C_2 z_g \right\} \qquad \textbf{(2)}$$

When the bending moment diagram is linear along a segment of a member delimited by lateral restraints, or when the transverse load is applied in the shear centre, $C_2\, z_g = 0$. The latter expression should be simplified as follows :

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{L^2} \sqrt{\frac{I_w}{I_z} + \frac{L^2 GI_t}{\pi^2 EI_z}} \qquad \textbf{(3)}$$

For doubly symmetric I-profiles, the warping constant I_w may be calculated as follows :

$$I_w = \frac{I_z (h - t_f)^2}{4} \qquad \textbf{(4)}$$

where

h is the total depth of the cross-section

t_f is the flange thickness

3. C_1 and C_2 factors

3.1 General

The C_1 and C_2 factors depend on various parameters :

- section properties,
- support conditions,
- moment diagram

It can be demonstrated that the C_1 and C_2 factors depend on the ratio :

$$\kappa = \frac{EI_w}{GI_t L^2} \qquad \textbf{(5)}$$

The values given in this document have been calculated with the assumption that $\kappa = 0$. This assumption leads to conservative values of C_1.

3.2 Member with end moments only

The factor C_1 may be determined from Table 3.1 for a member with end moment loading.

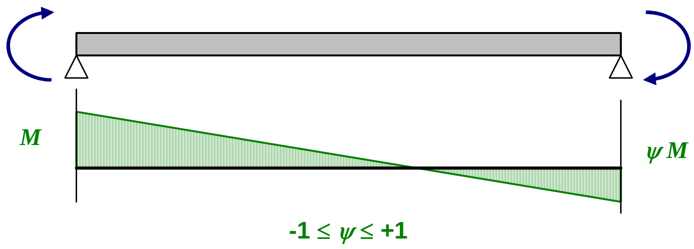


Figure 3.1 Member with end moments

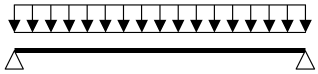
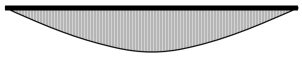
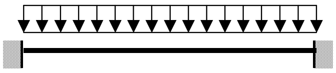
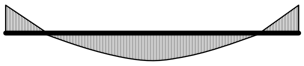
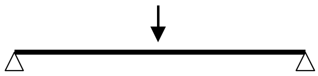
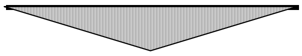
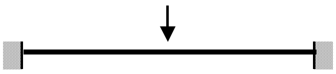
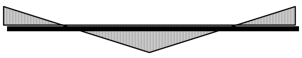
Table 3.1 Values of C_1 for end moment loading (for k = 1)

ψ	C_1
+1,00	1,00
+0,75	1,14
+0,50	1,31
+0,25	1,52
0,00	1,77
-0,25	2,05
-0,50	2,33
-0,75	2,57
-1,00	2,55

3.3 Member with transverse loading

Table 3.2 gives values of C_1 and C_2 for some cases of a member with transverse loading,

Table 3.2 Values of factors C_1 and C_2 for cases with transverse loading (for k = 1)

Loading and support conditions	Bending moment diagram	C_1	C_2
		1,127	0,454
		2,578	1,554
		1,348	0,630
		1,683	1,645

Note : the critical moment M_{cr} is calculated for the section with the maximal moment along the member

3.4 Member with end moments and transverse loading

For combined loading of end moments and transverse loads as shown in Figure 3.2, values of C_1 and C_2 may be obtained from the curves given hereafter. Two cases are considered:

Case a) end moments with a uniformly distributed load

Case b) end moments with a concentrated load at mid-span

The moment distribution may be defined using two parameters :

ψ is the ratio of end moments. By definition, M is the maximum end moment, and so :

$-1 \leq \psi \leq 1$ ($\psi = 1$ for a uniform moment)

μ is the ratio of the moment due to transverse load to the maximum end moment M

Case a) $\mu = \dfrac{qL^2}{8M}$

Case b) $\mu = \frac{FL}{4M}$

Sign convention for μ:

$\mu > 0$ if M and the transverse load (q or F), each supposed acting alone, bend the beam in the same direction (e.g. as shown in the figure below)

$\mu < 0$ otherwise

The values of C_1 and C_2 have been determined for $k = 1$ and $k_w = 1$.

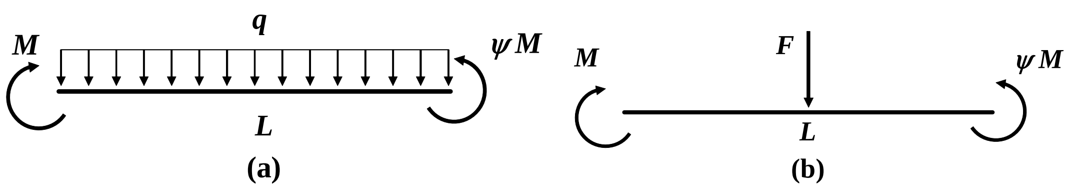
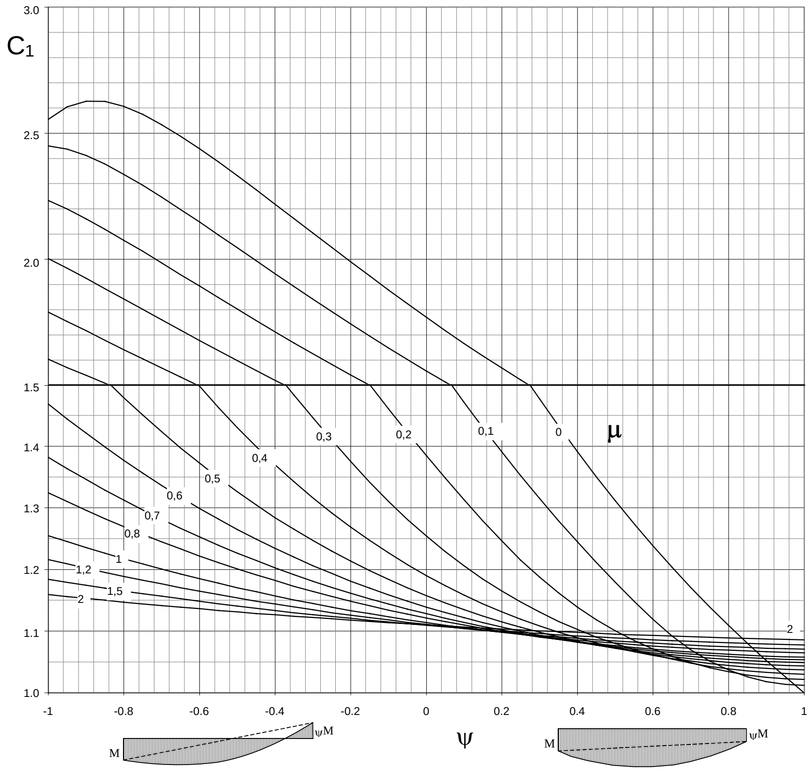
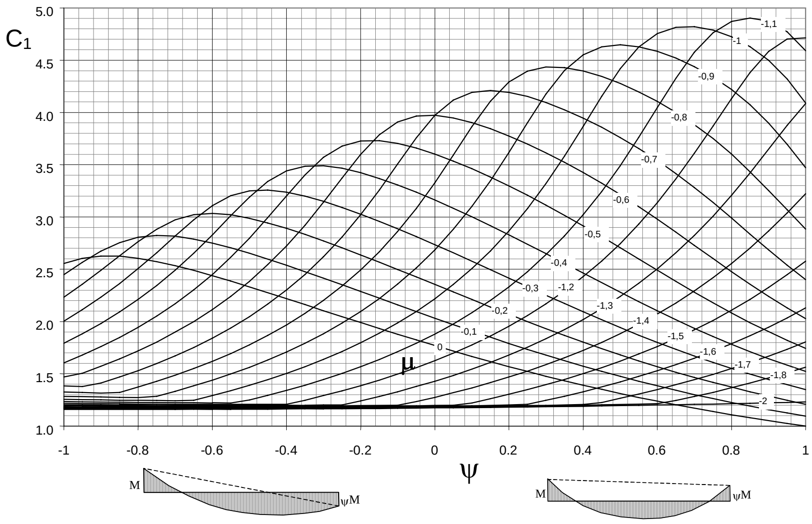


Figure 3.2 End moments with a transverse load

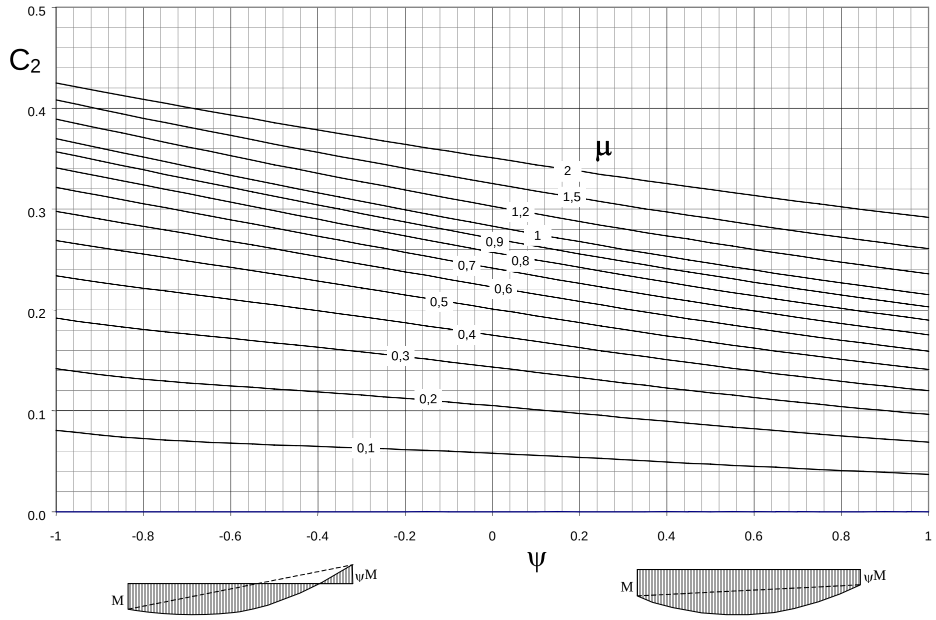


$\mu > 0$

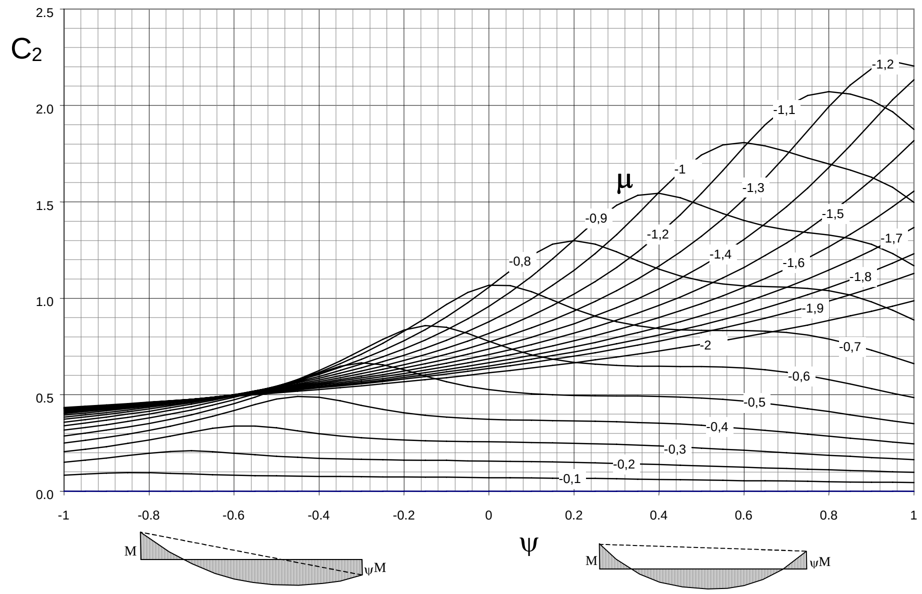


$\mu < 0$

Figure 3.3 End moments and uniformly distributed load – Factor C_1

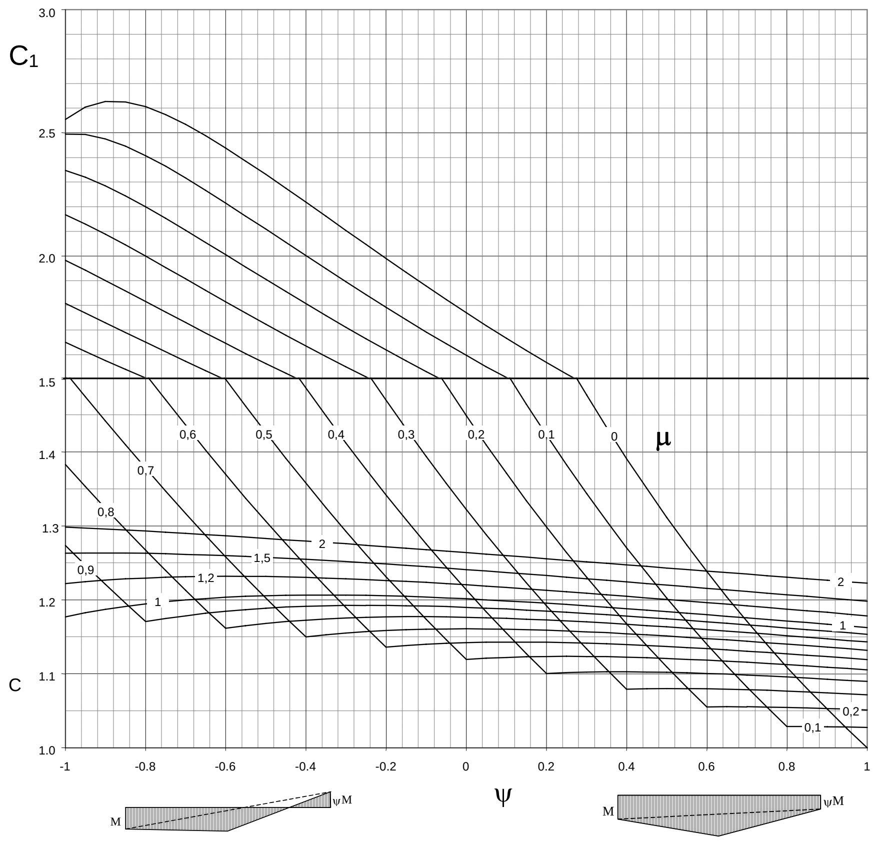


$\mu > 0$

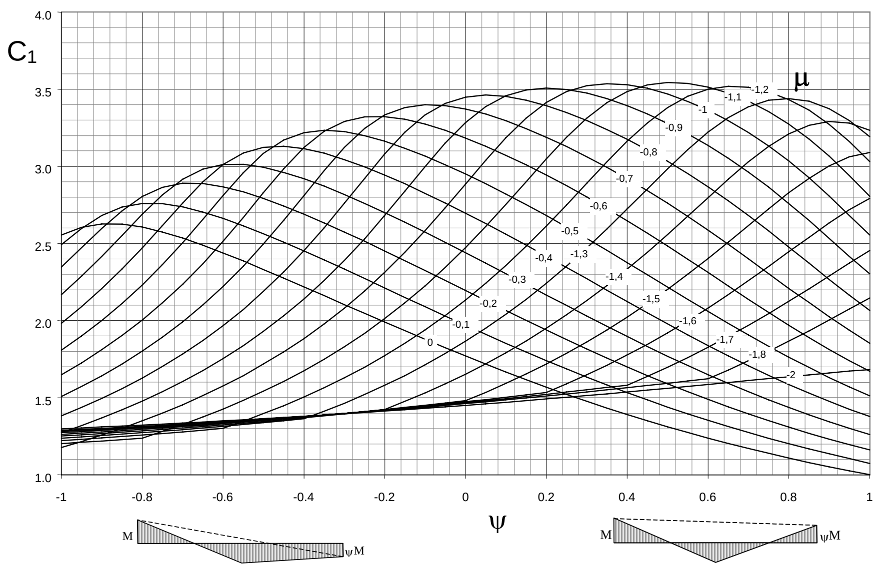


$\mu < 0$

Figure 3.4 ***End moments and uniformly distributed load – Factor C_2***

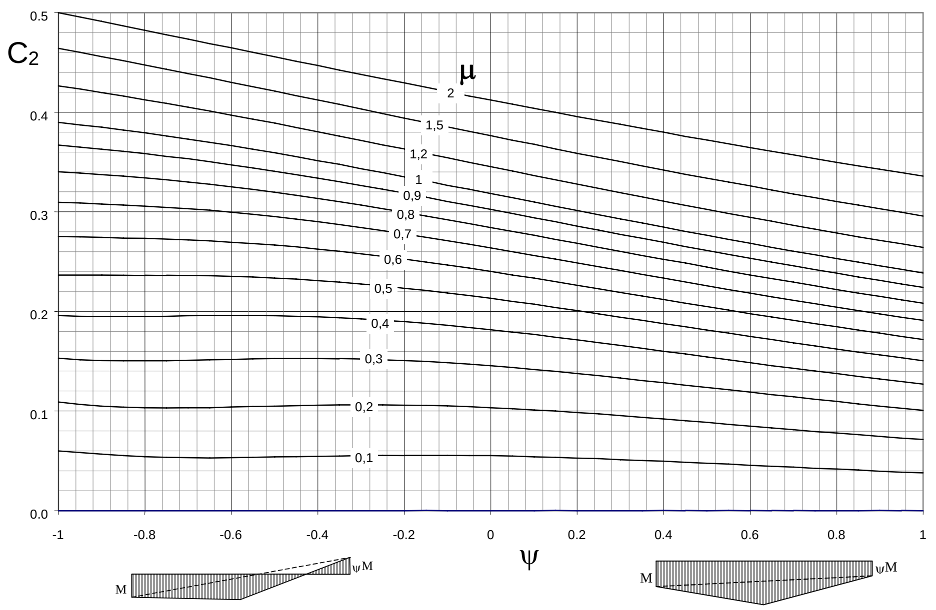


$\mu > 0$

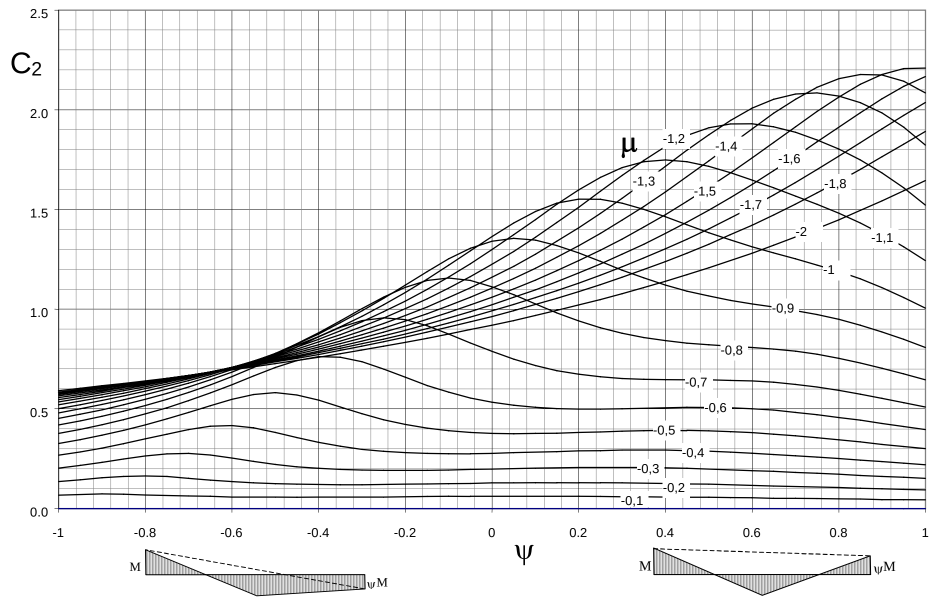


$\mu < 0$

Figure 3.5 End moments and point load at mid-span – Factor C_1



$\mu > 0$



$\mu < 0$

Figure 3.6 End moments and point load at mid-span – Factor C_2

4. References

1 ENV 1993-1-1

Eurocode 3 : Design of steel structures – Part 1.1 : General rules and rules for buildings. European Committee for Standardisation.

2 Timoshenko, S.P. and Gere, J. M.

Theory of elastic stability. 2nd Edition. Mc Graw-Hill. 1961.

3 Djalaly, H.

Calcul de la résistance ultime au déversement dans le cas de la flexion déviée. Revue Construction Métallique n°3-1974. CTICM.

4 Galéa, Y.

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Quality Record

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Table 13 — Effective length L_E for beams without intermediate restraint

Conditions of restraint at supports		Loading condition	
		Normal	Destabilizing
Compression flange laterally restrained. Nominal torsional restraint against rotation about longitudinal axis, as given in **4.2.2**.	Both flanges fully restrained against rotation on plan.	$0.7L_{LT}$	$0.85L_{LT}$
	Compression flange fully restrained against rotation on plan.	$0.75L_{LT}$	$0.9L_{LT}$
	Both flanges partially restrained against rotation on plan.	$0.8L_{LT}$	$0.95L_{LT}$
	Compression flange partially restrained against rotation on plan.	$0.85L_{LT}$	$1.0L_{LT}$
	Both flanges free to rotate on plan.	$1.0L_{LT}$	$1.2L_{LT}$
Compression flange laterally unrestrained. Both flanges free to rotate on plan.	Partial torsional restraint against rotation about longitudinal axis provided by connection of bottom flange to supports.	$1.0L_{LT} + 2D$	$1.2L_{LT} + 2D$
	Partial torsional restraint against rotation about longitudinal axis provided only by pressure of bottom flange onto supports.	$1.2L_{LT} + 2D$	$1.4L_{LT} + 2D$

D is the overall depth of the beam.

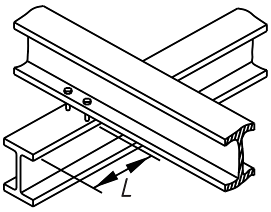
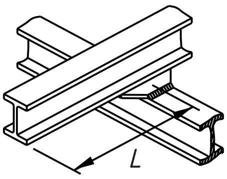
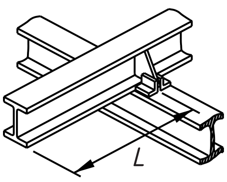
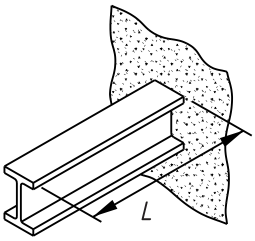
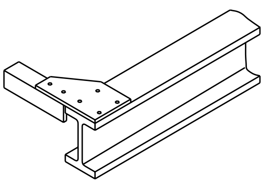
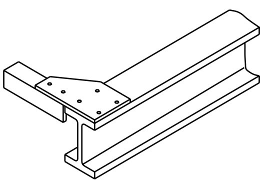
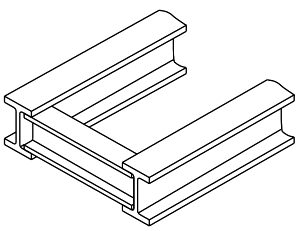
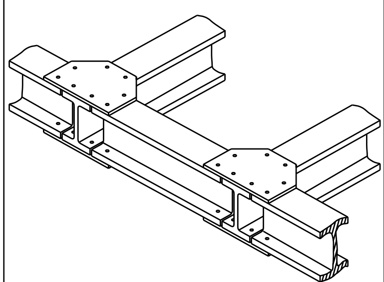
4.3.5.4 ***Cantilevers without intermediate restraints***

The effective length L_E for lateral-torsional buckling of a cantilever with no intermediate lateral restraint should be obtained from Table 14, taking L as the length of the cantilever. If a bending moment is applied at its tip, the effective length L_E from Table 14 should be increased by the greater of 30 % or $0.3L$.

4.3.5.5 ***Cantilevers with intermediate restraints***

Provided that the end restraint conditions correspond with cases c)4) or d)4) in Table 14, the effective length L_E for lateral-torsional buckling of a cantilever with intermediate lateral restraints to its compression flange should be taken as $1.0L$ for normal loading conditions, taking L as the length of the relevant segment between adjacent lateral restraints. However, for the destabilizing loading condition (see **4.3.4**) L_E should be obtained from Table 14, taking L as the length of the cantilever, unless the top flange also has intermediate lateral restraints.

Table 14 — Effective length L_E for cantilevers without intermediate restraint

Restraint conditions		Loading conditions	
At support	**At tip**	**Normal**	**Destabilizing**
a) Continuous, with lateral restraint to top flange 	1) Free	3.0L	7.5L
	2) Lateral restraint to top flange	2.7L	7.5L
	3) Torsional restraint	2.4L	4.5L
	4) Lateral and torsional restraint	2.1L	3.6L
b) Continuous, with partial torsional restraint 	1) Free	2.0L	5.0L
	2) Lateral restraint to top flange	1.8L	5.0L
	3) Torsional restraint	1.6L	3.0L
	4) Lateral and torsional restraint	1.4L	2.4L
c) Continuous, with lateral and torsional restraint 	1) Free	1.0L	2.5L
	2) Lateral restraint to top flange	0.9L	2.5L
	3) Torsional restraint	0.8L	1.5L
	4) Lateral and torsional restraint	0.7L	1.2L
d) Restrained laterally, torsionally and against rotation on plan 	1) Free	0.8L	1.4L
	2) Lateral restraint to top flange	0.7L	1.4L
	3) Torsional restraint	0.6L	0.6L
	4) Lateral and torsional restraint	0.5L	0.5L
Tip restraint conditions			
1) Free  (not braced on plan)	2) Lateral restraint to top flange  (braced on plan in at least one bay)	3) Torsional restraint  (not braced on plan)	4) Lateral and torsional restraint  (braced on plan in at least one bay)

4.3.6 Resistance to lateral-torsional buckling

4.3.6.1 *General*

Resistance to lateral-torsional buckling need not be checked separately (and the buckling resistance moment M_b may be taken as equal to the relevant moment capacity M_c) in the following cases:

— bending about the minor axis;

— CHS, square RHS or circular or square solid bars;

— RHS, unless L_E/r_y exceeds the limiting value given in Table 15 for the relevant value of D/B;

— I-, H-, channel or box sections, if λ_{LT} does not exceed λ_{L0}, see **4.3.6.5**.

Otherwise, for members subject to bending about their major axis, reference should be made as follows:

— for I-, H-, channel or box section members with equal flanges and a uniform cross-section throughout the length of the relevant segment L between adjacent lateral restraints, see **4.3.6.2**;

— for I-sections or box sections with unequal flanges but with a uniform cross-section throughout the length of the relevant segment L between adjacent lateral restraints, see **4.3.6.3**;

— for I-, H-, channel or box section members with a cross-section that varies within the length of the relevant segment L between adjacent lateral restraints, see **B.2.5**;

— for hot rolled angles, see **4.3.8**;

— for plates, flats or solid rectangular bars, see **B.2.7**;

— for T-sections see, **B.2.8**.

Table 15 — Limiting value of L_E/r_y for RHS

Ratio D/B	Limiting value of L_E/r_y	Ratio D/B	Limiting value of L_E/r_y	Ratio D/B	Limiting value of L_E/r_y
1.25	$770 \times (275/p_y)$	1.5	$515 \times (275/p_y)$	2.0	$340 \times (275/p_y)$
1.33	$670 \times (275/p_y)$	1.67	$435 \times (275/p_y)$	2.5	$275 \times (275/p_y)$
1.4	$580 \times (275/p_y)$	1.75	$410 \times (275/p_y)$	3.0	$225 \times (275/p_y)$
1.44	$550 \times (275/p_y)$	1.8	$395 \times (275/p_y)$	4.0	$170 \times (275/p_y)$

Key:

B is the width of the section;

D is the depth of the section;

L_E is the effective length for lateral-torsional buckling from **4.3.5**;

p_y is the design strength;

r_y is the radius of gyration of the section about its minor axis.

4.3.6.2 *I-, H-, channel and box sections with equal flanges*

In each segment of length L between adjacent lateral restraints, members of I-, H-, channel or box sections with equal flanges should satisfy:

$M_x \leq M_b/m_{LT}$ and $M_x \leq M_{cx}$

where

M_b is the buckling resistance moment, see **4.3.6.4**;

M_{cx} is the major axis moment capacity of the cross-section, see **4.2.5**;

M_x is the maximum major axis moment in the segment;

m_{LT} is the equivalent uniform moment factor for lateral-torsional buckling, see **4.3.6.6**.

4.3.7 Equal flanged rolled sections

As a simple (but more conservative) alternative to **4.3.6.5**, **4.3.6.6**, **4.3.6.7**, **4.3.6.8** and **4.3.6.9**, the buckling resistance moment M_b of a plain rolled I, H or channel section with equal flanges may be determined using the bending strength p_b obtained from Table 20 for the relevant values of $(\beta_W)^{0.5}L_E/r_y$ and D/T as follows:

— *for a class 1 plastic or class 2 compact cross-section:*

$M_b = p_b S_x$

— *for a class 3 semi-compact cross-section:*

$M_b = p_b Z_x$

where

D is the depth of the section;

L_E is the effective length from **4.3.5**;

r_y is the radius of gyration of the section about its y-y axis;

S_x is the plastic modulus about the major axis;

T is the flange thickness;

Z_x is the section modulus about the major axis;

β_W is the ratio specified in **4.3.6.9**.

4.3.8 Buckling resistance moment for single angles

4.3.8.1 *General*

The design of unrestrained single angle members to resist bending should take account of the fact that the rectangular axes of the cross-section (x-x and y-y) are not the principal axes, either by using the basic method given in **4.3.8.2** or the simplified method given in **4.3.8.3**.

4.3.8.2 *Basic method*

For this method the applied moments should be resolved into moments about the principal axes u-u and v-v. The buckling resistance moment M_b for bending about the u-u axis should be based on the value of λ_{LT} obtained from **B.2.9**. The effects of biaxial bending should then be combined in accordance with **4.9**.

4.3.8.3 *Simplified method*

Alternatively to **4.3.8.2**, for equal angles the buckling resistance moment of a single angle with $b/t \leq 15\varepsilon$ subject to bending about the x-x axis, may be determined as follows:

— heel of angle in compression:

$M_b = 0.8 p_y Z_x$

— heel of angle in tension:

$$M_b = p_y Z_x \left(\frac{1\,350\varepsilon - L_E/r_v}{1625\varepsilon} \right) \quad \text{but} \quad M_b \leq 0.8 p_y Z_x$$

where

L_E is the effective length from **4.3.5**, based on the length L_v between restraints against buckling about the v-v axis;

r_v is the radius of gyration about the v-v axis;

Z_x is the smaller section modulus about the x-x axis.

If the member is bent with the heel of the angle in tension anywhere within the length L_v between restraints against buckling about the v-v axis, the relevant value of M_b should be applied throughout that segment.

For unequal angles the basic method given in **4.3.8.2** should be used.

The monosymmetry index ψ should be taken as positive when the flange of the T-section is in compression and negative when the flange is in tension. It may be evaluated using:

$$\psi = \left(2y_o - \frac{y_o B^3 T/12 + BTy_o{}^3 + \frac{t}{4}[(c-T)^4 - (D-c)^4]}{I_x}\right)\frac{1}{(D-T/2)}$$

in which:

$$y_o = c - T/2$$

where c is the distance from the outside of the flange to the centroid of the section.

When the flange is in tension the monosymmetry index ψ may conservatively be taken as –1.0.

B.2.8.3 *Warping constant*

For a T-section the warping constant H should be obtained from:

$$H = \frac{B^3T^3}{144} + \frac{(D-T/2)^3 t^3}{36}$$

B.2.9 *Angle sections*

B.2.9.1 *Axes*

Except when using the approximate method given in **4.3.8**, moments applied to unrestrained angles should be related to their principal axes u-u and v-v, not their geometric axes x-x and y-y.

B.2.9.2 *Equal angles*

For a single equal leg angle, subject to moments about its major axis u-u, the equivalent slenderness λ_{LT} should be taken as:

$$\lambda_{LT} = 2.25(\phi_a \lambda_v)^{0.5}$$

in which:

$$\phi_a = \left(\frac{Z_u{}^2 \gamma_a}{AJ}\right)^{0.5}$$

$$\gamma_a = (1 - I_v/I_u)$$

$$\lambda_v = L_v/r_v$$

where

- A is the cross-sectional area;
- I_u is the second moment of area about the major axis;
- I_v is the second moment of area about the minor axis;
- J is the torsion constant;
- L_v is the length between points where the member is restrained in both the x-x and y-y directions;
- r_v is the radius of gyration about the minor axis v-v;
- Z_u is the section modulus about the major axis u-u.

B.2.9.3 *Unequal angles*

For a single unequal leg angle, subject to moments about its major axis u-u, the equivalent slenderness λ_{LT} should be taken as:

$$\lambda_{LT} = 2.25 \nu_a (\phi_a \lambda_v)^{0.5}$$

in which:

$$\nu_a = \frac{1}{\left[\left(1 + \left(\frac{4.5\psi_a}{\lambda_v}\right)^2\right)^{0.5} + \frac{4.5\psi_a}{\lambda_v}\right]^{0.5}}$$

The monosymmetry index ψ_a for an unequal angle should be taken as positive when the short leg is in compression and negative when the long leg is in compression. If the long leg is in compression anywhere within the segment length L_v then ψ_a should be taken as negative. It may be evaluated from:

$$\psi_a = \left[2\nu_o - \frac{\int \nu_i (u_i^2 + \nu_i^2) dA}{I_u}\right] \frac{1}{t}$$

in which u_i and ν_i are the coordinates of an element of the cross-section and ν_o is the coordinate of the shear centre along the v-v axis, relative to the centroid of the cross-section.

B.3 Internal moments

B.3.1 *General*

The additional internal "second-order" minor-axis moment (equivalent to the strut action moment in a compression member) in a member subject to external applied major axis moment, should be taken as having a maximum value $M_{y,max}$ midway between points of inflexion of the buckled shape (the points between which the effective length L_E is measured) given by:

$$M_{y,max} = (p_y / p_b - 1)(M_{cy} / M_{cx}) m_{LT} M_x$$

where

- M_{cx} is the major axis moment capacity of the cross-section, assuming zero shear, see **4.2.5**;
- M_{cy} is the minor axis moment capacity of the cross-section, assuming zero shear, see **4.2.5**;
- M_x is the maximum major axis moment in the length L of the segment;
- m_{LT} is the equivalent uniform moment factor for lateral-torsional buckling, see **4.3.6.6**;
- p_b is the bending strength for resistance to lateral-torsional buckling, see **4.3.6.5** (or **B.2.1**).

The additional internal minor axis moment M_{ys} at a distance L_z along the member from a point of inflexion should be obtained from:

$$M_{ys} = M_{y,max} \sin(180 L_z / L_E)$$

B.3.2 *T-sections*

In applying **B.3.1** to a T-section, the subscripts x and y should always be taken as referring to the major axis and the minor axis respectively, even where the opposite subscript is used in **B.2.8.2**b).

B.3.3 *Angles*

In applying **B.3.1** to an angle, the subscripts x and y should be taken as referring to the major axis u–u and minor axis v–v respectively.

SECTION PROPERTIES

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

B-2

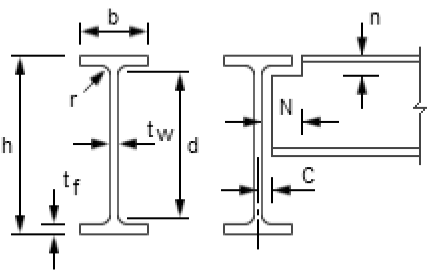
Table 2.1.1.1

SECTION PROPERTIES

UNIVERSAL BEAMS

Advance® UKB

DIMENSIONS



Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		h	b	t_w	t_f	r	d	c_f / t_f	c_w / t_w	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
1016 x 305 x 487 +	486.7	1036.3	308.5	30.0	54.1	30.0	868.1	2.02	28.9	17	150	86	3.20	6.58
1016 x 305 x 437 +	437.0	1026.1	305.4	26.9	49.0	30.0	868.1	2.23	32.3	15	150	80	3.17	7.25
1016 x 305 x 393 +	392.7	1015.9	303.0	24.4	43.9	30.0	868.1	2.49	35.6	14	150	74	3.14	8.00
1016 x 305 x 349 +	349.4	1008.1	302.0	21.1	40.0	30.0	868.1	2.76	41.1	13	152	70	3.13	8.96
1016 x 305 x 314 +	314.3	999.9	300.0	19.1	35.9	30.0	868.1	3.08	45.5	12	152	66	3.11	9.89
1016 x 305 x 272 +	272.3	990.1	300.0	16.5	31.0	30.0	868.1	3.60	52.6	10	152	62	3.10	11.4
1016 x 305 x 249 +	248.7	980.1	300.0	16.5	26.0	30.0	868.1	4.30	52.6	10	152	56	3.08	12.4
1016 x 305 x 222 +	222.0	970.3	300.0	16.0	21.1	30.0	868.1	5.31	54.3	10	152	52	3.06	13.8
914 x 419 x 388	388.0	921.0	420.5	21.4	36.6	24.1	799.6	4.79	37.4	13	210	62	3.44	8.87
914 x 419 x 343	343.3	911.8	418.5	19.4	32.0	24.1	799.6	5.48	41.2	12	210	58	3.42	9.96
914 x 305 x 289	289.1	926.6	307.7	19.5	32.0	19.1	824.4	3.91	42.3	12	156	52	3.01	10.4
914 x 305 x 253	253.4	918.4	305.5	17.3	27.9	19.1	824.4	4.48	47.7	11	156	48	2.99	11.8
914 x 305 x 224	224.2	910.4	304.1	15.9	23.9	19.1	824.4	5.23	51.8	10	156	44	2.97	13.2
914 x 305 x 201	200.9	903.0	303.3	15.1	20.2	19.1	824.4	6.19	54.6	10	156	40	2.96	14.7
838 x 292 x 226	226.5	850.9	293.8	16.1	26.8	17.8	761.7	4.52	47.3	10	150	46	2.81	12.4
838 x 292 x 194	193.8	840.7	292.4	14.7	21.7	17.8	761.7	5.58	51.8	9	150	40	2.79	14.4
838 x 292 x 176	175.9	834.9	291.7	14.0	18.8	17.8	761.7	6.44	54.4	9	150	38	2.78	15.8
762 x 267 x 197	196.8	769.8	268.0	15.6	25.4	16.5	686.0	4.32	44.0	10	138	42	2.55	13.0
762 x 267 x 173	173.0	762.2	266.7	14.3	21.6	16.5	686.0	5.08	48.0	9	138	40	2.53	14.6
762 x 267 x 147	146.9	754.0	265.2	12.8	17.5	16.5	686.0	6.27	53.6	8	138	34	2.51	17.1
762 x 267 x 134	133.9	750.0	264.4	12.0	15.5	16.5	686.0	7.08	57.2	8	138	32	2.51	18.7
686 x 254 x 170	170.2	692.9	255.8	14.5	23.7	15.2	615.1	4.45	42.4	9	132	40	2.35	13.8
686 x 254 x 152	152.4	687.5	254.5	13.2	21.0	15.2	615.1	5.02	46.6	9	132	38	2.34	15.4
686 x 254 x 140	140.1	683.5	253.7	12.4	19.0	15.2	615.1	5.55	49.6	8	132	36	2.33	16.6
686 x 254 x 125	125.2	677.9	253.0	11.7	16.2	15.2	615.1	6.51	52.6	8	132	32	2.32	18.5
610 x 305 x 238	238.1	635.8	311.4	18.4	31.4	16.5	540.0	4.14	29.3	11	158	48	2.45	10.3
610 x 305 x 179	179.0	620.2	307.1	14.1	23.6	16.5	540.0	5.51	38.3	9	158	42	2.41	13.5
610 x 305 x 149	149.2	612.4	304.8	11.8	19.7	16.5	540.0	6.60	45.8	8	158	38	2.39	16.0
610 x 229 x 140	139.9	617.2	230.2	13.1	22.1	12.7	547.6	4.34	41.8	9	120	36	2.11	15.1
610 x 229 x 125	125.1	612.2	229.0	11.9	19.6	12.7	547.6	4.89	46.0	8	120	34	2.09	16.7
610 x 229 x 113	113.0	607.6	228.2	11.1	17.3	12.7	547.6	5.54	49.3	8	120	30	2.08	18.4
610 x 229 x 101	101.2	602.6	227.6	10.5	14.8	12.7	547.6	6.48	52.2	7	120	28	2.07	20.5
610 x 178 x 100 +	100.3	607.4	179.2	11.3	17.2	12.7	547.6	4.14	48.5	8	94	30	1.89	18.8
610 x 178 x 92 +	92.2	603.0	178.8	10.9	15.0	12.7	547.6	4.75	50.2	7	94	28	1.88	20.4
610 x 178 x 82 +	81.8	598.6	177.9	10.0	12.8	12.7	547.6	5.57	54.8	7	94	26	1.87	22.9
533 x 312 x 272 +	273.3	577.1	320.2	21.1	37.6	12.7	476.5	3.64	22.6	13	160	52	2.37	8.67
533 x 312 x 219 +	218.8	560.3	317.4	18.3	29.2	12.7	476.5	4.69	26.0	11	160	42	2.33	10.7
533 x 312 x 182 +	181.5	550.7	314.5	15.2	24.4	12.7	476.5	5.61	31.3	10	160	38	2.31	12.7
533 x 312 x 150 +	150.6	542.5	312.0	12.7	20.3	12.7	476.5	6.75	37.5	8	160	34	2.29	15.2

Table 2.1.1.1. Advance® UKB. Dimensions

BS EN 1993-1-1: 2005
BS 4-1: 2005

B-3

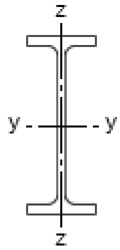
Table 2.1.1.2

SECTION PROPERTIES

UNIVERSAL BEAMS

Advance® UKB

PROPERTIES



Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	U	X	I_w	I_T	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
1016 x 305 x 487 +	1020000	26700	40.6	6.57	19700	1730	23200	2800	0.867	21.1	64.4	4300	620
1016 x 305 x 437 +	910000	23400	40.4	6.49	17700	1540	20800	2470	0.868	23.1	56.0	3190	557
1016 x 305 x 393 +	808000	20500	40.2	6.40	15900	1350	18500	2170	0.868	25.5	48.4	2330	500
1016 x 305 x 349 +	723000	18500	40.3	6.44	14300	1220	16600	1940	0.872	27.9	43.3	1720	445
1016 x 305 x 314 +	644000	16200	40.1	6.37	12900	1080	14800	1710	0.872	30.7	37.7	1260	400
1016 x 305 x 272 +	554000	14000	40.0	6.35	11200	934	12800	1470	0.872	35.0	32.2	835	347
1016 x 305 x 249 +	481000	11800	39.0	6.09	9820	784	11300	1240	0.861	39.9	26.8	582	317
1016 x 305 x 222 +	408000	9550	38.0	5.81	8410	636	9810	1020	0.850	45.7	21.5	390	283
914 x 419 x 388	720000	45400	38.2	9.59	15600	2160	17700	3340	0.885	26.7	88.9	1730	494
914 x 419 x 343	626000	39200	37.8	9.46	13700	1870	15500	2890	0.883	30.1	75.8	1190	437
914 x 305 x 289	504000	15600	37.0	6.51	10900	1010	12600	1600	0.867	31.9	31.2	926	368
914 x 305 x 253	436000	13300	36.8	6.42	9500	871	10900	1370	0.865	36.2	26.4	626	323
914 x 305 x 224	376000	11200	36.3	6.27	8270	739	9530	1160	0.860	41.3	22.1	422	286
914 x 305 x 201	325000	9420	35.7	6.07	7200	621	8350	982	0.853	46.9	18.4	291	256
838 x 292 x 226	340000	11400	34.3	6.27	7980	773	9160	1210	0.869	35.0	19.3	514	289
838 x 292 x 194	279000	9070	33.6	6.06	6640	620	7640	974	0.862	41.6	15.2	306	247
838 x 292 x 176	246000	7800	33.1	5.90	5890	535	6810	842	0.856	46.5	13.0	221	224
762 x 267 x 197	240000	8170	30.9	5.71	6230	610	7170	958	0.869	33.1	11.3	404	251
762 x 267 x 173	205000	6850	30.5	5.58	5390	514	6200	807	0.865	38.0	9.39	267	220
762 x 267 x 147	169000	5460	30.0	5.40	4470	411	5160	647	0.858	45.2	7.40	159	187
762 x 267 x 134	151000	4790	29.7	5.30	4020	362	4640	570	0.853	49.8	6.46	119	171
686 x 254 x 170	170000	6630	28.0	5.53	4920	518	5630	811	0.872	31.8	7.42	308	217
686 x 254 x 152	150000	5780	27.8	5.46	4370	455	5000	710	0.871	35.4	6.42	220	194
686 x 254 x 140	136000	5180	27.6	5.39	3990	409	4560	638	0.870	38.6	5.72	169	178
686 x 254 x 125	118000	4380	27.2	5.24	3480	346	3990	542	0.863	43.8	4.80	116	159
610 x 305 x 238	209000	15800	26.3	7.23	6590	1020	7490	1570	0.886	21.3	14.5	785	303
610 x 305 x 179	153000	11400	25.9	7.07	4930	743	5550	1140	0.885	27.7	10.2	340	228
610 x 305 x 149	126000	9310	25.7	7.00	4110	611	4590	937	0.886	32.7	8.17	200	190
610 x 229 x 140	112000	4510	25.0	5.03	3620	391	4140	611	0.875	30.6	3.99	216	178
610 x 229 x 125	98600	3930	24.9	4.97	3220	343	3680	535	0.875	34.0	3.45	154	159
610 x 229 x 113	87300	3430	24.6	4.88	2870	301	3280	469	0.870	38.0	2.99	111	144
610 x 229 x 101	75800	2910	24.2	4.75	2520	256	2880	400	0.863	43.0	2.52	77.0	129
610 x 178 x 100 +	72500	1660	23.8	3.60	2390	185	2790	296	0.854	38.7	1.44	95.0	128
610 x 178 x 92 +	64600	1440	23.4	3.50	2140	161	2510	258	0.850	42.7	1.24	71.0	117
610 x 178 x 82 +	55900	1210	23.2	3.40	1870	136	2190	218	0.843	48.5	1.04	48.8	104
533 x 312 x 272 +	199000	20600	23.9	7.69	6890	1290	7870	1990	0.891	15.9	15.0	1290	348
533 x 312 x 219 +	151000	15600	23.3	7.48	5400	982	6120	1510	0.884	19.8	11.0	642	279
533 x 312 x 182 +	123000	12700	23.1	7.40	4480	806	5040	1240	0.886	23.4	8.77	373	231
533 x 312 x 150 +	101000	10300	22.9	7.32	3710	659	4150	1010	0.885	27.8	7.01	216	192

Table 2.1.1.2. Advance® UKB. Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

Table 2.1.1.3

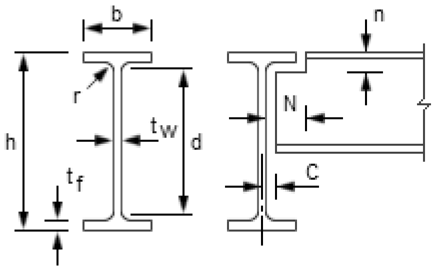
SECTION PROPERTIES

UNIVERSAL BEAMS

Advance® UKB

DIMENSIONS

B-4



Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		h	b	t_w	t_f	r	d	c_f / t_f	c_w / t_w	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
533 x 210 x 138 +	138.3	549.1	213.9	14.7	23.6	12.7	476.5	3.68	32.4	9	110	38	1.90	13.7
533 x 210 x 122	122.0	544.5	211.9	12.7	21.3	12.7	476.5	4.08	37.5	8	110	34	1.89	15.5
533 x 210 x 109	109.0	539.5	210.8	11.6	18.8	12.7	476.5	4.62	41.1	8	110	32	1.88	17.2
533 x 210 x 101	101.0	536.7	210.0	10.8	17.4	12.7	476.5	4.99	44.1	7	110	32	1.87	18.5
533 x 210 x 92	92.1	533.1	209.3	10.1	15.6	12.7	476.5	5.57	47.2	7	110	30	1.86	20.2
533 x 210 x 82	82.2	528.3	208.8	9.6	13.2	12.7	476.5	6.58	49.6	7	110	26	1.85	22.5
533 x 165 x 85 +	84.8	534.9	166.5	10.3	16.5	12.7	476.5	3.96	46.3	7	90	30	1.69	19.9
533 x 165 x 74 +	74.7	529.1	165.9	9.7	13.6	12.7	476.5	4.81	49.1	7	90	28	1.68	22.5
533 x 165 x 66 +	65.7	524.7	165.1	8.9	11.4	12.7	476.5	5.74	53.5	6	90	26	1.67	25.4
457 x 191 x 161 +	161.4	492.0	199.4	18.0	32.0	10.2	407.6	2.52	22.6	11	102	44	1.73	10.7
457 x 191 x 133 +	133.3	480.6	196.7	15.3	26.3	10.2	407.6	3.06	26.6	10	102	38	1.70	12.8
457 x 191 x 106 +	105.8	469.2	194.0	12.6	20.6	10.2	407.6	3.91	32.3	8	102	32	1.67	15.8
457 x 191 x 98	98.3	467.2	192.8	11.4	19.6	10.2	407.6	4.11	35.8	8	102	30	1.67	17.0
457 x 191 x 89	89.3	463.4	191.9	10.5	17.7	10.2	407.6	4.55	38.8	7	102	28	1.66	18.6
457 x 191 x 82	82.0	460.0	191.3	9.9	16.0	10.2	407.6	5.03	41.2	7	102	28	1.65	20.1
457 x 191 x 74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	5.55	45.3	7	102	26	1.64	22.1
457 x 191 x 67	67.1	453.4	189.9	8.5	12.7	10.2	407.6	6.34	48.0	6	102	24	1.63	24.3
457 x 152 x 82	82.1	465.8	155.3	10.5	18.9	10.2	407.6	3.29	38.8	7	84	30	1.51	18.4
457 x 152 x 74	74.2	462.0	154.4	9.6	17.0	10.2	407.6	3.66	42.5	7	84	28	1.50	20.2
457 x 152 x 67	67.2	458.0	153.8	9.0	15.0	10.2	407.6	4.15	45.3	7	84	26	1.50	22.3
457 x 152 x 60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	4.68	50.3	6	84	24	1.49	24.9
457 x 152 x 52	52.3	449.8	152.4	7.6	10.9	10.2	407.6	5.71	53.6	6	84	22	1.48	28.3
406 x 178 x 85 +	85.3	417.2	181.9	10.9	18.2	10.2	360.4	4.14	33.1	7	96	30	1.52	17.8
406 x 178 x 74	74.2	412.8	179.5	9.5	16.0	10.2	360.4	4.68	37.9	7	96	28	1.51	20.4
406 x 178 x 67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	5.23	41.0	6	96	26	1.50	22.3
406 x 178 x 60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	5.84	45.6	6	96	24	1.49	24.8
406 x 178 x 54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	6.86	46.8	6	96	22	1.48	27.3
406 x 140 x 53 +	53.3	406.6	143.3	7.9	12.9	10.2	360.4	4.46	45.6	6	78	24	1.35	25.3
406 x 140 x 46	46.0	403.2	142.2	6.8	11.2	10.2	360.4	5.13	53.0	5	78	22	1.34	29.1
406 x 140 x 39	39.0	398.0	141.8	6.4	8.6	10.2	360.4	6.69	56.3	5	78	20	1.33	34.1
356 x 171 x 67	67.1	363.4	173.2	9.1	15.7	10.2	311.6	4.58	34.2	7	94	26	1.38	20.6
356 x 171 x 57	57.0	358.0	172.2	8.1	13.0	10.2	311.6	5.53	38.5	6	94	24	1.37	24.1
356 x 171 x 51	51.0	355.0	171.5	7.4	11.5	10.2	311.6	6.25	42.1	6	94	22	1.36	26.7
356 x 171 x 45	45.0	351.4	171.1	7.0	9.7	10.2	311.6	7.41	44.5	6	94	20	1.36	30.2
356 x 127 x 39	39.1	353.4	126.0	6.6	10.7	10.2	311.6	4.63	47.2	5	70	22	1.18	30.2
356 x 127 x 33	33.1	349.0	125.4	6.0	8.5	10.2	311.6	5.82	51.9	5	70	20	1.17	35.4
305 x 165 x 54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	5.15	33.6	6	90	24	1.26	23.3
305 x 165 x 46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	5.98	39.6	5	90	22	1.25	27.1
305 x 165 x 40	40.3	303.4	165.0	6.0	10.2	8.9	265.2	6.92	44.2	5	90	20	1.24	30.8

Table 2.1.1.3. Advance® UKB. Dimensions

BS EN 1993-1-1: 2005
BS 4-1: 2005

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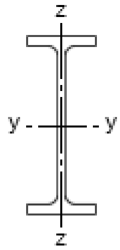
Table 2.1.1.4

SECTION PROPERTIES

UNIVERSAL BEAMS

Advance® UKB

PROPERTIES



Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	U	X	I_w	I_T	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
533 x 210 x 138 +	86100	3860	22.1	4.68	3140	361	3610	568	0.874	24.9	2.67	250	176
533 x 210 x 122	76000	3390	22.1	4.67	2790	320	3200	500	0.878	27.6	2.32	178	155
533 x 210 x 109	66800	2940	21.9	4.60	2480	279	2830	436	0.875	30.9	1.99	126	139
533 x 210 x 101	61500	2690	21.9	4.57	2290	256	2610	399	0.874	33.1	1.81	101	129
533 x 210 x 92	55200	2390	21.7	4.51	2070	228	2360	355	0.873	36.4	1.60	75.7	117
533 x 210 x 82	47500	2010	21.3	4.38	1800	192	2060	300	0.863	41.6	1.33	51.5	105
533 x 165 x 85 +	48500	1270	21.2	3.44	1820	153	2100	243	0.861	35.5	0.857	73.8	108
533 x 165 x 74 +	41100	1040	20.8	3.30	1550	125	1810	200	0.853	41.1	0.691	47.9	95.2
533 x 165 x 66 +	35000	859	20.5	3.20	1340	104	1560	166	0.847	47.0	0.566	32.0	83.7
457 x 191 x 161 +	79800	4250	19.7	4.55	3240	426	3780	672	0.881	16.5	2.25	515	206
457 x 191 x 133 +	63800	3350	19.4	4.44	2660	341	3070	535	0.879	19.6	1.73	292	170
457 x 191 x 106 +	48900	2510	19.0	4.32	2080	259	2390	405	0.876	24.4	1.27	146	135
457 x 191 x 98	45700	2350	19.1	4.33	1960	243	2230	379	0.881	25.8	1.18	121	125
457 x 191 x 89	41000	2090	19.0	4.29	1770	218	2010	338	0.878	28.3	1.04	90.7	114
457 x 191 x 82	37100	1870	18.8	4.23	1610	196	1830	304	0.879	30.8	0.922	69.2	104
457 x 191 x 74	33300	1670	18.8	4.20	1460	176	1650	272	0.877	33.8	0.818	51.8	94.6
457 x 191 x 67	29400	1450	18.5	4.12	1300	153	1470	237	0.873	37.8	0.705	37.1	85.5
457 x 152 x 82	36600	1180	18.7	3.37	1570	153	1810	240	0.872	27.4	0.591	89.2	105
457 x 152 x 74	32700	1050	18.6	3.33	1410	136	1630	213	0.872	30.1	0.518	65.9	94.5
457 x 152 x 67	28900	913	18.4	3.27	1260	119	1450	187	0.868	33.6	0.448	47.7	85.6
457 x 152 x 60	25500	795	18.3	3.23	1120	104	1290	163	0.868	37.5	0.387	33.8	76.2
457 x 152 x 52	21400	645	17.9	3.11	950	84.6	1100	133	0.859	43.8	0.311	21.4	66.6
406 x 178 x 85 +	31700	1830	17.1	4.11	1520	201	1730	313	0.880	24.4	0.728	93.0	109
406 x 178 x 74	27300	1550	17.0	4.04	1320	172	1500	267	0.882	27.5	0.608	62.8	94.5
406 x 178 x 67	24300	1360	16.9	3.99	1190	153	1350	237	0.880	30.4	0.533	46.1	85.5
406 x 178 x 60	21600	1200	16.8	3.97	1060	135	1200	209	0.880	33.7	0.466	33.3	76.5
406 x 178 x 54	18700	1020	16.5	3.85	930	115	1050	178	0.871	38.3	0.392	23.1	69.0
406 x 140 x 53 +	18300	635	16.4	3.06	899	88.6	1030	139	0.870	34.1	0.246	29.0	67.9
406 x 140 x 46	15700	538	16.4	3.03	778	75.7	888	118	0.871	39.0	0.207	19.0	58.6
406 x 140 x 39	12500	410	15.9	2.87	629	57.8	724	90.8	0.858	47.4	0.155	10.7	49.7
356 x 171 x 67	19500	1360	15.1	3.99	1070	157	1210	243	0.886	24.4	0.412	55.7	85.5
356 x 171 x 57	16000	1110	14.9	3.91	896	129	1010	199	0.882	28.8	0.330	33.4	72.6
356 x 171 x 51	14100	968	14.8	3.86	796	113	896	174	0.881	32.1	0.286	23.8	64.9
356 x 171 x 45	12100	811	14.5	3.76	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356 x 127 x 39	10200	358	14.3	2.68	576	56.8	659	89.0	0.871	35.2	0.105	15.1	49.8
356 x 127 x 33	8250	280	14.0	2.58	473	44.7	543	70.2	0.863	42.1	0.081	8.79	42.1
305 x 165 x 54	11700	1060	13.0	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305 x 165 x 46	9900	896	13.0	3.90	646	108	720	166	0.890	27.1	0.195	22.2	58.7
305 x 165 x 40	8500	764	12.9	3.86	560	92.6	623	142	0.889	31.0	0.164	14.7	51.3

Table 2.1.1.4. Advance® UKB. Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

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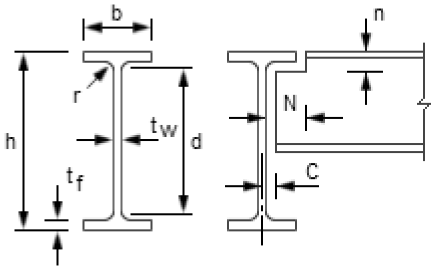
Table 2.1.1.5

SECTION PROPERTIES

UNIVERSAL BEAMS

Advance® UKB

DIMENSIONS



Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		h	b	t_w	t_f	r	d	c_f / t_f	c_w / t_w	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
305 x 127 x 48	48.1	311.0	125.3	9.0	14.0	8.9	265.2	3.52	29.5	7	70	24	1.09	22.7
305 x 127 x 42	41.9	307.2	124.3	8.0	12.1	8.9	265.2	4.07	33.2	6	70	22	1.08	25.8
305 x 127 x 37	37.0	304.4	123.4	7.1	10.7	8.9	265.2	4.60	37.4	6	70	20	1.07	28.9
305 x 102 x 33	32.8	312.7	102.4	6.6	10.8	7.6	275.9	3.73	41.8	5	58	20	1.01	30.8
305 x 102 x 28	28.2	308.7	101.8	6.0	8.8	7.6	275.9	4.58	46.0	5	58	18	1.00	35.5
305 x 102 x 25	24.8	305.1	101.6	5.8	7.0	7.6	275.9	5.76	47.6	5	58	16	0.992	40.0
254 x 146 x 43	43.0	259.6	147.3	7.2	12.7	7.6	219.0	4.92	30.4	6	82	22	1.08	25.1
254 x 146 x 37	37.0	256.0	146.4	6.3	10.9	7.6	219.0	5.73	34.8	5	82	20	1.07	28.9
254 x 146 x 31	31.1	251.4	146.1	6.0	8.6	7.6	219.0	7.26	36.5	5	82	18	1.06	34.0
254 x 102 x 28	28.3	260.4	102.2	6.3	10.0	7.6	225.2	4.04	35.7	5	58	18	0.904	31.9
254 x 102 x 25	25.2	257.2	101.9	6.0	8.4	7.6	225.2	4.80	37.5	5	58	16	0.897	35.7
254 x 102 x 22	22.0	254.0	101.6	5.7	6.8	7.6	225.2	5.93	39.5	5	58	16	0.890	40.5
203 x 133 x 30	30.0	206.8	133.9	6.4	9.6	7.6	172.4	5.85	26.9	5	74	18	0.923	30.8
203 x 133 x 25	25.1	203.2	133.2	5.7	7.8	7.6	172.4	7.20	30.2	5	74	16	0.915	36.5
203 x 102 x 23	23.1	203.2	101.8	5.4	9.3	7.6	169.4	4.37	31.4	5	60	18	0.790	34.2
178 x 102 x 19	19.0	177.8	101.2	4.8	7.9	7.6	146.8	5.14	30.6	4	60	16	0.738	38.7
152 x 89 x 16	16.0	152.4	88.7	4.5	7.7	7.6	121.8	4.48	27.1	4	54	16	0.638	40.0
127 x 76 x 13	13.0	127.0	76.0	4.0	7.6	7.6	96.6	3.74	24.2	4	46	16	0.537	41.4

Table 2.1.1.5. Advance® UKB. Dimensions

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK
EUROCODES

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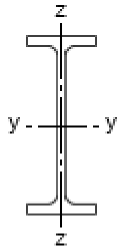
Table 2.1.1.6

SECTION PROPERTIES

UNIVERSAL BEAMS

Advance® UKB

PROPERTIES



Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	U	X	I_w	I_T	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
305 x 127 x 48	9570	461	12.5	2.74	616	73.6	711	116	0.873	23.3	0.102	31.8	61.2
305 x 127 x 42	8200	389	12.4	2.70	534	62.6	614	98.4	0.872	26.5	0.0846	21.1	53.4
305 x 127 x 37	7170	336	12.3	2.67	471	54.5	539	85.4	0.872	29.7	0.0725	14.8	47.2
305 x 102 x 33	6500	194	12.5	2.15	416	37.9	481	60.0	0.867	31.6	0.0442	12.2	41.8
305 x 102 x 28	5370	155	12.2	2.08	348	30.5	403	48.4	0.859	37.3	0.0349	7.40	35.9
305 x 102 x 25	4460	123	11.9	1.97	292	24.2	342	38.8	0.846	43.4	0.027	4.77	31.6
254 x 146 x 43	6540	677	10.9	3.52	504	92.0	566	141	0.891	21.1	0.103	23.9	54.8
254 x 146 x 37	5540	571	10.8	3.48	433	78.0	483	119	0.890	24.3	0.0857	15.3	47.2
254 x 146 x 31	4410	448	10.5	3.36	351	61.3	393	94.1	0.879	29.6	0.0660	8.55	39.7
254 x 102 x 28	4000	179	10.5	2.22	308	34.9	353	54.8	0.873	27.5	0.0280	9.57	36.1
254 x 102 x 25	3410	149	10.3	2.15	266	29.2	306	46.0	0.866	31.4	0.0230	6.42	32.0
254 x 102 x 22	2840	119	10.1	2.06	224	23.5	259	37.3	0.856	36.3	0.0182	4.15	28.0
203 x 133 x 30	2900	385	8.71	3.17	280	57.5	314	88.2	0.882	21.5	0.0374	10.3	38.2
203 x 133 x 25	2340	308	8.56	3.10	230	46.2	258	70.9	0.876	25.6	0.0294	5.96	32.0
203 x 102 x 23	2100	164	8.46	2.36	207	32.2	234	49.7	0.888	22.4	0.0154	7.02	29.4
178 x 102 x 19	1360	137	7.48	2.37	153	27.0	171	41.6	0.886	22.6	0.0099	4.41	24.3
152 x 89 x 16	834	89.8	6.41	2.10	109	20.2	123	31.2	0.890	19.5	0.00470	3.56	20.3
127 x 76 x 13	473	55.7	5.35	1.84	74.6	14.7	84.2	22.6	0.894	16.3	0.00200	2.85	16.5

Table 2.1.1.6. Advance® UKB. Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

B-8

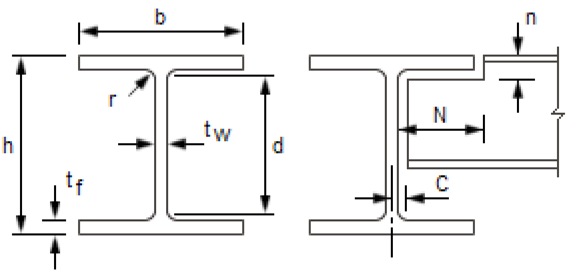
Table 2.1.2.1

SECTION PROPERTIES

UNIVERSAL COLUMNS

Advance® UKC

DIMENSIONS



Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		h	b	t_w	t_f	r	d	c_f / t_f	c_w / t_w	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
356 x 406 x 634	633.9	474.6	424.0	47.6	77.0	15.2	290.2	2.25	6.10	26	200	94	2.52	3.98
356 x 406 x 551	551.0	455.6	418.5	42.1	67.5	15.2	290.2	2.56	6.89	23	200	84	2.47	4.48
356 x 406 x 467	467.0	436.6	412.2	35.8	58.0	15.2	290.2	2.98	8.11	20	200	74	2.42	5.18
356 x 406 x 393	393.0	419.0	407.0	30.6	49.2	15.2	290.2	3.52	9.48	17	200	66	2.38	6.06
356 x 406 x 340	339.9	406.4	403.0	26.6	42.9	15.2	290.2	4.03	10.9	15	200	60	2.35	6.91
356 x 406 x 287	287.1	393.6	399.0	22.6	36.5	15.2	290.2	4.74	12.8	13	200	52	2.31	8.05
356 x 406 x 235	235.1	381.0	394.8	18.4	30.2	15.2	290.2	5.73	15.8	11	200	46	2.28	9.70
356 x 368 x 202	201.9	374.6	374.7	16.5	27.0	15.2	290.2	6.07	17.6	10	190	44	2.19	10.8
356 x 368 x 177	177.0	368.2	372.6	14.4	23.8	15.2	290.2	6.89	20.2	9	190	40	2.17	12.3
356 x 368 x 153	152.9	362.0	370.5	12.3	20.7	15.2	290.2	7.92	23.6	8	190	36	2.16	14.1
356 x 368 x 129	129.0	355.6	368.6	10.4	17.5	15.2	290.2	9.4	27.9	7	190	34	2.14	16.6
305 x 305 x 283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.00	9.21	15	158	60	1.94	6.86
305 x 305 x 240	240.0	352.5	318.4	23.0	37.7	15.2	246.7	3.51	10.7	14	158	54	1.91	7.96
305 x 305 x 198	198.1	339.9	314.5	19.1	31.4	15.2	246.7	4.22	12.9	12	158	48	1.87	9.44
305 x 305 x 158	158.1	327.1	311.2	15.8	25.0	15.2	246.7	5.30	15.6	10	158	42	1.84	11.6
305 x 305 x 137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	6.11	17.90	9	158	38	1.82	13.3
305 x 305 x 118	117.9	314.5	307.4	12.0	18.7	15.2	246.7	7.09	20.6	8	158	34	1.81	15.4
305 x 305 x 97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	8.60	24.9	7	158	32	1.79	18.5
254 x 254 x 167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	3.48	10.4	12	134	46	1.58	9.46
254 x 254 x 132	132.0	276.3	261.3	15.3	25.3	12.7	200.3	4.36	13.1	10	134	38	1.55	11.7
254 x 254 x 107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	5.38	15.6	8	134	34	1.52	14.2
254 x 254 x 89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	6.38	19.4	7	134	30	1.50	16.9
254 x 254 x 73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	7.77	23.3	6	134	28	1.49	20.4
203 x 203 x 127 +	127.5	241.4	213.9	18.1	30.1	10.2	160.8	2.91	8.88	11	108	42	1.28	10.0
203 x 203 x 113 +	113.5	235.0	212.1	16.3	26.9	10.2	160.8	3.26	9.87	10	108	38	1.27	11.2
203 x 203 x 100 +	99.6	228.6	210.3	14.5	23.7	10.2	160.8	3.70	11.1	9	108	34	1.25	12.6
203 x 203 x 86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	4.29	12.7	8	110	32	1.24	14.4
203 x 203 x 71	71.0	215.8	206.4	10.0	17.3	10.2	160.8	5.09	16.1	7	110	28	1.22	17.2
203 x 203 x 60	60.0	209.6	205.8	9.4	14.2	10.2	160.8	6.20	17.1	7	110	26	1.21	20.2
203 x 203 x 52	52.0	206.2	204.3	7.9	12.5	10.2	160.8	7.04	20.4	6	110	24	1.20	23.1
203 x 203 x 46	46.1	203.2	203.6	7.2	11.0	10.2	160.8	8.00	22.3	6	110	22	1.19	25.8
152 x 152 x 51 +	51.2	170.2	157.4	11.0	15.7	7.6	123.6	4.18	11.2	8	84	24	0.935	18.3
152 x 152 x 44 +	44.0	166.0	155.9	9.5	13.6	7.6	123.6	4.82	13.0	7	84	22	0.924	21.0
152 x 152 x 37	37.0	161.8	154.4	8.0	11.5	7.6	123.6	5.70	15.5	6	84	20	0.912	24.7
152 x 152 x 30	30.0	157.6	152.9	6.5	9.4	7.6	123.6	6.98	19.0	5	84	18	0.901	30.0
152 x 152 x 23	23.0	152.4	152.2	5.8	6.8	7.6	123.6	9.65	21.3	5	84	16	0.889	38.7

Table 2.1.2.1. Advance® UKC. Dimensions

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

B-9

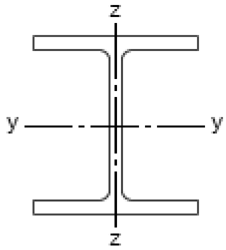
Table 2.1.2.2

SECTION PROPERTIES

UNIVERSAL COLUMNS

Advance® UKC

PROPERTIES



Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	U	X	I_w	I_T	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
356 x 406 x 634	275000	98100	18.4	11.0	11600	4630	14200	7110	0.843	5.46	38.8	13700	808
356 x 406 x 551	227000	82700	18.0	10.9	9960	3950	12100	6060	0.841	6.05	31.1	9240	702
356 x 406 x 467	183000	67800	17.5	10.7	8380	3290	10000	5030	0.839	6.85	24.3	5810	595
356 x 406 x 393	147000	55400	17.1	10.5	7000	2720	8220	4150	0.837	7.86	18.9	3550	501
356 x 406 x 340	123000	46900	16.8	10.4	6030	2330	7000	3540	0.836	8.84	15.5	2340	433
356 x 406 x 287	99900	38700	16.5	10.3	5070	1940	5810	2950	0.835	10.17	12.3	1440	366
356 x 406 x 235	79100	31000	16.3	10.2	4150	1570	4690	2380	0.834	12.04	9.54	812	299
356 x 368 x 202	66300	23700	16.1	9.60	3540	1260	3970	1920	0.844	13.35	7.16	558	257
356 x 368 x 177	57100	20500	15.9	9.54	3100	1100	3460	1670	0.844	15.00	6.09	381	226
356 x 368 x 153	48600	17600	15.8	9.49	2680	948	2960	1430	0.844	17.01	5.11	251	195
356 x 368 x 129	40200	14600	15.6	9.43	2260	793	2480	1200	0.844	19.81	4.18	153	164
305 x 305 x 283	78900	24600	14.8	8.27	4320	1530	5110	2340	0.855	7.64	6.35	2030	360
305 x 305 x 240	64200	20300	14.5	8.15	3640	1280	4250	1950	0.854	8.73	5.03	1270	306
305 x 305 x 198	50900	16300	14.2	8.04	3000	1040	3440	1580	0.854	10.23	3.88	734	252
305 x 305 x 158	38700	12600	13.9	7.90	2370	808	2680	1230	0.851	12.46	2.87	378	201
305 x 305 x 137	32800	10700	13.7	7.83	2050	692	2300	1050	0.851	14.13	2.39	249	174
305 x 305 x 118	27700	9060	13.6	7.77	1760	589	1960	895	0.850	16.14	1.98	161	150
305 x 305 x 97	22200	7310	13.4	7.69	1450	479	1590	726	0.850	19.19	1.56	91.2	123
254 x 254 x 167	30000	9870	11.9	6.81	2080	744	2420	1140	0.851	8.48	1.63	626	213
254 x 254 x 132	22500	7530	11.6	6.69	1630	576	1870	878	0.850	10.32	1.19	319	168
254 x 254 x 107	17500	5930	11.3	6.59	1310	458	1480	697	0.848	12.38	0.898	172	136
254 x 254 x 89	14300	4860	11.2	6.55	1100	379	1220	575	0.850	14.46	0.717	102	113
254 x 254 x 73	11400	3910	11.1	6.48	898	307	992	465	0.849	17.24	0.562	57.6	93.1
203 x 203 x 127 +	15400	4920	9.75	5.50	1280	460	1520	704	0.854	7.38	0.549	427	162
203 x 203 x 113 +	13300	4290	9.59	5.45	1130	404	1330	618	0.853	8.11	0.464	305	145
203 x 203 x 100 +	11300	3680	9.44	5.39	988	350	1150	534	0.852	9.02	0.386	210	127
203 x 203 x 86	9450	3130	9.28	5.34	850	299	977	456	0.850	10.20	0.318	137	110
203 x 203 x 71	7620	2540	9.18	5.30	706	246	799	374	0.853	11.90	0.250	80.2	90.4
203 x 203 x 60	6120	2060	8.96	5.20	584	201	656	305	0.846	14.10	0.197	47.2	76.4
203 x 203 x 52	5260	1780	8.91	5.18	510	174	567	264	0.848	15.80	0.167	31.8	66.3
203 x 203 x 46	4570	1550	8.82	5.13	450	152	497	231	0.847	17.70	0.143	22.2	58.7
152 x 152 x 51 +	3230	1020	7.04	3.96	379	130	438	199	0.848	10.10	0.061	48.8	65.2
152 x 152 x 44 +	2700	860	6.94	3.92	326	110	372	169	0.848	11.50	0.050	31.7	56.1
152 x 152 x 37	2210	706	6.85	3.87	273	91.5	309	140	0.848	13.30	0.040	19.2	47.1
152 x 152 x 30	1750	560	6.76	3.83	222	73.3	248	112	0.849	16.00	0.031	10.5	38.3
152 x 152 x 23	1250	400	6.54	3.70	164	52.6	182	80.1	0.840	20.70	0.021	4.63	29.2

Table 2.1.2.2. Advance® UKC. Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

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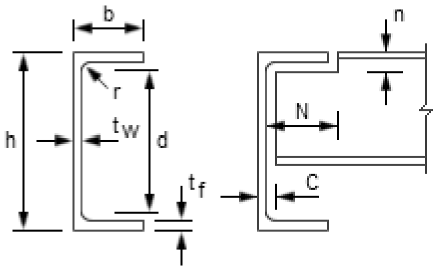
Table 2.1.4.1

SECTION PROPERTIES

PARALLEL FLANGE CHANNELS

Advance® UKPFC

DIMENSIONS



Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Distance	Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web		End Clearance	Notch		Per Metre	Per Tonne
		h	b	t_w	t_f	r	d	c_f / t_f	c_w / t_w	e_0	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			cm	mm	mm	mm	m^2	m^2
430 x 100 x 64	64.4	430	100	11.0	19.0	15	362	3.89	32.9	3.27	13	96	36	1.23	19.0
380 x 100 x 54	54.0	380	100	9.5	17.5	15	315	4.31	33.2	3.48	12	98	34	1.13	20.9
300 x 100 x 46	45.5	300	100	9.0	16.5	15	237	4.61	26.3	3.68	11	98	32	0.969	21.3
300 x 90 x 41	41.4	300	90	9.0	15.5	12	245	4.45	27.2	3.18	11	88	28	0.932	22.5
260 x 90 x 35	34.8	260	90	8.0	14.0	12	208	5.00	26.0	3.32	10	88	28	0.854	24.5
260 x 75 x 28	27.6	260	75	7.0	12.0	12	212	4.67	30.3	2.62	9	74	26	0.796	28.8
230 x 90 x 32	32.2	230	90	7.5	14.0	12	178	5.04	23.7	3.46	10	90	28	0.795	24.7
230 x 75 x 26	25.7	230	75	6.5	12.5	12	181	4.52	27.8	2.78	9	76	26	0.737	28.7
200 x 90 x 30	29.7	200	90	7.0	14.0	12	148	5.07	21.1	3.60	9	90	28	0.736	24.8
200 x 75 x 23	23.4	200	75	6.0	12.5	12	151	4.56	25.2	2.91	8	76	26	0.678	28.9
180 x 90 x 26	26.1	180	90	6.5	12.5	12	131	5.72	20.2	3.64	9	90	26	0.697	26.7
180 x 75 x 20	20.3	180	75	6.0	10.5	12	135	5.43	22.5	2.87	8	76	24	0.638	31.4
150 x 90 x 24	23.9	150	90	6.5	12.0	12	102	5.96	15.7	3.71	9	90	26	0.637	26.7
150 x 75 x 18	17.9	150	75	5.5	10.0	12	106	5.75	19.3	2.99	8	76	24	0.579	32.4
125 x 65 x 15	14.8	125	65	5.5	9.5	12	82.0	5.00	14.9	2.56	8	66	22	0.489	33.1
100 x 50 x 10	10.2	100	50	5.0	8.5	9	65.0	4.24	13.0	1.94	7	52	18	0.382	37.5

Table 2.1.4.1. Advance® UKPFC. Dimensions

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

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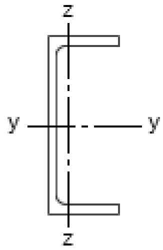
Table 2.1.4.2

SECTION PROPERTIES

PARALLEL FLANGE CHANNELS

Advance® UKPFC

PROPERTIES

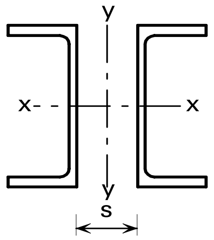


Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	U	X	I_w	I_T	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
430 x 100 x 64	21900	722	16.3	2.97	1020	97.9	1220	176	0.917	22.5	0.219	63.0	82.1
380 x 100 x 54	15000	643	14.8	3.06	791	89.2	933	161	0.933	21.2	0.150	45.7	68.7
300 x 100 x 46	8230	568	11.9	3.13	549	81.7	641	148	0.944	17.0	0.0813	36.8	58.0
300 x 90 x 41	7220	404	11.7	2.77	481	63.1	568	114	0.934	18.3	0.0581	28.8	52.7
260 x 90 x 35	4730	353	10.3	2.82	364	56.3	425	102	0.943	17.2	0.0379	20.6	44.4
260 x 75 x 28	3620	185	10.1	2.30	278	34.4	328	62.0	0.932	20.5	0.0203	11.7	35.1
230 x 90 x 32	3520	334	9.27	2.86	306	55.0	355	98.9	0.949	15.1	0.0279	19.3	41.0
230 x 75 x 26	2750	181	9.17	2.35	239	34.8	278	63.2	0.945	17.3	0.0153	11.8	32.7
200 x 90 x 30	2520	314	8.16	2.88	252	53.4	291	94.5	0.952	12.9	0.0197	18.3	37.9
200 x 75 x 23	1960	170	8.11	2.39	196	33.8	227	60.6	0.956	14.7	0.0107	11.1	29.9
180 x 90 x 26	1820	277	7.40	2.89	202	47.4	232	83.5	0.950	12.8	0.0141	13.3	33.2
180 x 75 x 20	1370	146	7.27	2.38	152	28.8	176	51.8	0.945	15.3	0.00754	7.34	25.9
150 x 90 x 24	1160	253	6.18	2.89	155	44.4	179	76.9	0.937	10.8	0.00890	11.8	30.4
150 x 75 x 18	861	131	6.15	2.40	115	26.6	132	47.2	0.945	13.1	0.00467	6.10	22.8
125 x 65 x 15	483	80.0	5.07	2.06	77.3	18.8	89.9	33.2	0.942	11.1	0.00194	4.72	18.8
100 x 50 x 10	208	32.3	4.00	1.58	41.5	9.89	48.9	17.5	0.942	10.0	0.000491	2.53	13.0

Table 2.1.4.2. Advance® UKPFC. Properties

TWO PARALLEL FLANGE CHANNELS LACED

TWO Advance UKPFC LACED



Dimensions and properties

Composed of Two Channels	Total Mass per Metre	Total Area	Space between Webs s	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus	
				Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y
	kg/m	cm^2	mm	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3
430x100x64	129	164	270	43900	44100	16.3	16.4	2040	1880	2440	2650
380x100x54	108	137	235	30100	30400	14.8	14.9	1580	1400	1870	2000
300x100x46	91.1	116	170	16500	16600	11.9	12.0	1100	898	1280	1340
300x90x41	82.8	105	175	14400	14400	11.7	11.7	962	811	1140	1200
260x90x35	69.7	88.8	145	9460	9560	10.3	10.4	727	588	849	886
260x75x28	55.2	70.3	155	7240	7190	10.1	10.1	557	472	656	692
230x90x32	64.3	81.9	120	7040	7190	9.27	9.37	612	479	709	731
230x75x26	51.3	65.4	135	5500	5720	9.17	9.35	478	401	557	592
200x90x30	59.4	75.7	90.0	5050	5030	8.16	8.15	505	372	583	577
200x75x23	46.9	59.7	105	3930	3910	8.11	8.09	393	306	454	462
180x90x26	52.1	66.4	75.0	3640	3730	7.40	7.49	404	292	464	459
180x75x20	40.7	51.8	90.0	2740	2770	7.27	7.31	304	231	352	358
150x90x24	47.7	60.8	45.0	2320	2380	6.18	6.26	310	212	357	338
150x75x18	35.7	45.5	65.0	1720	1810	6.15	6.30	230	168	264	265
125x65x15	29.5	37.6	50.0	966	1010	5.07	5.18	155	112	180	178
100x50x10	20.4	26.0	40.0	415	427	4.00	4.05	83.1	61.0	97.7	97.1

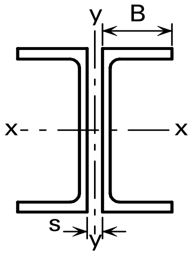
Advance and UKPFC are trademarks of Corus. A fuller description of the relationship between Parallel Flange Channels (PFC) and the Advance range of sections manufactured by Corus is given on page A - 42.

FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

BS 5950-1: 2000
BS 4-1: 2005

TWO PARALLEL FLANGE CHANNELS BACK TO BACK

TWO Advance UKPFC BACK TO BACK



Dimensions and properties

Composed of Two Channels	Total Mass per Metre	Total Area	Properties about Axis x-x				Radius of Gyration r_y about Axis y-y (cm)				
			I_x	r_x	Z_x	S_x	Space between webs, s (mm)				
	kg/m	cm^2	cm^4	cm	cm^3	cm^3	0	8	10	12	15
430x100x64	129	164	43900	16.3	2040	2440	3.96	4.23	4.31	4.38	4.49
380x100x54	108	137	30100	14.8	1580	1870	4.14	4.42	4.49	4.57	4.68
300x100x46	91.1	116	16500	11.9	1100	1280	4.37	4.66	4.73	4.81	4.92
300x90x41	82.8	105	14400	11.7	962	1140	3.80	4.08	4.16	4.23	4.35
260x90x35	69.7	88.8	9460	10.3	727	849	3.93	4.22	4.29	4.37	4.48
260x75x28	55.2	70.3	7240	10.1	557	656	3.11	3.40	3.47	3.55	3.66
230x90x32	64.3	81.9	7040	9.27	612	709	4.09	4.38	4.46	4.53	4.65
230x75x26	51.3	65.4	5500	9.17	478	557	3.29	3.58	3.66	3.73	3.85
200x90x30	59.4	75.7	5050	8.16	505	583	4.25	4.55	4.63	4.71	4.83
200x75x23	46.9	59.7	3930	8.11	393	454	3.44	3.74	3.82	3.89	4.01
180x90x26	52.1	66.4	3640	7.40	404	464	4.29	4.59	4.67	4.75	4.87
180x75x20	40.7	51.8	2740	7.27	304	352	3.39	3.68	3.76	3.84	3.95
150x90x24	47.7	60.8	2320	6.18	310	357	4.39	4.69	4.77	4.85	4.98
150x75x18	35.7	45.5	1720	6.15	230	264	3.52	3.82	3.90	3.98	4.10
125x65x15	29.5	37.6	966	5.07	155	180	3.05	3.36	3.44	3.52	3.64
100x50x10	20.4	26.0	415	4.00	83.1	97.7	2.34	2.65	2.73	2.82	2.94

Advance and UKPFC are trademarks of Corus. A fuller description of the relationship between Parallel Flange Channels (PFC) and the Advance range of sections manufactured by Corus is given on page A - 42.

Properties about y axis:

I_y = (Total Area).$(r_y)^2$

$Z_y = I_y/(B+0.5s)$

where s is the space between webs.

FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

BS EN 1993-1-1: 2005
BS EN 10056-1: 1999

UK EUROCODES

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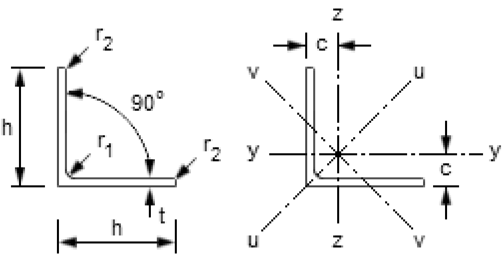
Table 2.1.5.1

SECTION PROPERTIES

EQUAL ANGLES

Advance® UKA - Equal

DIMENSIONS AND PROPERTIES



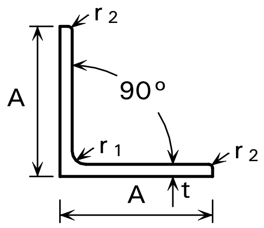
Section Designation		Mass per Metre	Radius		Area of Section	Distance to Centroid	Second Moment of Area			Radius of Gyration			Elastic Modulus	Torsional Constant	Equivalent Slenderness Coefficient
Size	Thickness		Root	Toe			Axis y-y, z-z	Axis u-u	Axis v-v	Axis y-y, z-z	Axis u-u	Axis v-v	Axis y-y, z-z		
h x h	t		r_1	r_2		c								I_T	φ_a
mm	mm	kg/m	mm	mm	cm^2	cm	cm^4	cm^4	cm^4	cm	cm	cm	cm^3	cm^4	
200 x 200	24	71.1	18.0	9.00	90.6	5.84	3330	5280	1380	6.06	7.64	3.90	235	182	2.50
	20	59.9	18.0	9.00	76.3	5.68	2850	4530	1170	6.11	7.70	3.92	199	107	3.05
	18	54.3	18.0	9.00	69.1	5.60	2600	4150	1050	6.13	7.75	3.90	181	78.9	3.43
	16	48.5	18.0	9.00	61.8	5.52	2340	3720	960	6.16	7.76	3.94	162	56.1	3.85
150 x 150	18 +	40.1	16.0	8.00	51.2	4.38	1060	1680	440	4.55	5.73	2.93	99.8	58.6	2.48
	15	33.8	16.0	8.00	43.0	4.25	898	1430	370	4.57	5.76	2.93	83.5	34.6	3.01
	12	27.3	16.0	8.00	34.8	4.12	737	1170	303	4.60	5.80	2.95	67.7	18.2	3.77
	10	23.0	16.0	8.00	29.3	4.03	624	990	258	4.62	5.82	2.97	56.9	10.8	4.51
120 x 120	15 +	26.6	13.0	6.50	34.0	3.52	448	710	186	3.63	4.57	2.34	52.8	27.0	2.37
	12	21.6	13.0	6.50	27.5	3.40	368	584	152	3.65	4.60	2.35	42.7	14.2	2.99
	10	18.2	13.0	6.50	23.2	3.31	313	497	129	3.67	4.63	2.36	36.0	8.41	3.61
	8 +	14.7	13.0	6.50	18.8	3.24	259	411	107	3.71	4.67	2.38	29.5	4.44	4.56
100 x 100	15 +	21.9	12.0	6.00	28.0	3.02	250	395	105	2.99	3.76	1.94	35.8	22.3	1.92
	12	17.8	12.0	6.00	22.7	2.90	207	328	85.7	3.02	3.80	1.94	29.1	11.8	2.44
	10	15.0	12.0	6.00	19.2	2.82	177	280	73.0	3.04	3.83	1.95	24.6	6.97	2.94
	8	12.2	12.0	6.00	15.5	2.74	145	230	59.9	3.06	3.85	1.96	19.9	3.68	3.70
90 x 90	12 +	15.9	11.0	5.50	20.3	2.66	149	235	62.0	2.71	3.40	1.75	23.5	10.5	2.17
	10	13.4	11.0	5.50	17.1	2.58	127	201	52.6	2.72	3.42	1.75	19.8	6.20	2.64
	8	10.9	11.0	5.50	13.9	2.50	104	166	43.1	2.74	3.45	1.76	16.1	3.28	3.33
	7	9.61	11.0	5.50	12.2	2.45	92.6	147	38.3	2.75	3.46	1.77	14.1	2.24	3.80

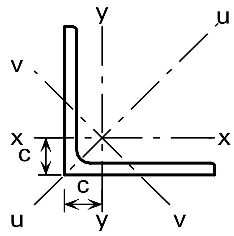
Table 2.1.5.1. Advance® UKA - Equal. Dimensions and Properties

BS 5950-1: 2000
BS EN 10056-1: 1999

EQUAL ANGLES

Advance UKA - Equal Angles





Dimensions and properties

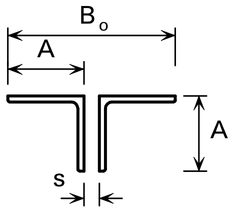
Section Designation Size	Section Designation Thickness	Mass per Metre	Radius Root	Radius Toe	Area of Section	Dimension	Second Moment of Area Axis x-x, y-y	Second Moment of Area Axis u-u	Second Moment of Area Axis v-v	Radius of Gyration Axis x-x, y-y	Radius of Gyration Axis u-u	Radius of Gyration Axis v-v	Elastic Modulus Axis x-x, y-y	Torsional Constant	Equivalent Slenderness Coefficient
A x A	t		r_1	r_2		c								J	ϕ_a
mm	mm	kg/m	mm	mm	cm^2	cm	cm^4	cm^4	cm^4	cm	cm	cm	cm^3	cm^4	
200x200	24	71.1	18.0	9.00	90.6	5.84	3330	5280	1380	6.06	7.64	3.90	235	182	2.50
	20	59.9	18.0	9.00	76.3	5.68	2850	4530	1170	6.11	7.70	3.92	199	107	3.05
	18	54.3	18.0	9.00	69.1	5.60	2600	4150	1050	6.13	7.75	3.90	181	78.9	3.43
	16	48.5	18.0	9.00	61.8	5.52	2340	3720	960	6.16	7.76	3.94	162	56.1	3.85
150x150	18 +	40.1	16.0	8.00	51.2	4.38	1060	1680	440	4.55	5.73	2.93	99.8	58.6	2.48
	15	33.8	16.0	8.00	43.0	4.25	898	1430	370	4.57	5.76	2.93	83.5	34.6	3.01
	12	27.3	16.0	8.00	34.8	4.12	737	1170	303	4.60	5.80	2.95	67.7	18.2	3.77
	10	23.0	16.0	8.00	29.3	4.03	624	990	258	4.62	5.82	2.97	56.9	10.8	4.51
120x120	15 +	26.6	13.0	6.50	34.0	3.52	448	710	186	3.63	4.57	2.34	52.8	27.0	2.37
	12	21.6	13.0	6.50	27.5	3.40	368	584	152	3.65	4.60	2.35	42.7	14.2	2.99
	10	18.2	13.0	6.50	23.2	3.31	313	497	129	3.67	4.63	2.36	36.0	8.41	3.61
	8 +	14.7	13.0	6.50	18.8	3.24	259	411	107	3.71	4.67	2.38	29.5	4.44	4.56
100x100	15 +	21.9	12.0	6.00	28.0	3.02	250	395	105	2.99	3.76	1.94	35.8	22.3	1.92
	12	17.8	12.0	6.00	22.7	2.90	207	328	85.7	3.02	3.80	1.94	29.1	11.8	2.44
	10	15.0	12.0	6.00	19.2	2.82	177	280	73.0	3.04	3.83	1.95	24.6	6.97	2.94
	8	12.2	12.0	6.00	15.5	2.74	145	230	59.9	3.06	3.85	1.96	19.9	3.68	3.70
90x90	12 +	15.9	11.0	5.50	20.3	2.66	149	235	62.0	2.71	3.40	1.75	23.5	10.5	2.17
	10	13.4	11.0	5.50	17.1	2.58	127	201	52.6	2.72	3.42	1.75	19.8	6.20	2.64
	8	10.9	11.0	5.50	13.9	2.50	104	166	43.1	2.74	3.45	1.76	16.1	3.28	3.33
	7	9.61	11.0	5.50	12.2	2.45	92.6	147	38.3	2.75	3.46	1.77	14.1	2.24	3.80
80x80	10	11.9	10.0	5.00	15.1	2.34	87.5	139	36.4	2.41	3.03	1.55	15.4	5.45	2.33
	8	9.63	10.0	5.00	12.3	2.26	72.2	115	29.9	2.43	3.06	1.56	12.6	2.88	2.94
75x75	8	8.99	9.00	4.50	11.4	2.14	59.1	93.8	24.5	2.27	2.86	1.46	11.0	2.65	2.76
	6	6.85	9.00	4.50	8.73	2.05	45.8	72.7	18.9	2.29	2.89	1.47	8.41	1.17	3.70
70x70	7	7.38	9.00	4.50	9.40	1.97	42.3	67.1	17.5	2.12	2.67	1.36	8.41	1.69	2.92
	6	6.38	9.00	4.50	8.13	1.93	36.9	58.5	15.3	2.13	2.68	1.37	7.27	1.09	3.41
65x65	7	6.83	9.00	4.50	8.73	2.05	33.4	53.0	13.8	1.96	2.47	1.26	7.18	1.58	2.67
60x60	8	7.09	8.00	4.00	9.03	1.77	29.2	46.1	12.2	1.80	2.26	1.16	6.89	2.09	2.14
	6	5.42	8.00	4.00	6.91	1.69	22.8	36.1	9.44	1.82	2.29	1.17	5.29	0.922	2.90
	5	4.57	8.00	4.00	5.82	1.64	19.4	30.7	8.03	1.82	2.30	1.17	4.45	0.550	3.48
50x50	6	4.47	7.00	3.50	5.69	1.45	12.8	20.3	5.34	1.50	1.89	0.968	3.61	0.755	2.38
	5	3.77	7.00	3.50	4.80	1.40	11.0	17.4	4.55	1.51	1.90	0.973	3.05	0.450	2.88
	4	3.06	7.00	3.50	3.89	1.36	8.97	14.2	3.73	1.52	1.91	0.979	2.46	0.240	3.57
45x45	5	3.06	7.00	3.50	3.90	1.25	7.14	11.4	2.94	1.35	1.71	0.870	2.20	0.304	2.84
40x40	5	2.97	6.00	3.00	3.79	1.16	5.43	8.60	2.26	1.20	1.51	0.773	1.91	0.352	2.26
	4	2.42	6.00	3.00	3.08	1.12	4.47	7.09	1.86	1.21	1.52	0.777	1.55	0.188	2.83
35x35	4	2.09	5.00	2.50	2.67	1.00	2.95	4.68	1.23	1.05	1.32	0.678	1.18	0.158	2.50
30x30	4	1.78	5.00	2.50	2.27	0.878	1.80	2.85	0.754	0.892	1.12	0.577	0.850	0.137	2.07
	3	1.36	5.00	2.50	1.74	0.835	1.40	2.22	0.585	0.899	1.13	0.581	0.649	0.0613	2.75
25x25	4	1.45	3.50	1.75	1.85	0.762	1.02	1.61	0.430	0.741	0.931	0.482	0.586	0.1070	1.75
	3	1.12	3.50	1.75	1.42	0.723	0.803	1.27	0.334	0.751	0.945	0.484	0.452	0.0472	2.38
20x20	3	0.882	3.50	1.75	1.12	0.598	0.392	0.618	0.165	0.590	0.742	0.383	0.279	0.0382	1.81

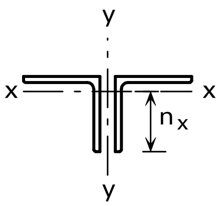
Advance and UKA are trademarks of Corus. A fuller description of the relationship between Angles and the Advance range of sections manufactured by Corus is given on page A - 42.
+ These sections are in addition to the range of BS EN 10056-1 sections.
c is the distance from the back of the leg to the centre of gravity.
FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

BS 5950-1: 2000
BS EN 10056-1: 1999

EQUAL ANGLES BACK TO BACK

Advance UKA - Equal Angles BACK TO BACK





Dimensions and properties

Composed of Two Angles		Total Mass per Metre	Distance	Total Area	Properties about Axis x-x			Radius of Gyration r_y about Axis y-y (cm)				
								Space between angles, s, (mm)				
A x A	t		n_x		I_x	r_x	Z_x					
mm	mm	kg/m	cm	cm^2	cm^4	cm	cm^3	0	8	10	12	15
200x200	24	142	14.2	181	6660	6.06	470	8.42	8.70	8.77	8.84	8.95
	20	120	14.3	153	5700	6.11	398	8.34	8.62	8.69	8.76	8.87
	18	109	14.4	138	5200	6.13	362	8.31	8.58	8.65	8.72	8.83
	16	97.0	14.5	124	4680	6.16	324	8.27	8.54	8.61	8.68	8.79
150x150	18 +	80.2	10.6	102	2120	4.55	200	6.32	6.60	6.67	6.75	6.86
	15	67.6	10.8	86.0	1800	4.57	167	6.24	6.52	6.59	6.66	6.77
	12	54.6	10.9	69.6	1470	4.60	135	6.18	6.45	6.52	6.59	6.70
	10	46.0	11.0	58.6	1250	4.62	114	6.13	6.40	6.47	6.54	6.64
120x120	15 +	53.2	8.48	68.0	896	3.63	106	5.06	5.34	5.42	5.49	5.60
	12	43.2	8.60	55.0	736	3.65	85.4	4.99	5.27	5.35	5.42	5.53
	10	36.4	8.69	46.4	626	3.67	72.0	4.94	5.22	5.29	5.36	5.47
	8 +	29.4	8.76	37.6	518	3.71	59.0	4.93	5.20	5.27	5.34	5.45
100x100	15 +	43.8	6.98	56.0	500	2.99	71.6	4.25	4.54	4.62	4.69	4.81
	12	35.6	7.10	45.4	414	3.02	58.2	4.19	4.47	4.55	4.62	4.74
	10	30.0	7.18	38.4	354	3.04	49.2	4.14	4.43	4.50	4.57	4.69
	8	24.4	7.26	31.0	290	3.06	39.8	4.11	4.38	4.46	4.53	4.64
90x90	12 +	31.8	6.34	40.6	298	2.71	47.0	3.80	4.09	4.16	4.24	4.36
	10	26.8	6.42	34.2	254	2.72	39.6	3.75	4.04	4.11	4.19	4.30
	8	21.8	6.50	27.8	208	2.74	32.2	3.71	3.99	4.06	4.13	4.25
	7	19.2	6.55	24.4	185	2.75	28.2	3.69	3.96	4.04	4.11	4.22
80x80	10	23.8	5.66	30.2	175	2.41	30.8	3.36	3.65	3.72	3.80	3.92
	8	19.3	5.74	24.6	144	2.43	25.2	3.31	3.60	3.67	3.75	3.86
75x75	8	18.0	5.36	22.8	118	2.27	22.0	3.12	3.41	3.49	3.56	3.68
	6	13.7	5.45	17.5	91.6	2.29	16.8	3.07	3.35	3.43	3.50	3.62
70x70	7	14.8	5.03	18.8	84.6	2.12	16.8	2.89	3.18	3.26	3.33	3.45
	6	12.8	5.07	16.3	73.8	2.13	14.5	2.87	3.16	3.23	3.31	3.42
65x65	7	13.7	4.45	17.5	66.8	1.96	14.4	2.83	3.14	3.21	3.29	3.42
60x60	8	14.2	4.23	18.1	58.4	1.80	13.8	2.52	2.82	2.90	2.97	3.10
	6	10.8	4.31	13.8	45.6	1.82	10.6	2.48	2.77	2.85	2.92	3.04
	5	9.14	4.36	11.6	38.8	1.82	8.90	2.45	2.74	2.81	2.89	3.01
50x50	6	8.94	3.55	11.4	25.6	1.50	7.22	2.09	2.38	2.46	2.54	2.66
	5	7.54	3.60	9.60	22.0	1.51	6.10	2.06	2.35	2.43	2.51	2.63
	4	6.12	3.64	7.78	17.9	1.52	4.92	2.04	2.32	2.40	2.48	2.60

Advance and UKA are trademarks of Corus. A fuller description of the relationship between Angles and the Advance range of sections manufactured by Corus is given on page A - 42.

+ These sections are in addition to the range of BS EN 10056-1 sections.

Properties about y-y axis:

I_y = (Total Area).$(r_y)^2$

$Z_y = I_y / (0.5B_o)$

FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

BS EN 1993-1-1: 2005
BS EN 10056-1: 1999

UK EUROCODES

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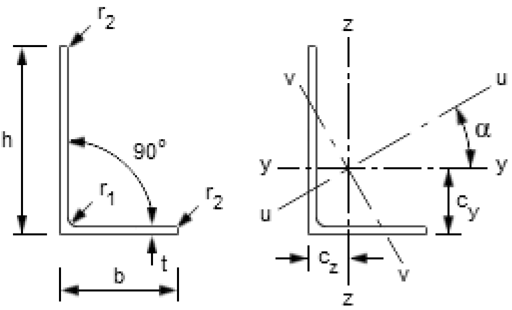
Table 2.1.6.1

SECTION PROPERTIES

UNEQUAL ANGLES

Advance® UKA - Unqual

DIMENSIONS AND PROPERTIES



Section Designation		Mass per Metre	Radius		Dimension		Second Moment of Area				Radius of Gyration			
Size h x b mm	Thickness t mm	kg/m	Root r_1 mm	Toe r_2 mm	c_y cm	c_z cm	Axis y-y cm^4	Axis z-z cm^4	Axis u-u cm^4	Axis v-v cm^4	Axis y-y cm	Axis z-z cm	Axis u-u cm	Axis v-v cm
200 x 150	18 +	47.1	15.0	7.50	6.33	3.85	2380	1150	2920	623	6.29	4.37	6.97	3.22
	15	39.6	15.0	7.50	6.21	3.73	2020	979	2480	526	6.33	4.40	7.00	3.23
	12	32.0	15.0	7.50	6.08	3.61	1650	803	2030	430	6.36	4.44	7.04	3.25
200 x 100	15	33.8	15.0	7.50	7.16	2.22	1760	299	1860	193	6.40	2.64	6.59	2.12
	12	27.3	15.0	7.50	7.03	2.10	1440	247	1530	159	6.43	2.67	6.63	2.14
	10	23.0	15.0	7.50	6.93	2.01	1220	210	1290	135	6.46	2.68	6.65	2.15
150 x 90	15	33.9	12.0	6.00	5.21	2.23	761	205	841	126	4.74	2.46	4.98	1.93
	12	21.6	12.0	6.00	5.08	2.12	627	171	694	104	4.77	2.49	5.02	1.94
	10	18.2	12.0	6.00	5.00	2.04	533	146	591	88.3	4.80	2.51	5.05	1.95
150 x 75	15	24.8	12.0	6.00	5.52	1.81	713	119	753	78.6	4.75	1.94	4.88	1.58
	12	20.2	12.0	6.00	5.40	1.69	588	99.6	623	64.7	4.78	1.97	4.92	1.59
	10	17.0	12.0	6.00	5.31	1.61	501	85.6	531	55.1	4.81	1.99	4.95	1.60
125 x 75	12	17.8	11.0	5.50	4.31	1.84	354	95.5	391	58.5	3.95	2.05	4.15	1.61
	10	15.0	11.0	5.50	4.23	1.76	302	82.1	334	49.9	3.97	2.07	4.18	1.61
	8	12.2	11.0	5.50	4.14	1.68	247	67.6	274	40.9	4.00	2.09	4.21	1.63
100 x 75	12	15.4	10.0	5.00	3.27	2.03	189	90.2	230	49.5	3.10	2.14	3.42	1.59
	10	13.0	10.0	5.00	3.19	1.95	162	77.6	197	42.2	3.12	2.16	3.45	1.59
	8	10.6	10.0	5.00	3.10	1.87	133	64.1	162	34.6	3.14	2.18	3.47	1.60
100 x 65	10 +	12.3	10.0	5.00	3.36	1.63	154	51.0	175	30.1	3.14	1.81	3.35	1.39
	8 +	9.94	10.0	5.00	3.27	1.55	127	42.2	144	24.8	3.16	1.83	3.37	1.40
	7 +	8.77	10.0	5.00	3.23	1.51	113	37.6	128	22.0	3.17	1.83	3.39	1.40

Table 2.1.6.1. Advance® UKA - Unequal. Dimensions and Properties

BS EN 1993-1-1: 2005
BS EN 10056-1: 1999

UK EUROCODES

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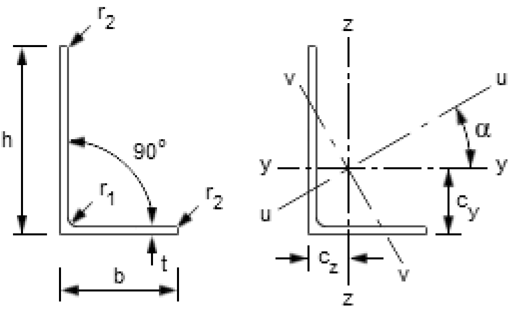
Table 2.1.6.2

SECTION PROPERTIES

UNEQUAL ANGLES

Advance® UKA - Unqual

DIMENSIONS AND PROPERTIES



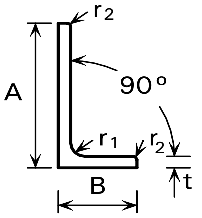
Section Designation		Elastic Modulus		Angle Axis y-y to Axis u-u Tan α	Torsional Constant	Equivalent Slenderness Coefficient		Mono-symmetry Index	Area of Section
Size h x b mm	Thickness t mm	Axis y-y cm^3	Axis z-z cm^3		I_T cm^4	Min φ_a	Max φ_a	ψ_a	cm^2
200 x 150	18 +	174	103	0.549	67.9	2.93	3.72	4.60	60.0
	15	147	86.9	0.551	39.9	3.53	4.50	5.55	50.5
	12	119	70.5	0.552	20.9	4.43	5.70	6.97	40.8
200 x 100	15	137	38.5	0.260	34.3	3.54	5.17	9.19	43.0
	12	111	31.3	0.262	18.0	4.42	6.57	11.5	34.8
	10	93.2	26.3	0.263	10.66	5.26	7.92	13.9	29.2
150 x 90	15	77.7	30.4	0.354	26.8	2.58	3.59	5.96	33.9
	12	63.3	24.8	0.358	14.1	3.24	4.58	7.50	27.5
	10	53.3	21.0	0.360	8.30	3.89	5.56	9.03	23.2
150 x 75	15	75.2	21.0	0.253	25.1	2.62	3.74	6.84	31.7
	12	61.3	17.1	0.258	13.2	3.30	4.79	8.60	25.7
	10	51.6	14.5	0.261	7.80	3.95	5.83	10.4	21.7
125 x 75	12	43.2	16.9	0.354	11.6	2.66	3.73	6.23	22.7
	10	36.5	14.3	0.357	6.87	3.21	4.55	7.50	19.1
	8	29.6	11.6	0.360	3.62	4.00	5.75	9.43	15.5
100 x 75	12	28.0	16.5	0.540	10.05	2.10	2.64	3.46	19.7
	10	23.8	14.0	0.544	5.95	2.54	3.22	4.17	16.6
	8	19.3	11.4	0.547	3.13	3.18	4.08	5.24	13.5
100 x 65	10 +	23.2	10.5	0.410	5.61	2.52	3.43	5.45	15.6
	8 +	18.9	8.54	0.413	2.96	3.14	4.35	6.86	12.7
	7 +	16.6	7.53	0.415	2.02	3.58	5.00	7.85	11.2

Table 2.1.6.2. Advance® UKA - Unequal. Dimensions and Properties

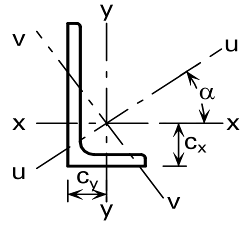
BS 5950-1: 2000
BS EN 10056-1: 1999

UNEQUAL ANGLES

Advance UKA - Unequal Angles



Dimensions and properties



Section Designation		Mass per	Radius		Dimension		Second Moment of Area				Radius of Gyration			
Size	Thickness	Metre	Root	Toe			Axis x-x	Axis y-y	Axis u-u	Axis v-v	Axis x-x	Axis y-y	Axis u-u	Axis v-v
A x B	t		r_1	r_2	c_x	c_y								
mm	mm	kg/m	mm	mm	cm	cm	cm^4	cm^4	cm^4	cm^4	cm	cm	cm	cm
200x150	18 +	47.1	15.0	7.50	6.33	3.85	2380	1150	2920	623	6.29	4.37	6.97	3.22
	15	39.6	15.0	7.50	6.21	3.73	2020	979	2480	526	6.33	4.40	7.00	3.23
	12	32.0	15.0	7.50	6.08	3.61	1650	803	2030	430	6.36	4.44	7.04	3.25
200x100	15	33.8	15.0	7.50	7.16	2.22	1760	299	1860	193	6.40	2.64	6.59	2.12
	12	27.3	15.0	7.50	7.03	2.10	1440	247	1530	159	6.43	2.67	6.63	2.14
	10	23.0	15.0	7.50	6.93	2.01	1220	210	1290	135	6.46	2.68	6.65	2.15
150x90	15	33.9	12.0	6.00	5.21	2.23	761	205	841	126	4.74	2.46	4.98	1.93
	12	21.6	12.0	6.00	5.08	2.12	627	171	694	104	4.77	2.49	5.02	1.94
	10	18.2	12.0	6.00	5.00	2.04	533	146	591	88.3	4.80	2.51	5.05	1.95
150x75	15	24.8	12.0	6.00	5.52	1.81	713	119	753	78.6	4.75	1.94	4.88	1.58
	12	20.2	12.0	6.00	5.40	1.69	588	99.6	623	64.7	4.78	1.97	4.92	1.59
	10	17.0	12.0	6.00	5.31	1.61	501	85.6	531	55.1	4.81	1.99	4.95	1.60
125x75	12	17.8	11.0	5.50	4.31	1.84	354	95.5	391	58.5	3.95	2.05	4.15	1.61
	10	15.0	11.0	5.50	4.23	1.76	302	82.1	334	49.9	3.97	2.07	4.18	1.61
	8	12.2	11.0	5.50	4.14	1.68	247	67.6	274	40.9	4.00	2.09	4.21	1.63
100x75	12	15.4	10.0	5.00	3.27	2.03	189	90.2	230	49.5	3.10	2.14	3.42	1.59
	10	13.0	10.0	5.00	3.19	1.95	162	77.6	197	42.2	3.12	2.16	3.45	1.59
	8	10.6	10.0	5.00	3.10	1.87	133	64.1	162	34.6	3.14	2.18	3.47	1.60
100x65	10 +	12.3	10.0	5.00	3.36	1.63	154	51.0	175	30.1	3.14	1.81	3.35	1.39
	8 +	9.94	10.0	5.00	3.27	1.55	127	42.2	144	24.8	3.16	1.83	3.37	1.40
	7 +	8.77	10.0	5.00	3.23	1.51	113	37.6	128	22.0	3.17	1.83	3.39	1.40
100x50	8	8.97	8.00	4.00	3.60	1.13	116	19.7	123	12.8	3.19	1.31	3.28	1.06
	6	6.84	8.00	4.00	3.51	1.05	89.9	15.4	95.4	9.92	3.21	1.33	3.31	1.07
80x60	7	7.36	8.00	4.00	2.51	1.52	59.0	28.4	72.0	15.4	2.51	1.74	2.77	1.28
80x40	8	7.07	7.00	3.50	2.94	0.963	57.6	9.61	60.9	6.34	2.53	1.03	2.60	0.838
	6	5.41	7.00	3.50	2.85	0.884	44.9	7.59	47.6	4.93	2.55	1.05	2.63	0.845
75x50	8	7.39	7.00	3.50	2.52	1.29	52.0	18.4	59.6	10.8	2.35	1.40	2.52	1.07
	6	5.65	7.00	3.50	2.44	1.21	40.5	14.4	46.6	8.36	2.37	1.42	2.55	1.08
70x50	6	5.41	7.00	3.50	2.23	1.25	33.4	14.2	39.7	7.92	2.20	1.43	2.40	1.07
65x50	5	4.35	6.00	3.00	1.99	1.25	23.2	11.9	28.8	6.32	2.05	1.47	2.28	1.07
60x40	6	4.46	6.00	3.00	2.00	1.01	20.1	7.12	23.1	4.16	1.88	1.12	2.02	0.855
	5	3.76	6.00	3.00	1.96	0.972	17.2	6.11	19.7	3.54	1.89	1.13	2.03	0.860
60x30	5	3.36	5.00	2.50	2.17	0.684	15.6	2.63	16.5	1.71	1.91	0.784	1.97	0.633
50x30	5	2.96	5.00	2.50	1.73	0.741	9.36	2.51	10.3	1.54	1.57	0.816	1.65	0.639
45x30	4	2.25	4.50	2.25	1.48	0.740	5.78	2.05	6.65	1.18	1.42	0.850	1.52	0.640
40x25	4	1.93	4.00	2.00	1.36	0.623	3.89	1.16	4.35	0.700	1.26	0.687	1.33	0.534
40x20	4	1.77	4.00	2.00	1.47	0.480	3.59	0.600	3.80	0.393	1.26	0.514	1.30	0.417
30x20	4	1.46	4.00	2.00	1.03	0.541	1.59	0.553	1.81	0.330	0.925	0.546	0.988	0.421
	3	1.12	4.00	2.00	0.990	0.502	1.25	0.437	1.43	0.256	0.935	0.553	1.00	0.424

Advance and UKA are trademarks of Corus. A fuller description of the relationship between Angles and the Advance range of sections manufactured by Corus is given on page A - 42.

+ These sections are in addition to the range of BS EN 10056-1 sections.

c_x is the distance from the back of the short leg to the centre of gravity.

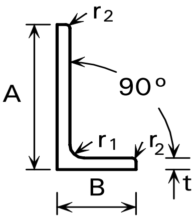
c_y is the distance from the back of the long leg to the centre of gravity.

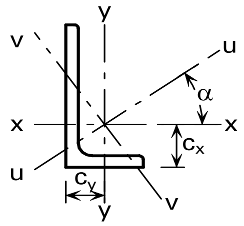
FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

BS 5950-1: 2000
BS EN 10056-1: 1999

UNEQUAL ANGLES

Advance UKA - Unequal Angles





Dimensions and properties (continued)

Section Designation		Elastic Modulus		Angle Axis x-x to Axis u-u	Torsional Constant	Equivalent Slenderness Coefficient		Mono-symmetry Index	Area of Section
Size A x B mm	Thickness t mm	Axis x-x cm^3	Axis y-y cm^3	Tan α	J cm^4	Min ϕ_a	Max ϕ_a	ψ_a	cm^2
200x150	18 +	174	103	0.549	67.9	2.93	3.72	4.60	60.0
	15	147	86.9	0.551	39.9	3.53	4.50	5.55	50.5
	12	119	70.5	0.552	20.9	4.43	5.70	6.97	40.8
200x100	15	137	38.5	0.260	34.3	3.54	5.17	9.19	43.0
	12	111	31.3	0.262	18.0	4.42	6.57	11.5	34.8
	10	93.2	26.3	0.263	10.66	5.26	7.92	13.9	29.2
150x90	15	77.7	30.4	0.354	26.8	2.58	3.59	5.96	33.9
	12	63.3	24.8	0.358	14.1	3.24	4.58	7.50	27.5
	10	53.3	21.0	0.360	8.30	3.89	5.56	9.03	23.2
150x75	15	75.2	21.0	0.253	25.1	2.62	3.74	6.84	31.7
	12	61.3	17.1	0.258	13.2	3.30	4.79	8.60	25.7
	10	51.6	14.5	0.261	7.80	3.95	5.83	10.4	21.7
125x75	12	43.2	16.9	0.354	11.6	2.66	3.73	6.23	22.7
	10	36.5	14.3	0.357	6.87	3.21	4.55	7.50	19.1
	8	29.6	11.6	0.360	3.62	4.00	5.75	9.43	15.5
100x75	12	28.0	16.5	0.540	10.05	2.10	2.64	3.46	19.7
	10	23.8	14.0	0.544	5.95	2.54	3.22	4.17	16.6
	8	19.3	11.4	0.547	3.13	3.18	4.08	5.24	13.5
100x65	10 +	23.2	10.5	0.410	5.61	2.52	3.43	5.45	15.6
	8 +	18.9	8.54	0.413	2.96	3.14	4.35	6.86	12.7
	7 +	16.6	7.53	0.415	2.02	3.58	5.00	7.85	11.2
100x50	8	18.2	5.08	0.258	2.61	3.30	4.80	8.61	11.4
	6	13.8	3.89	0.262	1.14	4.38	6.52	11.6	8.71
80x60	7	10.7	6.34	0.546	1.66	2.92	3.72	4.78	9.38
80x40	8	11.4	3.16	0.253	2.05	2.61	3.73	6.85	9.01
	6	8.73	2.44	0.258	0.899	3.48	5.12	9.22	6.89
75x50	8	10.4	4.95	0.430	2.14	2.36	3.18	4.92	9.41
	6	8.01	3.81	0.435	0.935	3.18	4.34	6.60	7.19
70x50	6	7.01	3.78	0.500	0.899	2.96	3.89	5.44	6.89
65x50	5	5.14	3.19	0.577	0.498	3.38	4.26	5.08	5.54
60x40	6	5.03	2.38	0.431	0.735	2.51	3.39	5.26	5.68
	5	4.25	2.02	0.434	0.435	3.02	4.11	6.34	4.79
60x30	5	4.07	1.14	0.257	0.382	3.15	4.56	8.26	4.28
50x30	5	2.86	1.11	0.352	0.340	2.51	3.52	5.99	3.78
45x30	4	1.91	0.910	0.436	0.166	2.85	3.87	5.92	2.87
40x25	4	1.47	0.619	0.380	0.142	2.51	3.48	5.75	2.46
40x20	4	1.42	0.393	0.252	0.131	2.57	3.68	6.86	2.26
30x20	4	0.807	0.379	0.421	0.1096	1.79	2.39	3.95	1.86
	3	0.621	0.292	0.427	0.0486	2.40	3.28	5.31	1.43

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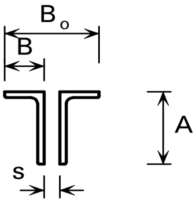
+ These sections are in addition to the range of BS EN 10056-1 sections.

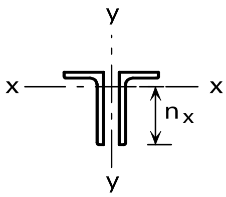
FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

BS 5950-1: 2000
BS EN 10056-1: 1999

UNEQUAL ANGLES BACK TO BACK

Advance UKA - Unequal Angles BACK TO BACK





Dimensions and properties

Composed of Two Angles		Total Mass per Metre	Distance	Total Area	Properties about Axis x-x			Radius of Gyration r_y about Axis y-y (cm)				
A x B	t		n_x		I_x	r_x	Z_x	Space between angles, s, (mm)				
mm	mm	kg/m	cm	cm^2	cm^4	cm	cm^3	0	8	10	12	15
200x150	18 +	94.2	13.7	120	4750	6.29	348	5.84	6.11	6.18	6.25	6.36
	15	79.2	13.8	101	4040	6.33	294	5.77	6.04	6.11	6.18	6.28
	12	64.0	13.9	81.6	3300	6.36	238	5.72	5.98	6.05	6.12	6.22
200x100	15	67.5	12.8	86.0	3520	6.40	274	3.45	3.72	3.79	3.86	3.97
	12	54.6	13.0	69.6	2880	6.43	222	3.39	3.65	3.72	3.79	3.90
	10	46.0	13.1	58.4	2440	6.46	186	3.35	3.61	3.67	3.74	3.85
150x90	15	53.2	9.79	67.8	1522	4.74	155	3.32	3.60	3.67	3.75	3.86
	12	43.2	9.92	55.0	1250	4.77	127	3.27	3.55	3.62	3.69	3.80
	10	36.4	10.0	46.4	1070	4.80	107	3.23	3.50	3.57	3.64	3.75
150x75	15	49.6	9.48	63.4	1430	4.75	150	2.65	2.94	3.01	3.09	3.21
	12	40.4	9.60	51.4	1180	4.78	123	2.59	2.87	2.94	3.02	3.14
	10	34.0	9.69	43.4	1000	4.81	103	2.56	2.83	2.90	2.97	3.08
125x75	12	35.6	8.19	45.4	708	3.95	86.4	2.76	3.04	3.11	3.19	3.30
	10	30.0	8.27	38.2	604	3.97	73.0	2.72	2.99	3.07	3.14	3.26
	8	24.4	8.36	31.0	494	4.00	59.2	2.68	2.95	3.02	3.09	3.20
100x75	12	30.8	6.73	39.4	378	3.10	56.0	2.95	3.24	3.31	3.39	3.51
	10	26.0	6.81	33.2	324	3.12	47.6	2.91	3.19	3.27	3.34	3.46
	8	21.2	6.90	27.0	266	3.14	38.6	2.87	3.15	3.22	3.29	3.41
100x65	10 +	24.6	6.64	31.2	308	3.14	46.4	2.43	2.72	2.79	2.87	2.99
	8 +	19.9	6.73	25.4	254	3.16	37.8	2.39	2.67	2.74	2.82	2.93
	7 +	17.5	6.77	22.4	226	3.17	33.2	2.37	2.65	2.72	2.79	2.91
100x50	8	17.9	6.40	22.8	232	3.19	36.4	1.73	2.02	2.09	2.17	2.29
	6	13.7	6.49	17.4	180	3.21	27.6	1.69	1.97	2.04	2.12	2.24
80x60	7	14.7	5.49	18.8	118	2.51	21.4	2.31	2.59	2.67	2.74	2.86
80x40	8	14.1	5.06	18.0	115	2.53	22.8	1.41	1.71	1.79	1.87	2.00
	6	10.8	5.15	13.8	89.8	2.55	17.5	1.37	1.66	1.74	1.82	1.94
75x50	8	14.8	4.98	18.8	104	2.35	20.8	1.90	2.19	2.27	2.35	2.47
	6	11.3	5.06	14.4	81.0	2.37	16.0	1.86	2.14	2.22	2.30	2.42
70x50	6	10.8	4.77	13.8	66.8	2.20	14.0	1.90	2.19	2.26	2.34	2.46
65x50	5	8.70	4.51	11.1	46.4	2.05	10.3	1.93	2.21	2.28	2.36	2.48
60x40	6	8.92	4.00	11.4	40.2	1.88	10.1	1.51	1.80	1.88	1.96	2.09
	5	7.52	4.04	9.58	34.4	1.89	8.50	1.49	1.78	1.86	1.94	2.06

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+ These sections are in addition to the range of BS EN 10056-1 sections.

Properties about y-y axis:

I_y = (Total Area).$(r_y)^2$

$Z_y = I_y / (0.5B_o)$

FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

BS EN 1993-1-1: 2005
BS 4-1: 2005

Table 2.1.7.1

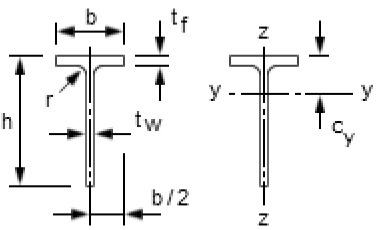
SECTION PROPERTIES

STRUCTURAL TEES CUT FROM UNIVERSAL BEAMS

UKT Split from Advance® UKB

DIMENSIONS AND PROPERTIES

B-44



Section Designation	Cut from Universal Beam Section Designation	Mass per Metre kg/m	Width of Section b mm	Depth of Section h mm	Thickness Web t_w mm	Thickness Flange t_f mm	Root Radius r mm	Ratios for Local Buckling Flange c_f / t_f	Ratios for Local Buckling Web c_w / t_w	Dimension c_y cm	Second Moment of Area Axis y-y cm^4	Second Moment of Area Axis z-z cm^4
254 x 343 x 63	686 x 254 x 125	62.6	253.0	338.9	11.7	16.2	15.2	6.51	29.0	8.85	8980	2190
305 x 305 x 119	610 x 305 x 238	119.0	311.4	317.9	18.4	31.4	16.5	4.14	17.3	7.11	12400	7920
305 x 305 x 90	610 x 305 x 179	89.5	307.1	310.0	14.1	23.6	16.5	5.51	22.0	6.69	9040	5700
305 x 305 x 75	610 x 305 x 149	74.6	304.8	306.1	11.8	19.7	16.5	6.60	25.9	6.45	7410	4650
229 x 305 x 70	610 x 229 x 140	69.9	230.2	308.5	13.1	22.1	12.7	4.34	23.5	7.61	7740	2250
229 x 305 x 63	610 x 229 x 125	62.5	229.0	306.0	11.9	19.6	12.7	4.89	25.7	7.54	6900	1970
229 x 305 x 57	610 x 229 x 113	56.5	228.2	303.7	11.1	17.3	12.7	5.54	27.4	7.58	6270	1720
229 x 305 x 51	610 x 229 x 101	50.6	227.6	301.2	10.5	14.8	12.7	6.48	28.7	7.78	5690	1460
178 x 305 x 50 +	610 x 178 x 100	50.1	179.2	303.7	11.3	17.2	12.7	4.14	26.9	8.57	5890	829
178 x 305 x 46 +	610 x 178 x 92	46.1	178.8	301.5	10.9	15.0	12.7	4.75	27.7	8.78	5450	718
178 x 305 x 41 +	610 x 178 x 82	40.9	177.9	299.3	10.0	12.8	12.7	5.57	29.9	8.88	4840	603
312 x 267 x 136 +	533 x 312 x 272	136.6	320.2	288.8	21.1	37.6	12.7	3.64	13.7	6.28	10600	10300
312 x 267 x 110 +	533 x 312 x 219	109.4	317.4	280.4	18.3	29.2	12.7	4.69	15.3	6.09	8530	7790
312 x 267 x 91 +	533 x 312 x 182	90.7	314.5	275.6	15.2	24.4	12.7	5.61	18.1	5.78	6890	6330
312 x 267 x 75 +	533 x 312 x 151	75.3	312.0	271.5	12.7	20.3	12.7	6.75	21.4	5.54	5620	5140
210 x 267 x 69 +	533 x 210 x 138	69.1	213.9	274.5	14.7	23.6	12.7	3.68	18.7	6.94	5990	1930
210 x 267 x 61	533 x 210 x 122	61.0	211.9	272.2	12.7	21.3	12.7	4.08	21.4	6.66	5160	1690
210 x 267 x 55	533 x 210 x 109	54.5	210.8	269.7	11.6	18.8	12.7	4.62	23.3	6.61	4600	1470
210 x 267 x 51	533 x 210 x 101	50.5	210.0	268.3	10.8	17.4	12.7	4.99	24.8	6.53	4250	1350
210 x 267 x 46	533 x 210 x 92	46.0	209.3	266.5	10.1	15.6	12.7	5.57	26.4	6.55	3880	1190
210 x 267 x 41	533 x 210 x 82	41.1	208.8	264.1	9.6	13.2	12.7	6.58	27.5	6.75	3530	1000
165 x 267 x 43 +	533 x 165 x 85	42.3	166.5	267.1	10.3	16.5	12.7	3.96	25.9	7.23	3750	637
165 x 267 x 37 +	533 x 165 x 75	37.3	165.9	264.5	9.7	13.6	12.7	4.81	27.3	7.46	3350	520
165 x 267 x 33 +	533 x 165 x 66	32.8	165.1	262.4	8.9	11.4	12.7	5.74	29.5	7.59	2960	429
191 x 229 x 81 +	457 x 191 x 161	80.7	199.4	246.0	18.0	32.0	10.2	2.52	13.7	6.22	5160	2130
191 x 229 x 67 +	457 x 191 x 133	66.6	196.7	240.3	15.3	26.3	10.2	3.06	15.7	5.96	4180	1670
191 x 229 x 53 +	457 x 191 x 106	52.9	194.0	234.6	12.6	20.6	10.2	3.91	18.6	5.73	3260	1260
191 x 229 x 49	457 x 191 x 98	49.1	192.8	233.5	11.4	19.6	10.2	4.11	20.5	5.53	2970	1170
191 x 229 x 45	457 x 191 x 89	44.6	191.9	231.6	10.5	17.7	10.2	4.55	22.1	5.47	2680	1040
191 x 229 x 41	457 x 191 x 82	41.0	191.3	229.9	9.9	16.0	10.2	5.03	23.2	5.47	2470	935
191 x 229 x 37	457 x 191 x 74	37.1	190.4	228.4	9.0	14.5	10.2	5.55	25.4	5.38	2220	836
191 x 229 x 34	457 x 191 x 67	33.5	189.9	226.6	8.5	12.7	10.2	6.34	26.7	5.46	2030	726
152 x 229 x 41	457 x 152 x 82	41.0	155.3	232.8	10.5	18.9	10.2	3.29	22.2	5.96	2600	592
152 x 229 x 37	457 x 152 x 74	37.1	154.4	230.9	9.6	17.0	10.2	3.66	24.1	5.88	2330	523
152 x 229 x 34	457 x 152 x 67	33.6	153.8	228.9	9.0	15.0	10.2	4.15	25.4	5.91	2120	456
152 x 229 x 30	457 x 152 x 60	29.9	152.9	227.2	8.1	13.3	10.2	4.68	28.0	5.84	1880	397
152 x 229 x 26	457 x 152 x 52	26.1	152.4	224.8	7.6	10.9	10.2	5.71	29.6	6.04	1670	322

Table 2.1.7.1. UKT Split from Advance® UKC. Dimensions and Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

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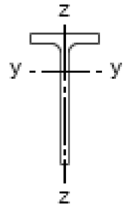
Table 2.1.7.2

SECTION PROPERTIES

STRUCTURAL TEES CUT FROM UNIVERSAL BEAMS

UKT Split from Advance® UKB

PROPERTIES



Section Designation	Radius of Gyration		Elastic Modulus			Plastic Modulus		Buckling Parameter	Torsional Index	Mono-symmetry Index	Warping Constant (*)	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y Flange	Axis y-y Toe	Axis z-z	Axis y-y	Axis z-z	U	X	Ψ	I_w	I_T	A
	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^3				cm^6	cm^4	cm^2
254 x 343 x 63	10.6	5.24	1010	358	173	643	271	0.651	21.9	0.740	2090	57.9	79.7
305 x 305 x 119	9.03	7.23	1740	501	509	894	787	0.483	10.6	0.662	11300	391	152
305 x 305 x 90	8.91	7.07	1350	372	371	656	572	0.484	13.8	0.664	4710	170	114
305 x 305 x 75	8.83	7.00	1150	307	305	538	469	0.483	16.4	0.666	2690	99.8	95.0
229 x 305 x 70	9.32	5.03	1020	333	196	592	306	0.613	15.3	0.727	2560	108	89.1
229 x 305 x 63	9.31	4.97	915	299	172	531	268	0.617	17.1	0.728	1840	76.9	79.7
229 x 305 x 57	9.33	4.88	826	275	150	489	235	0.626	19.0	0.731	1400	55.5	72.0
229 x 305 x 51	9.40	4.76	732	255	128	456	200	0.644	21.6	0.736	1080	38.3	64.4
178 x 305 x 50 +	9.60	3.60	688	270	92.5	490	148	0.694	19.4	0.768	1230	47.3	63.9
178 x 305 x 46 +	9.64	3.50	621	255	80.3	468	129	0.710	21.5	0.774	1050	35.3	58.7
178 x 305 x 41 +	9.64	3.40	545	230	67.8	425	109	0.722	24.3	0.778	780	24.3	52.1
312 x 267 x 136 +	7.81	7.69	1690	469	644	857	993	0.247	7.96	0.613	17300	642	174
312 x 267 x 110 +	7.82	7.48	1400	389	491	696	757	0.332	9.93	0.617	8730	320	139
312 x 267 x 91 +	7.72	7.40	1190	317	403	562	619	0.324	11.7	0.618	4920	186	116
312 x 267 x 75 +	7.65	7.32	1010	260	330	458	505	0.326	14.0	0.619	2780	108	95.9
210 x 267 x 69 +	8.24	4.68	862	292	181	520	284	0.609	12.5	0.719	2490	125	88.1
210 x 267 x 61	8.15	4.67	775	251	160	446	250	0.600	13.8	0.719	1660	88.9	77.7
210 x 267 x 55	8.14	4.60	697	226	140	401	218	0.605	15.5	0.721	1200	63.0	69.4
210 x 267 x 51	8.12	4.57	650	209	128	371	200	0.606	16.6	0.722	951	50.3	64.3
210 x 267 x 46	8.14	4.51	593	193	114	343	178	0.613	18.3	0.724	737	37.7	58.7
210 x 267 x 41	8.21	4.38	523	179	96.1	320	150	0.634	20.8	0.730	565	25.7	52.3
165 x 267 x 43 +	8.34	3.44	519	192	76.6	346	122	0.672	17.7	0.758	670	36.8	54.0
165 x 267 x 37 +	8.39	3.30	449	176	62.7	321	100	0.693	20.6	0.765	514	23.9	47.6
165 x 267 x 33 +	8.41	3.20	390	159	52.0	291	83.1	0.708	23.6	0.771	378	15.9	41.9
191 x 229 x 81 +	7.09	4.55	830	281	213	507	336	0.573	8.24	0.699	3780	256	103
191 x 229 x 67 +	7.01	4.44	702	231	170	414	267	0.576	9.82	0.702	2130	146	84.9
191 x 229 x 53 +	6.96	4.32	569	184	130	328	203	0.583	12.2	0.706	1070	72.6	67.4
191 x 229 x 49	6.88	4.33	536	167	122	296	189	0.573	12.9	0.705	835	60.5	62.6
191 x 229 x 45	6.87	4.29	491	152	109	269	169	0.576	14.1	0.706	628	45.2	56.9
191 x 229 x 41	6.88	4.23	452	141	97.8	250	152	0.583	15.5	0.709	494	34.5	52.2
191 x 229 x 37	6.86	4.20	413	127	87.8	225	136	0.583	16.9	0.709	365	25.8	47.3
191 x 229 x 34	6.90	4.12	372	118	76.5	209	119	0.597	18.9	0.713	280	18.5	42.7
152 x 229 x 41	7.05	3.37	436	150	76.3	267	120	0.634	13.7	0.740	534	44.5	52.3
152 x 229 x 37	7.03	3.33	397	135	67.8	242	107	0.636	15.1	0.742	396	32.9	47.2
152 x 229 x 34	7.04	3.27	359	125	59.3	223	93.3	0.646	16.8	0.745	305	23.8	42.8
152 x 229 x 30	7.02	3.23	322	111	52.0	199	81.5	0.648	18.8	0.746	217	16.9	38.1
152 x 229 x 26	7.08	3.11	276	102	42.3	183	66.6	0.671	22.0	0.753	161	10.7	33.3

Table 2.1.7.2. UKT Split from Advance® UKC. Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

Table 2.1.7.3

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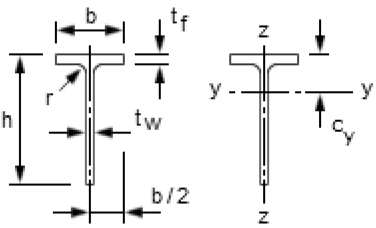
SECTION PROPERTIES

STRUCTURAL TEES CUT FROM UNIVERSAL BEAMS

UKT Split from Advance® UKB

DIMENSIONS AND PROPERTIES



Section Designation	Cut from Universal Beam Section Designation	Mass per Metre kg/m	Width of Section b mm	Depth of Section h mm	Thickness Web t_w mm	Thickness Flange t_f mm	Root Radius r mm	Ratios for Local Buckling Flange c_f / t_f	Ratios for Local Buckling Web c_w / t_w	Dimension c_y cm	Second Moment of Area Axis y-y cm^4	Second Moment of Area Axis z-z cm^4
178 x 203 x 43 +	406 x 178 x 85	42.6	181.9	208.6	10.9	18.2	10.2	4.14	19.1	4.91	2030	915
178 x 203 x 37	406 x 178 x 74	37.1	179.5	206.3	9.5	16.0	10.2	4.68	21.7	4.76	1740	773
178 x 203 x 34	406 x 178 x 67	33.5	178.8	204.6	8.8	14.3	10.2	5.23	23.3	4.73	1570	682
178 x 203 x 30	406 x 178 x 60	30.0	177.9	203.1	7.9	12.8	10.2	5.84	25.7	4.64	1400	602
178 x 203 x 27	406 x 178 x 54	27.0	177.7	201.2	7.7	10.9	10.2	6.86	26.1	4.83	1290	511
140 x 203 x 27 +	406 x 140 x 53	26.6	143.3	203.3	7.9	12.9	10.2	4.46	25.7	5.16	1320	317
140 x 203 x 23	406 x 140 x 46	23.0	142.2	201.5	6.8	11.2	10.2	5.13	29.6	5.02	1120	269
140 x 203 x 20	406 x 140 x 39	19.5	141.8	198.9	6.4	8.6	10.2	6.69	31.1	5.32	979	205
171 x 178 x 34	356 x 171 x 67	33.5	173.2	181.6	9.1	15.7	10.2	4.58	20.0	4.00	1150	681
171 x 178 x 29	356 x 171 x 57	28.5	172.2	178.9	8.1	13.0	10.2	5.53	22.1	3.97	986	554
171 x 178 x 26	356 x 171 x 51	25.5	171.5	177.4	7.4	11.5	10.2	6.25	24.0	3.94	882	484
171 x 178 x 23	356 x 171 x 45	22.5	171.1	175.6	7.0	9.7	10.2	7.41	25.1	4.05	798	406
127 x 178 x 20	356 x 127 x 39	19.5	126.0	176.6	6.6	10.7	10.2	4.63	26.8	4.43	728	179
127 x 178 x 17	356 x 127 x 33	16.5	125.4	174.4	6.0	8.5	10.2	5.82	29.1	4.56	626	140
165 x 152 x 27	305 x 165 x 54	27.0	166.9	155.1	7.9	13.7	8.9	5.15	19.6	3.21	642	531
165 x 152 x 23	305 x 165 x 46	23.0	165.7	153.2	6.7	11.8	8.9	5.98	22.9	3.07	536	448
165 x 152 x 20	305 x 165 x 40	20.1	165.0	151.6	6.0	10.2	8.9	6.92	25.3	3.03	468	382
127 x 152 x 24	305 x 127 x 48	24.0	125.3	155.4	9.0	14.0	8.9	3.52	17.3	3.94	662	231
127 x 152 x 21	305 x 127 x 42	20.9	124.3	153.5	8.0	12.1	8.9	4.07	19.2	3.87	573	194
127 x 152 x 19	305 x 127 x 37	18.5	123.4	152.1	7.1	10.7	8.9	4.60	21.4	3.78	501	168
102 x 152 x 17	305 x 102 x 33	16.4	102.4	156.3	6.6	10.8	7.6	3.73	23.7	4.14	487	97.1
102 x 152 x 14	305 x 102 x 28	14.1	101.8	154.3	6.0	8.8	7.6	4.58	25.7	4.20	420	77.7
102 x 152 x 13	305 x 102 x 25	12.4	101.6	152.5	5.8	7.0	7.6	5.76	26.3	4.43	377	61.5
146 x 127 x 22	254 x 146 x 43	21.5	147.3	129.7	7.2	12.7	7.6	4.92	18.0	2.64	343	339
146 x 127 x 19	254 x 146 x 37	18.5	146.4	127.9	6.3	10.9	7.6	5.73	20.3	2.55	292	285
146 x 127 x 16	254 x 146 x 31	15.5	146.1	125.6	6.0	8.6	7.6	7.26	20.9	2.66	259	224
102 x 127 x 14	254 x 102 x 28	14.1	102.2	130.1	6.3	10.0	7.6	4.04	20.7	3.24	277	89.3
102 x 127 x 13	254 x 102 x 25	12.6	101.9	128.5	6.0	8.4	7.6	4.80	21.4	3.32	250	74.3
102 x 127 x 11	254 x 102 x 22	11.0	101.6	126.9	5.7	6.8	7.6	5.93	22.3	3.45	223	59.7
133 x 102 x 15	203 x 133 x 30	15.0	133.9	103.3	6.4	9.6	7.6	5.85	16.1	2.11	154	192
133 x 102 x 13	203 x 133 x 25	12.5	133.2	101.5	5.7	7.8	7.6	7.20	17.8	2.10	131	154

Table 2.1.7.3. UKT Split from Advance® UKC. Dimensions and Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

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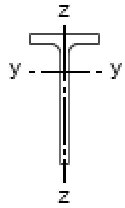
Table 2.1.7.4

SECTION PROPERTIES

STRUCTURAL TEES CUT FROM UNIVERSAL BEAMS

UKT Split from Advance® UKB

PROPERTIES



Section Designation	Radius of Gyration Axis y-y	Radius of Gyration Axis z-z	Elastic Modulus Axis y-y Flange	Elastic Modulus Axis y-y Toe	Elastic Modulus Axis z-z	Plastic Modulus Axis y-y	Plastic Modulus Axis z-z	Buckling Parameter U	Torsional Index X	Mono-symmetry Index Ψ	Warping Constant (*) I_w	Torsional Constant I_T	Area of Section A
	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^3				cm^6	cm^4	cm^2
178 x 203 x 43 +	6.11	4.11	413	127	101	226	157	0.556	12.2	0.694	538	46.3	54.3
178 x 203 x 37	6.06	4.04	365	109	86.1	194	133	0.555	13.8	0.696	350	31.3	47.2
178 x 203 x 34	6.07	3.99	332	100	76.3	177	118	0.561	15.2	0.698	262	23.0	42.8
178 x 203 x 30	6.04	3.97	301	89.0	67.6	157	104	0.561	16.9	0.699	186	16.6	38.3
178 x 203 x 27	6.13	3.85	268	84.6	57.5	150	89.1	0.588	19.2	0.705	146	11.5	34.5
140 x 203 x 27 +	6.23	3.06	256	87.0	44.3	155	69.5	0.636	17.1	0.739	148	14.4	34.0
140 x 203 x 23	6.19	3.03	224	74.2	37.8	132	59.0	0.633	19.5	0.740	93.7	9.49	29.3
140 x 203 x 20	6.28	2.87	184	67.2	28.9	121	45.4	0.668	23.8	0.750	66.3	5.33	24.8
171 x 178 x 34	5.20	3.99	288	81.5	78.6	145	121	0.500	12.2	0.672	249	27.8	42.7
171 x 178 x 29	5.21	3.91	248	70.9	64.4	125	99.4	0.514	14.4	0.676	154	16.6	36.3
171 x 178 x 26	5.21	3.86	224	63.9	56.5	113	87.1	0.521	16.1	0.677	110	11.9	32.4
171 x 178 x 23	5.28	3.76	197	59.1	47.4	104	73.3	0.546	18.4	0.683	79.2	7.90	28.7
127 x 178 x 20	5.41	2.68	164	55.0	28.4	98.0	44.5	0.632	17.6	0.739	57.1	7.53	24.9
127 x 178 x 17	5.45	2.58	137	48.6	22.3	87.2	35.1	0.655	21.1	0.746	38.0	4.38	21.1
165 x 152 x 27	4.32	3.93	200	52.2	63.7	92.8	97.8	0.389	11.8	0.636	128	17.3	34.4
165 x 152 x 23	4.27	3.91	174	43.7	54.1	77.1	82.8	0.380	13.6	0.636	78.6	11.1	29.4
165 x 152 x 20	4.27	3.86	155	38.6	46.3	67.6	70.9	0.393	15.5	0.638	52.0	7.35	25.7
127 x 152 x 24	4.65	2.74	168	57.1	36.8	102	58.0	0.602	11.7	0.714	104	15.8	30.6
127 x 152 x 21	4.63	2.70	148	49.9	31.3	88.9	49.2	0.606	13.3	0.716	69.2	10.5	26.7
127 x 152 x 19	4.61	2.67	132	43.8	27.2	77.9	42.7	0.606	14.9	0.718	47.4	7.36	23.6
102 x 152 x 17	4.82	2.15	118	42.3	19.0	75.8	30.0	0.656	15.8	0.749	36.8	6.08	20.9
102 x 152 x 14	4.84	2.08	100.0	37.4	15.3	67.5	24.2	0.673	18.7	0.756	25.2	3.69	17.9
102 x 152 x 13	4.88	1.97	85.0	34.8	12.1	63.9	19.4	0.705	21.8	0.766	20.4	2.37	15.8
146 x 127 x 22	3.54	3.52	130	33.2	46.0	59.5	70.5	0.202	10.6	0.613	64.9	11.9	27.4
146 x 127 x 19	3.52	3.48	115	28.5	39.0	50.7	59.7	0.233	12.2	0.616	41.0	7.65	23.6
146 x 127 x 16	3.61	3.36	97.4	26.2	30.6	46.0	47.1	0.376	14.8	0.623	24.5	4.26	19.8
102 x 127 x 14	3.92	2.22	85.5	28.3	17.5	50.4	27.4	0.607	13.8	0.720	21.0	4.77	18.0
102 x 127 x 13	3.95	2.15	75.3	26.2	14.6	46.9	23.0	0.628	15.8	0.727	15.9	3.20	16.0
102 x 127 x 11	3.99	2.06	64.5	24.1	11.7	43.5	18.6	0.656	18.2	0.736	12.0	2.06	14.0
133 x 102 x 15	2.84	3.17	73.1	18.8	28.7	33.5	44.1	-	-	0.569	21.7	5.13	19.1
133 x 102 x 13	2.86	3.10	62.4	16.2	23.1	28.7	35.5	-	-	0.572	12.6	2.97	16.0

Table 2.1.7.4. UKT Split from Advance® UKC. Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

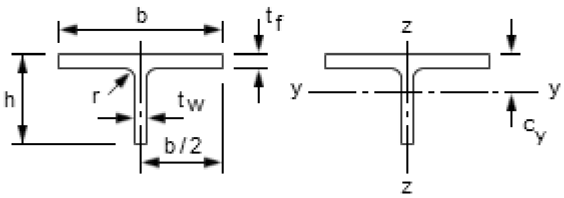
Table 2.1.8.1

SECTION PROPERTIES

STRUCTURAL TEES CUT FROM UNIVERSAL COLUMNS

UKT Split from Advance® UKC

DIMENSIONS AND PROPERTIES



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Section Designation	Cut from Universal Column Section Designation	Mass per Metre kg/m	Width of Section b mm	Depth of Section h mm	Thickness Web t_w mm	Thickness Flange t_f mm	Root Radius r mm	Ratios for Local Buckling Flange c_f / t_f	Ratios for Local Buckling Web c_w / t_w	Dimension c_y cm
305 x 152 x 79	305 x 305 x 158	79.0	311.2	163.5	15.8	25.0	15.2	5.30	10.3	3.04
305 x 152 x 69	305 x 305 x 137	68.4	309.2	160.2	13.8	21.7	15.2	6.11	11.6	2.86
305 x 152 x 59	305 x 305 x 118	58.9	307.4	157.2	12.0	18.7	15.2	7.09	13.1	2.69
305 x 152 x 49	305 x 305 x 97	48.4	305.3	153.9	9.9	15.4	15.2	8.60	15.5	2.50
254 x 127 x 84	254 x 254 x 167	83.5	265.2	144.5	19.2	31.7	12.7	3.48	7.53	3.07
254 x 127 x 66	254 x 254 x 132	66.0	261.3	138.1	15.3	25.3	12.7	4.36	9.03	2.70
254 x 127 x 54	254 x 254 x 107	53.5	258.8	133.3	12.8	20.5	12.7	5.38	10.4	2.45
254 x 127 x 45	254 x 254 x 89	44.4	256.3	130.1	10.3	17.3	12.7	6.38	12.6	2.21
254 x 127 x 37	254 x 254 x 73	36.5	254.6	127.0	8.6	14.2	12.7	7.77	14.8	2.05
203 x 102 x 64 +	203 x 203 x 127	63.7	213.9	120.7	18.1	30.1	10.2	2.91	6.67	2.73
203 x 102 x 57 +	203 x 203 x 113	56.7	212.1	117.5	16.3	26.9	10.2	3.26	7.21	2.56
203 x 102 x 50 +	203 x 203 x 100	49.8	210.3	114.3	14.5	23.7	10.2	3.70	7.88	2.38
203 x 102 x 43	203 x 203 x 86	43.0	209.1	111.0	12.7	20.5	10.2	4.29	8.74	2.20
203 x 102 x 36	203 x 203 x 71	35.5	206.4	107.8	10.0	17.3	10.2	5.09	10.8	1.95
203 x 102 x 30	203 x 203 x 60	30.0	205.8	104.7	9.4	14.2	10.2	6.20	11.1	1.89
203 x 102 x 26	203 x 203 x 52	26.0	204.3	103.0	7.9	12.5	10.2	7.04	13.0	1.75
203 x 102 x 23	203 x 203 x 46	23.0	203.6	101.5	7.2	11.0	10.2	8.00	14.1	1.69
152 x 76 x 26 +	152 x 152 x 51	25.6	157.4	85.1	11.0	15.7	7.6	4.18	7.74	1.79
152 x 76 x 22 +	152 x 152 x 44	22.0	155.9	83.0	9.5	13.6	7.6	4.82	8.74	1.66
152 x 76 x 19	152 x 152 x 37	18.5	154.4	80.8	8.0	11.5	7.6	5.70	10.1	1.53
152 x 76 x 15	152 x 152 x 30	15.0	152.9	78.7	6.5	9.4	7.6	6.98	12.1	1.41
152 x 76 x 12	152 x 152 x 23	11.5	152.2	76.1	5.8	6.8	7.6	9.65	13.1	1.39

Table 2.1.8.1. UKT Split from Advance® UKC. Dimensions and Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

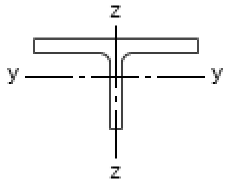
SECTION PROPERTIES

Table 2.1.8.2

STRUCTURAL TEES CUT FROM UNIVERSAL COLUMNS

UKT Split from Advance® UKC

PROPERTIES



B-51

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus			Plastic Modulus		Mono-symmetry Index	Warping Constant (*)	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y Flange	Axis y-y Toe	Axis z-z	Axis y-y	Axis z-z	Ψ	I_w	I_T	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^3		cm^6	cm^4	cm^2
305 x 152 x 79	1530	6280	3.90	7.90	503	115	404	225	615	0.268	3650	188	101
305 x 152 x 69	1290	5350	3.84	7.83	450	97.7	346	188	526	0.263	2340	124	87.2
305 x 152 x 59	1080	4530	3.79	7.77	401	82.8	295	156	448	0.262	1470	80.3	75.1
305 x 152 x 49	858	3650	3.73	7.69	343	66.5	239	123	363	0.258	806	45.5	61.7
254 x 127 x 84	1200	4930	3.36	6.81	391	105	372	220	569	0.261	4540	312	106
254 x 127 x 66	871	3770	3.22	6.69	323	78.3	288	159	439	0.250	2200	159	84.1
254 x 127 x 54	676	2960	3.15	6.59	276	62.1	229	122	348	0.245	1150	85.9	68.2
254 x 127 x 45	524	2430	3.04	6.55	237	48.5	190	94.0	288	0.242	660	51.1	56.7
254 x 127 x 37	417	1950	2.99	6.48	204	39.2	153	74.0	233	0.236	359	28.8	46.5
203 x 102 x 64 +	637	2460	2.80	5.50	233	68.2	230	145	352	0.279	2050	212	81.2
203 x 102 x 57 +	540	2140	2.73	5.45	211	58.8	202	123	309	0.270	1430	152	72.3
203 x 102 x 50 +	453	1840	2.67	5.39	190	50.0	175	103	267	0.266	951	104	63.4
203 x 102 x 43	373	1560	2.61	5.34	169	41.9	150	84.6	228	0.257	605	68.1	54.8
203 x 102 x 36	280	1270	2.49	5.30	143	31.8	123	63.6	187	0.254	343	40.0	45.2
203 x 102 x 30	244	1030	2.53	5.20	129	28.4	100	54.3	153	0.245	195	23.5	38.2
203 x 102 x 26	200	889	2.46	5.18	115	23.4	87.0	44.5	132	0.243	128	15.8	33.1
203 x 102 x 23	177	774	2.45	5.13	105	20.9	76.0	39.0	115	0.242	87.2	11.0	29.4
152 x 76 x 26 +	141	511	2.08	3.96	79.0	21.0	64.9	41.4	99.5	0.281	122	24.3	32.6
152 x 76 x 22 +	116	430	2.04	3.92	70.0	17.5	55.2	34.0	84.4	0.281	76.7	15.8	28.0
152 x 76 x 19	93.1	353	1.99	3.87	60.7	14.2	45.7	27.1	69.8	0.277	44.9	9.54	23.5
152 x 76 x 15	72.2	280	1.94	3.83	51.4	11.2	36.7	20.9	55.8	0.269	23.7	5.24	19.1
152 x 76 x 12	58.5	200	2.00	3.70	41.9	9.41	26.3	16.9	40.1	0.278	9.78	2.30	14.6

Table 2.1.8.2. UKT Split from Advance® UKC. Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

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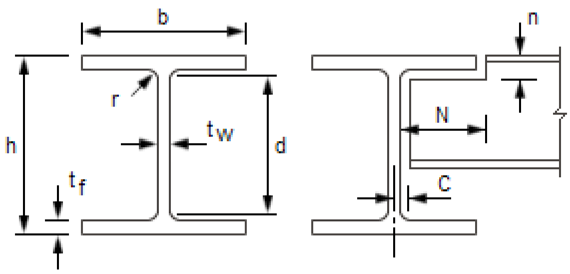
Table 2.1.3.1

SECTION PROPERTIES

UNIVERSAL BEARING PILES

Advance® UKBP

DIMENSIONS



Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		h	b	t_w	t_f	r	d	c_f / t_f	c_w / t_w	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
356 x 368 x 174	173.9	361.4	378.5	20.3	20.4	15.2	290.2	8.03	14.3	12	190	36	2.17	12.5
356 x 368 x 152	152.0	356.4	376.0	17.8	17.9	15.2	290.2	9.16	16.3	11	190	34	2.16	14.2
356 x 368 x 133	133.0	352.0	373.8	15.6	15.7	15.2	290.2	10.44	18.6	10	190	32	2.14	16.1
356 x 368 x 109	108.9	346.4	371.0	12.8	12.9	15.2	290.2	12.71	22.7	8	190	30	2.13	19.5
305 x 305 x 223	222.9	337.9	325.7	30.3	30.4	15.2	246.7	4.36	8.14	17	158	46	1.89	8.49
305 x 305 x 186	186.0	328.3	320.9	25.5	25.6	15.2	246.7	5.18	9.67	15	158	42	1.86	10.0
305 x 305 x 149	149.1	318.5	316.0	20.6	20.7	15.2	246.7	6.40	12.0	12	158	36	1.83	12.3
305 x 305 x 126	126.1	312.3	312.9	17.5	17.6	15.2	246.7	7.53	14.1	11	158	34	1.82	14.4
305 x 305 x 110	110.0	307.9	310.7	15.3	15.4	15.2	246.7	8.60	16.1	10	158	32	1.80	16.4
305 x 305 x 95	94.9	303.7	308.7	13.3	13.3	15.2	246.7	9.96	18.5	9	158	30	1.79	18.9
305 x 305 x 88	88.0	301.7	307.8	12.4	12.3	15.2	246.7	10.77	19.9	8	158	28	1.78	20.3
305 x 305 x 79	78.9	299.3	306.4	11.0	11.1	15.2	246.7	11.94	22.4	8	158	28	1.78	22.5
254 x 254 x 85	85.1	254.3	260.4	14.4	14.3	12.7	200.3	7.71	13.9	9	134	28	1.50	17.6
254 x 254 x 71	71.0	249.7	258.0	12.0	12.0	12.7	200.3	9.19	16.7	8	134	26	1.49	20.9
254 x 254 x 63	63.0	247.1	256.6	10.6	10.7	12.7	200.3	10.31	18.9	7	134	24	1.48	23.5
203 x 203 x 54	53.9	204.0	207.7	11.3	11.4	10.2	160.8	7.72	14.2	8	110	22	1.20	22.2
203 x 203 x 45	44.9	200.2	205.9	9.5	9.5	10.2	160.8	9.26	16.9	7	110	20	1.19	26.4

Table 2.1.3.1. Advance® UKBP. Dimensions

BS EN 1993-1-1: 2005
BS 4-1: 2005

UK EUROCODES

B-13

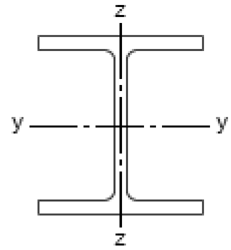
Table 2.1.3.2

SECTION PROPERTIES

UNIVERSAL BEARING PILES

Advance® UKBP

PROPERTIES



Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	U	X	I_w	I_T	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
356 x 368 x 174	51000	18500	15.2	9.13	2820	976	3190	1500	0.822	15.8	5.37	330	221
356 x 368 x 152	44000	15900	15.1	9.05	2470	845	2770	1290	0.821	17.9	4.55	223	194
356 x 368 x 133	38000	13700	15.0	8.99	2160	732	2410	1120	0.823	20.1	3.87	151	169
356 x 368 x 109	30600	11000	14.9	8.90	1770	592	1960	903	0.822	24.2	3.05	84.6	139
305 x 305 x 223	52700	17600	13.6	7.87	3120	1080	3650	1680	0.827	9.5	4.15	943	284
305 x 305 x 186	42600	14100	13.4	7.73	2600	881	3000	1370	0.827	11.1	3.24	560	237
305 x 305 x 149	33100	10900	13.2	7.58	2080	691	2370	1070	0.828	13.5	2.42	295	190
305 x 305 x 126	27400	9000	13.1	7.49	1760	575	1990	885	0.829	15.7	1.95	182	161
305 x 305 x 110	23600	7710	13.0	7.42	1530	496	1720	762	0.830	17.7	1.65	122	140
305 x 305 x 95	20000	6530	12.9	7.35	1320	423	1470	648	0.829	20.2	1.38	80.0	121
305 x 305 x 88	18400	5980	12.8	7.31	1220	389	1360	595	0.831	21.6	1.25	64.2	112
305 x 305 x 79	16400	5330	12.8	7.28	1100	348	1220	531	0.833	23.8	1.11	46.9	100
254 x 254 x 85	12300	4220	10.6	6.24	966	324	1090	498	0.826	15.6	0.607	81.8	108
254 x 254 x 71	10100	3440	10.6	6.17	807	267	904	409	0.826	18.4	0.486	48.4	90.4
254 x 254 x 63	8860	3020	10.5	6.13	717	235	799	360	0.828	20.4	0.421	34.3	80.2
203 x 203 x 54	5030	1710	8.55	4.98	493	164	557	252	0.827	15.8	0.158	32.7	68.7
203 x 203 x 45	4100	1380	8.46	4.92	410	134	459	206	0.827	18.6	0.126	19.2	57.2

Table 2.1.3.2. Advance® UKBP. Properties

BS EN 1993-1-1: 2005
Tata Steel ASB

UK EUROCODES

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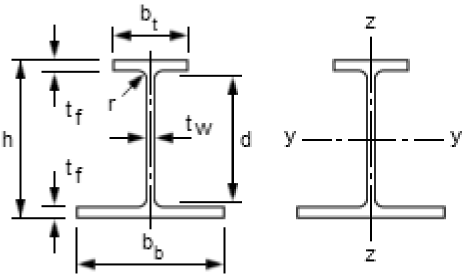
Table 2.1.9.1

SECTION PROPERTIES

ASB
(ASYMMETRIC BEAMS)

DIMENSIONS AND PROPERTIES



Section Designation	Mass per Metre	Depth of Section	Width of Flange		Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling			Second Moment of Area		Surface Area	
			Top	Bottom	Web	Flange			Flanges		Web	Axis y-y	Axis z-z	Per Metre	Per Tonne
		h	b_t	b_b	t_w	t_f	r	d	c_{ft} / t_f	c_{fb} / t_f	c_w / t_w				
	kg/m	mm	mm	mm	mm	mm	mm	mm				cm^4	cm^4	m^2	m^2
300 ASB 249 ^	249	342	203	313	40.0	40.0	27.0	208	1.36	2.74	5.20	52900	13200	1.59	6.38
300 ASB 196	196	342	183	293	20.0	40.0	27.0	208	1.36	2.74	10.4	45900	10500	1.55	7.93
300 ASB 185 ^	185	320	195	305	32.0	29.0	27.0	208	1.88	3.78	6.50	35700	8750	1.53	8.29
300 ASB 155	155	326	179	289	16.0	32.0	27.0	208	1.70	3.42	13.0	34500	7990	1.51	9.71
300 ASB 153 ^	153	310	190	300	27.0	24.0	27.0	208	2.27	4.56	7.70	28400	6840	1.50	9.81
280 ASB 136 ^	136	288	190	300	25.0	22.0	24.0	196	2.66	5.16	7.84	22200	6260	1.46	10.7
280 ASB 124	124	296	178	288	13.0	26.0	24.0	196	2.25	4.37	15.1	23500	6410	1.46	11.8
280 ASB 105	105	288	176	286	11.0	22.0	24.0	196	2.66	5.16	17.8	19200	5300	1.44	13.7
280 ASB 100 ^	100	276	184	294	19.0	16.0	24.0	196	3.66	7.09	10.3	15500	4250	1.43	14.2
280 ASB 74	73.6	272	175	285	10.0	14.0	24.0	196	4.18	8.11	19.6	12200	3330	1.40	19.1

Table 2.1.9.1. ASB - Asymmetric Beams. Dimensions and Properties

Table 2.1.9.2

BS EN 1993-1-1: 2005
Tata Steel ASB

UK EUROCODES

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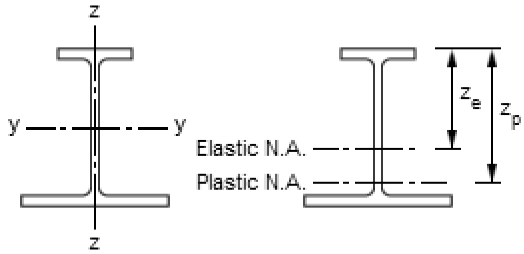
SECTION PROPERTIES

ASB
(ASYMMETRIC BEAMS)

PROPERTIES



Section Designation	Radius of Gyration		Elastic Modulus			Neutral Axis Position		Plastic Modulus		Buckling Parameter	Torsional Index	Mono-symmetry Index *	Warping Constant	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y Top	Axis y-y Bottom	Axis z-z	Elastic z_e	Plastic z_p	Axis y-y	Axis z-z	U	X	Ψ	I_w	I_T	A
	cm	cm	cm^3	cm^3	cm^3	cm	cm	cm^3	cm^3				dm^6	cm^4	cm^2
300 ASB 249 ^	12.9	6.40	2760	3530	843	19.2	22.6	3760	1510	0.820	6.80	0.663	2.00	2000	318
300 ASB 196	13.6	6.48	2320	3180	714	19.8	28.1	3060	1230	0.840	7.86	0.895	1.50	1180	249
300 ASB 185 ^	12.3	6.10	1980	2540	574	18.0	21.0	2660	1030	0.820	8.56	0.662	1.20	871	235
300 ASB 155	13.2	6.35	1830	2520	553	18.9	27.3	2360	950	0.840	9.40	0.868	1.07	620	198
300 ASB 153 ^	12.1	5.93	1630	2090	456	17.4	20.4	2160	817	0.820	9.97	0.643	0.895	513	195
280 ASB 136 ^	11.3	6.00	1370	1770	417	16.3	19.2	1810	741	0.810	10.2	0.628	0.710	379	174
280 ASB 124	12.2	6.37	1360	1900	445	17.3	25.7	1730	761	0.830	10.5	0.807	0.721	332	158
280 ASB 105	12.0	6.30	1150	1610	370	16.8	25.3	1440	633	0.830	12.1	0.777	0.574	207	133
280 ASB 100 ^	11.0	5.76	995	1290	289	15.6	18.4	1290	511	0.810	13.2	0.616	0.451	160	128
280 ASB 74	11.4	5.96	776	1060	234	15.7	21.3	978	403	0.830	16.7	0.699	0.338	72.0	93.7

Table 2.1.9.0. ASB - Asymmetric Beams. Properties

BS EN 1993-1-1: 2005
BS 4-1: 2005

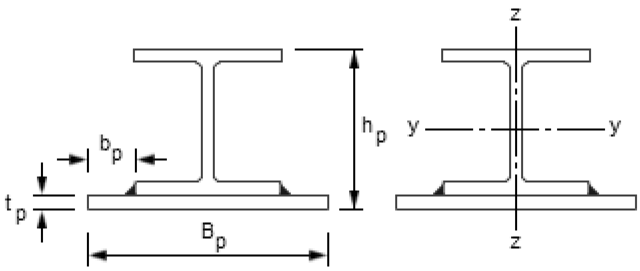
UK EUROCODES

Table 2.1.10.1

SECTION PROPERTIES

Slimflor® Beams

DIMENSIONS



Designation		Thickness of Plate	Width of Outstand	Mass per Metre of Compound Section	Depth of Compound Section	Width of Compound Section	Area of Section comp	Second Moment of Area		Radius of Gyration	
Base Section	SFB	t_p	b_p		h_p	B_p	A	Axis y-y	Axis z-z	Axis y-y	Axis z-z
		mm	mm	kg/m	mm	mm	cm^2	cm^4	cm^4	cm	cm
356 x 406 x 634	356 SFB 707	15	100	707	490	624	901	325128	128496	19.0	11.9
356 x 406 x 551	356 SFB 624	15	100	624	471	619	795	272325	112246	18.5	11.9
356 x 406 x 467	356 SFB 539	15	100	539	452	612	687	223580	96514	18.0	11.9
356 x 406 x 393	356 SFB 464	15	100	464	434	607	592	182911	83323	17.6	11.9
356 x 406 x 340	356 SFB 411	15	100	411	421	603	523	155777	74260	17.3	11.9
356 x 406 x 287	356 SFB 358	15	100	358	409	599	456	129997	65543	16.9	12.0
356 x 406 x 235	356 SFB 305	15	100	305	396	595	389	106050	57297	16.5	12.1
356 x 368 x 202	356 SFB 270	15	100	270	390	575	343	90779	47415	16.3	11.8
356 x 368 x 177	356 SFB 244	15	100	244	383	573	311	79968	43997	16.0	11.9
356 x 368 x 153	356 SFB 220	15	100	220	377	571	280	69732	40763	15.8	12.1
356 x 368 x 129	356 SFB 196	15	100	196	371	569	250	59541	37590	15.4	12.3
305 x 305 x 283	305 SFB 344	15	100	344	380	522	439	102152	42435	15.3	9.83
305 x 305 x 240	305 SFB 301	15	100	301	368	518	384	85149	37729	14.9	9.92
305 x 305 x 198	305 SFB 259	15	100	259	355	515	330	69530	33323	14.5	10.1
305 x 305 x 158	305 SFB 218	15	100	218	342	511	278	55009	29268	14.1	10.3
305 x 305 x 137	305 SFB 197	15	100	197	336	509	251	47776	27203	13.8	10.4
305 x 305 x 118	305 SFB 178	15	100	178	330	507	226	41397	25388	13.5	10.6
305 x 305 x 97	305 SFB 156	15	100	156	323	505	199	34504	23435	13.2	10.8
254 x 254 x 167	254 SFB 222	15	100	222	304	465	283	42160	22454	12.2	8.91
254 x 254 x 132	254 SFB 186	15	100	186	291	461	237	32941	19802	11.8	9.13
254 x 254 x 107	254 SFB 161	15	100	161	282	459	205	26597	18000	11.4	9.37
254 x 254 x 89	254 SFB 143	15	100	143	275	456	182	22366	16733	11.1	9.60
254 x 254 x 73	254 SFB 127	15	100	127	269	455	161	18546	15651	10.7	9.85
203 x 203 x 127 +	203 SFB 176	15	100	176	256	414	225	22831	13783	10.1	7.83
203 x 203 x 113 +	203 SFB 162	15	100	162	250	412	206	20077	13034	9.86	7.95
203 x 203 x 100 +	203 SFB 148	15	100	148	244	410	188	17457	12313	9.63	8.08
203 x 203 x 86	203 SFB 134	15	100	134	237	409	171	14994	11686	9.36	8.27
203 x 203 x 71	203 SFB 119	15	100	119	231	406	151	12479	10927	9.08	8.50
203 x 203 x 60	203 SFB 108	15	100	108	225	406	137	10408	10418	8.71	8.71
203 x 203 x 52	203 SFB 100	15	100	99.6	221	404	127	9144	10038	8.49	8.89
203 x 203 x 46	203 SFB 94	15	100	93.6	218	404	119	8128	9766	8.25	9.05
152 x 152 x 51 +	152 SFB 93	15	100	93.3	185	357	119	5760	6729	6.96	7.53
152 x 152 x 44 +	152 SFB 86	15	100	85.9	181	356	109	4953	6495	6.73	7.70
152 x 152 x 37	152 SFB 79	15	100	78.7	177	354	100	4172	6270	6.45	7.91
152 x 152 x 30	152 SFB 72	15	100	71.6	173	353	91.2	3412	6054	6.12	8.15
152 x 152 x 23	152 SFB 64	15	100	64.4	167	352	82.1	2579	5861	5.61	8.45

Table 2.1.10.1. Section Properties. Slimflor® Beams. Dimensions and Properties

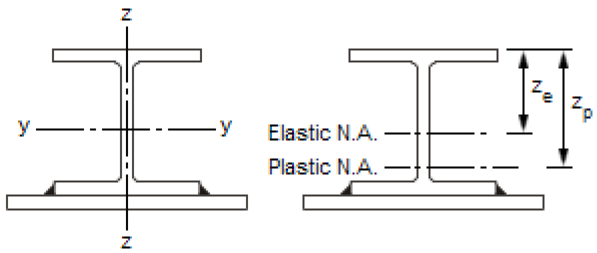
BS EN 1993-1-1: 2005
BS 4-1: 2005

Table 2.1.10.2

SECTION PROPERTIES

Slimflor® Beams

PROPERTIES



Designation: Base Section	Designation: SFB	Elastic Modulus $W_{el,y,t}$ cm^3	Elastic Modulus $W_{el,y,b}$ cm^3	Elastic Modulus $W_{el,z}$ cm^3	Neutral Axis Position: Elastic z_e cm	Neutral Axis Position: Plastic z_p cm	Plastic Modulus $W_{pl,y}$ cm^3	Plastic Modulus $W_{pl,z}$ cm^3	Buckling Parameter U	Torsional Index X	Warping Constant I_w dm^6	Torsional Constant I_T cm^4
356 x 406 x 634	356 SFB 707	12375	14331	4118	22.7	15.4	16065	8568	0.797	6.31	57.4	13790
356 x 406 x 551	356 SFB 624	10668	12647	3630	21.5	13.3	13747	7492	0.793	6.98	46.3	9310
356 x 406 x 467	356 SFB 539	8997	11008	3153	20.3	10.5	11486	6440	0.787	7.89	36.4	5878
356 x 406 x 393	356 SFB 464	7530	9571	2745	19.1	7.57	9520	5535	0.776	9.03	28.7	3613
356 x 406 x 340	356 SFB 411	6501	8569	2463	18.2	5.75	8139	4907	0.764	10.2	23.7	2411
356 x 406 x 287	356 SFB 358	5483	7580	2188	17.2	4.96	6788	4295	0.748	11.7	19.2	1508
356 x 406 x 235	356 SFB 305	4495	6626	1927	16.0	4.16	5491	3710	0.724	13.8	15.1	879
356 x 368 x 202	356 SFB 270	3843	5918	1650	15.3	3.78	4687	3158	0.723	15.2	11.6	623
356 x 368 x 177	356 SFB 244	3375	5468	1537	14.6	3.37	4085	2900	0.703	16.9	9.98	445
356 x 368 x 153	356 SFB 220	2923	5036	1429	13.8	2.97	3510	2655	0.677	18.8	8.51	315
356 x 368 x 129	356 SFB 196	2469	4598	1322	12.9	2.57	2943	2411	0.643	21.1	7.08	217
305 x 305 x 283	305 SFB 344	4716	6240	1625	16.4	5.88	6024	3365	0.782	8.90	10.3	2093
305 x 305 x 240	305 SFB 301	3988	5529	1456	15.4	5.08	5040	2958	0.767	10.1	8.25	1329
305 x 305 x 198	305 SFB 259	3287	4849	1295	14.3	4.29	4104	2573	0.744	11.8	6.46	792
305 x 305 x 158	305 SFB 218	2610	4187	1145	13.1	3.50	3226	2210	0.710	14.2	4.88	436
305 x 305 x 137	305 SFB 197	2261	3848	1068	12.4	3.09	2775	2025	0.685	15.9	4.12	306
305 x 305 x 118	305 SFB 178	1947	3543	1001	11.7	2.71	2374	1861	0.654	17.6	3.46	218
305 x 305 x 97	305 SFB 156	1602	3209	928	10.8	2.28	1939	1683	0.606	19.7	2.78	148
254 x 254 x 167	254 SFB 222	2315	3455	965	12.2	4.20	2936	1949	0.721	9.98	2.87	678
254 x 254 x 132	254 SFB 186	1824	2976	859	11.1	3.39	2281	1676	0.679	11.9	2.12	371
254 x 254 x 107	254 SFB 161	1473	2630	785	10.1	2.81	1826	1486	0.628	13.9	1.63	224
254 x 254 x 89	254 SFB 143	1229	2397	733	9.33	2.38	1506	1356	0.575	15.5	1.31	153
254 x 254 x 73	254 SFB 127	1008	2178	689	8.52	1.99	1228	1240	0.493	17.0	1.04	109
203 x 203 x 127 +	203 SFB 176	1462	2277	666	10.0	3.85	1890	1347	0.684	8.82	1.03	474
203 x 203 x 113 +	203 SFB 162	1296	2112	633	9.51	3.45	1664	1255	0.657	9.61	0.877	351
203 x 203 x 100 +	203 SFB 148	1133	1950	600	8.95	3.05	1445	1166	0.620	10.5	0.734	256
203 x 203 x 86	203 SFB 134	976	1795	571	8.35	2.65	1236	1084	0.566	11.6	0.608	183
203 x 203 x 71	203 SFB 119	808	1633	538	7.64	2.21	1011	993	0.477	12.9	0.481	126
203 x 203 x 60	203 SFB 108	673	1487	513	7.00	1.88	843	923	0.000	13.9	0.381	92.9
203 x 203 x 52	203 SFB 100	586	1401	497	6.53	1.64	728	877	0.000	14.5	0.324	77.3
203 x 203 x 46	203 SFB 94	518	1328	484	6.12	1.48	642	842	0.000	14.9	0.278	67.6
152 x 152 x 51 +	152 SFB 93	454	988	377	5.83	1.87	593	678	0.000	10.6	0.124	89.0
152 x 152 x 44 +	152 SFB 86	390	920	365	5.39	1.59	505	644	0.000	11.1	0.102	71.7
152 x 152 x 37	152 SFB 79	327	851	354	4.90	1.41	421	611	0.000	11.5	0.081	59.1
152 x 152 x 30	152 SFB 72	265	781	343	4.37	1.29	340	579	0.000	11.7	0.062	50.2
152 x 152 x 23	152 SFB 64	198	691	333	3.73	1.17	259	545	0.000	11.5	0.043	44.3

Table 2.1.10.2. Section Properties. Slimflor® Beams. Dimensions and Properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

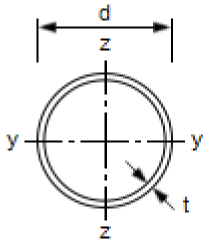
Table 2.8.1.1

SECTION PROPERTIES

HOT FINISHED CIRCULAR HOLLOW SECTIONS

Celsius® CHS

Dimensions and properties



Hot Finished

Section Designation: Outside Diameter d (mm)	Section Designation: Thickness t (mm)	Mass per Metre (kg/m)	Area of Section A (cm^2)	Ratio for Local Buckling d/t	Second Moment of Area I (cm^4)	Radius of Gyration i (cm)	Elastic Modulus W_{el} (cm^3)	Plastic Modulus W_{pl} (cm^3)	Torsional Constants I_T (cm^4)	Torsional Constants W_t (cm^3)	Surface Area Per Metre (m^2)	Surface Area Per Tonne (m^2)
21.3	2.6 #	1.20	1.53	8.19	0.681	0.668	0.639	0.915	1.36	1.28	0.067	55.9
	2.9 #	1.32	1.68	7.34	0.727	0.659	0.683	0.990	1.45	1.37	0.067	50.9
	3.2	1.43	1.82	6.66	0.768	0.650	0.722	1.06	1.54	1.44	0.067	46.9
26.9	2.6 #	1.56	1.98	10.3	1.48	0.864	1.10	1.54	2.96	2.20	0.085	54.6
	2.9 #	1.72	2.19	9.28	1.60	0.855	1.19	1.68	3.19	2.38	0.085	49.6
	3.2	1.87	2.38	8.41	1.70	0.846	1.27	1.81	3.41	2.53	0.085	45.5
	3.6 #	2.07	2.64	7.47	1.83	0.834	1.36	1.97	3.66	2.72	0.085	41.1
33.7	2.6 #	1.99	2.54	13.0	3.09	1.10	1.84	2.52	6.19	3.67	0.106	53.1
	2.9 #	2.20	2.81	11.6	3.36	1.09	1.99	2.76	6.71	3.98	0.106	48.1
	3.2	2.41	3.07	10.5	3.60	1.08	2.14	2.99	7.21	4.28	0.106	44.0
	3.6 #	2.67	3.40	9.36	3.91	1.07	2.32	3.28	7.82	4.64	0.106	39.6
	4.0	2.93	3.73	8.43	4.19	1.06	2.49	3.55	8.38	4.97	0.106	36.1
	4.5 #	3.24	4.13	7.49	4.50	1.04	2.67	3.87	9.01	5.35	0.106	32.8
	5.0 #	3.54	4.51	6.74	4.78	1.03	2.84	4.16	9.57	5.68	0.106	30.0
42.4	2.6 #	2.55	3.25	16.3	6.46	1.41	3.05	4.12	12.9	6.10	0.133	52.1
	2.9 #	2.82	3.60	14.6	7.06	1.40	3.33	4.53	14.1	6.66	0.133	47.1
	3.2	3.09	3.94	13.3	7.62	1.39	3.59	4.93	15.2	7.19	0.133	43.0
	3.6 #	3.44	4.39	11.8	8.33	1.38	3.93	5.44	16.7	7.86	0.133	38.6
	4.0	3.79	4.83	10.6	8.99	1.36	4.24	5.92	18.0	8.48	0.133	35.1
	4.5 #	4.21	5.36	9.42	9.76	1.35	4.60	6.49	19.5	9.20	0.133	31.7
	5.0 #	4.61	5.87	8.48	10.5	1.33	4.93	7.04	20.9	9.86	0.133	28.9
48.3	2.6 #	2.93	3.73	18.6	9.78	1.62	4.05	5.44	19.6	8.10	0.152	51.8
	2.9 #	3.25	4.14	16.7	10.7	1.61	4.43	5.99	21.4	8.86	0.152	46.8
	3.2	3.56	4.53	15.1	11.6	1.60	4.80	6.52	23.2	9.59	0.152	42.7
	3.6 #	3.97	5.06	13.4	12.7	1.59	5.26	7.21	25.4	10.5	0.152	38.3
	4.0	4.37	5.57	12.1	13.8	1.57	5.70	7.87	27.5	11.4	0.152	34.8
	4.5 #	4.86	6.19	10.7	15.0	1.56	6.21	8.66	30.0	12.4	0.152	31.3
	5.0	5.34	6.80	9.66	16.2	1.54	6.69	9.42	32.3	13.4	0.152	28.4
	5.6 #	5.90	7.51	8.63	17.4	1.52	7.21	10.3	34.8	14.4	0.152	25.8
	6.3	6.53	8.31	7.67	18.7	1.50	7.76	11.2	37.5	15.5	0.152	23.3
60.3	2.6 #	3.70	4.71	23.2	19.7	2.04	6.52	8.66	39.3	13.0	0.189	51.0
	2.9 #	4.11	5.23	20.8	21.6	2.03	7.16	9.56	43.2	14.3	0.189	46.1
	3.2	4.51	5.74	18.8	23.5	2.02	7.78	10.4	46.9	15.6	0.189	42.0
	3.6 #	5.03	6.41	16.8	25.9	2.01	8.58	11.6	51.7	17.2	0.189	37.6
	4.0	5.55	7.07	15.1	28.2	2.00	9.34	12.7	56.3	18.7	0.189	34.0
	4.5 #	6.19	7.89	13.4	30.9	1.98	10.2	14.0	61.8	20.5	0.189	30.4
	5.0	6.82	8.69	12.1	33.5	1.96	11.1	15.3	67.0	22.2	0.189	27.8
	5.6 #	7.55	9.62	10.8	36.4	1.94	12.1	16.8	72.7	24.1	0.189	24.9
	6.3	8.39	10.7	9.57	39.5	1.92	13.1	18.5	79.0	26.2	0.189	22.5
	8.0 #	10.3	13.1	7.54	46.0	1.87	15.3	22.1	92.0	30.5	0.189	18.3

Table 2.8.1.1. Celsius® CHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

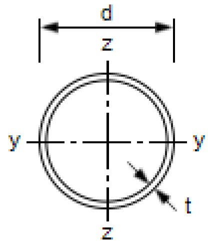
Table 2.8.1.2

SECTION PROPERTIES

HOT FINISHED CIRCULAR HOLLOW SECTIONS

Celsius® CHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
Outside Diameter d	Thickness t		A	d/t	I	i	W_{el}	W_{pl}	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
76.1	2.9	5.24	6.67	26.2	44.7	2.59	11.8	15.5	89.5	23.5	0.239	45.6
	3.2	5.75	7.33	23.8	48.8	2.58	12.8	17.0	97.6	25.6	0.239	41.6
	3.6 #	6.44	8.20	21.1	54.0	2.57	14.2	18.9	108	28.4	0.239	37.0
	4.0	7.11	9.06	19.0	59.1	2.55	15.5	20.8	118	31.0	0.239	33.7
	4.5 #	7.95	10.1	16.9	65.1	2.54	17.1	23.1	130	34.2	0.239	30.1
	5.0	8.77	11.2	15.2	70.9	2.52	18.6	25.3	142	37.3	0.239	27.2
	5.6 #	9.74	12.4	13.6	77.5	2.50	20.4	27.9	155	40.8	0.239	24.6
	6.3	10.8	13.8	12.1	84.8	2.48	22.3	30.8	170	44.6	0.239	22.0
	8.0	13.4	17.1	9.51	101	2.42	26.4	37.3	201	52.9	0.239	17.8
88.9	2.9 #	6.15	7.84	30.7	72.5	3.04	16.3	21.5	145	32.6	0.279	45.5
	3.2 #	6.76	8.62	27.8	79.2	3.03	17.8	23.5	158	35.6	0.279	41.3
	3.6 #	7.57	9.65	24.7	87.9	3.02	19.8	26.2	176	39.5	0.279	36.8
	4.0	8.38	10.7	22.2	96.3	3.00	21.7	28.9	193	43.3	0.279	33.2
	4.5 #	9.37	11.9	19.8	107	2.99	24.0	32.1	213	47.9	0.279	29.9
	5.0	10.3	13.2	17.8	116	2.97	26.2	35.2	233	52.4	0.279	27.0
	5.6 #	11.5	14.7	15.9	128	2.95	28.7	38.9	255	57.5	0.279	24.2
	6.3	12.8	16.3	14.1	140	2.93	31.5	43.1	280	63.1	0.279	21.7
	8.0	16.0	20.3	11.1	168	2.87	37.8	52.5	336	75.6	0.279	17.5
	10.0 #	19.5	24.8	8.89	196	2.81	44.1	62.6	392	88.2	0.279	14.3
101.6	3.2 #	7.77	9.89	31.8	120	3.48	23.6	31.0	240	47.2	0.319	41.2
	3.6 #	8.70	11.1	28.2	133	3.47	26.2	34.6	266	52.5	0.319	36.7
	4.0 #	9.63	12.3	25.4	146	3.45	28.8	38.1	293	57.6	0.319	33.2
	4.5 #	10.8	13.7	22.6	162	3.44	31.9	42.5	324	63.8	0.319	29.6
	5.0 #	11.9	15.2	20.3	177	3.42	34.9	46.7	355	69.9	0.319	26.8
	5.6 #	13.3	16.9	18.1	195	3.40	38.4	51.7	390	76.9	0.319	24.1
	6.3 #	14.8	18.9	16.1	215	3.38	42.3	57.3	430	84.7	0.319	21.5
	8.0 #	18.5	23.5	12.7	260	3.32	51.1	70.3	519	102	0.319	17.3
	10.0 #	22.6	28.8	10.2	305	3.26	60.1	84.2	611	120	0.319	14.1
114.3	3.2 #	8.77	11.2	35.7	172	3.93	30.2	39.5	345	60.4	0.359	40.9
	3.6	9.83	12.5	31.8	192	3.92	33.6	44.1	384	67.2	0.359	36.6
	4.0	10.9	13.9	28.6	211	3.90	36.9	48.7	422	73.9	0.359	33.0
	4.5 #	12.2	15.5	25.4	234	3.89	41.0	54.3	469	82.0	0.359	29.5
	5.0	13.5	17.2	22.9	257	3.87	45.0	59.8	514	89.9	0.359	26.6
	5.6 #	15.0	19.1	20.4	283	3.85	49.6	66.2	566	99.1	0.359	23.9
	6.3	16.8	21.4	18.1	313	3.82	54.7	73.6	625	109	0.359	21.4
	8.0	21.0	26.7	14.3	379	3.77	66.4	90.6	759	133	0.359	17.1
	10.0 #	25.7	32.8	11.4	450	3.70	78.7	109	899	157	0.359	14.0

Table 2.8.1.2. Celsius® CHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

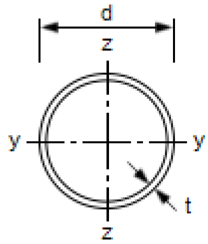
Table 2.8.1.3

SECTION PROPERTIES

HOT FINISHED CIRCULAR HOLLOW SECTIONS

Celsius® CHS

Dimensions and properties



Hot Finished

Section Designation: Outside Diameter d	Section Designation: Thickness t	Mass per Metre	Area of Section A	Ratio for Local Buckling d/t	Second Moment of Area I	Radius of Gyration i	Elastic Modulus W_{el}	Plastic Modulus W_{pl}	Torsional Constants I_T	Torsional Constants W_t	Surface Area Per Metre	Surface Area Per Tonne
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
139.7	3.2 #	10.8	13.7	43.7	320	4.83	45.8	59.6	640	91.6	0.439	40.7
	3.6 #	12.1	15.4	38.8	357	4.81	51.1	66.7	713	102	0.439	36.3
	4.0 #	13.4	17.1	34.9	393	4.80	56.2	73.7	786	112	0.439	32.8
	4.5 #	15.0	19.1	31.0	437	4.78	62.6	82.3	874	125	0.439	29.2
	5.0	16.6	21.2	27.9	481	4.77	68.8	90.8	961	138	0.439	26.4
	5.6 #	18.5	23.6	24.9	531	4.75	76.1	101	1060	152	0.439	23.7
	6.3	20.7	26.4	22.2	589	4.72	84.3	112	1180	169	0.439	21.2
	8.0	26.0	33.1	17.5	720	4.66	103	139	1440	206	0.439	16.9
	10.0	32.0	40.7	14.0	862	4.60	123	169	1720	247	0.439	13.7
	12.5 #	39.2	50.0	11.2	1020	4.52	146	203	2040	292	0.439	11.2
168.3	5.0	20.1	25.7	33.7	856	5.78	102	133	1710	203	0.529	26.3
	5.6 #	22.5	28.6	30.1	948	5.76	113	148	1900	225	0.529	23.5
	6.3	25.2	32.1	26.7	1050	5.73	125	165	2110	250	0.529	21.0
	8.0	31.6	40.3	21.0	1300	5.67	154	206	2600	308	0.529	16.7
	10.0	39.0	49.7	16.8	1560	5.61	186	251	3130	372	0.529	13.5
	12.5	48.0	61.2	13.5	1870	5.53	222	304	3740	444	0.529	11.0
193.7	5.0	23.3	29.6	38.7	1320	6.67	136	178	2640	273	0.609	26.2
	5.6 #	26.0	33.1	34.6	1470	6.65	151	198	2930	303	0.609	23.4
	6.3	29.1	37.1	30.7	1630	6.63	168	221	3260	337	0.609	20.9
	8.0	36.6	46.7	24.2	2020	6.57	208	276	4030	416	0.609	16.6
	10.0	45.3	57.7	19.4	2440	6.50	252	338	4880	504	0.609	13.5
	12.5	55.9	71.2	15.5	2930	6.42	303	411	5870	606	0.609	10.9
	16.0 #	70.1	89.3	12.1	3550	6.31	367	507	7110	734	0.609	8.71
219.1	4.5 #	23.8	30.3	48.7	1750	7.59	159	207	3490	319	0.688	28.9
	5.0 #	26.4	33.6	43.8	1930	7.57	176	229	3860	352	0.688	26.1
	5.6 #	29.5	37.6	39.1	2140	7.55	195	255	4280	391	0.688	23.3
	6.3	33.1	42.1	34.8	2390	7.53	218	285	4770	436	0.688	20.8
	8.0	41.6	53.1	27.4	2960	7.47	270	357	5920	540	0.688	16.5
	10.0	51.6	65.7	21.9	3600	7.40	328	438	7200	657	0.688	13.3
	12.5	63.7	81.1	17.5	4350	7.32	397	534	8690	793	0.688	10.8
	14.2 #	71.8	91.4	15.4	4820	7.26	440	597	9640	880	0.688	9.56
	16.0	80.1	102	13.7	5300	7.20	483	661	10600	967	0.688	8.60
244.5	5.0 #	29.5	37.6	48.9	2700	8.47	221	287	5400	441	0.768	26.0
	5.6 #	33.0	42.0	43.7	3000	8.45	245	320	6000	491	0.768	23.3
	6.3 #	37.0	47.1	38.8	3350	8.42	274	358	6690	547	0.768	20.7
	8.0 #	46.7	59.4	30.6	4160	8.37	340	448	8320	681	0.768	16.4
	10.0 #	57.8	73.7	24.5	5070	8.30	415	550	10100	830	0.768	13.3
	12.5	71.5	91.1	19.6	6150	8.21	503	673	12300	1010	0.768	10.8
	14.2 #	80.6	103	17.2	6840	8.16	559	754	13700	1120	0.768	9.52
	16.0	90.2	115	15.3	7530	8.10	616	837	15100	1230	0.768	8.52

Table 2.8.1.3. Celsius® CHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

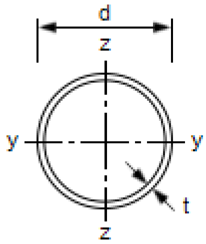
Table 2.8.1.4

SECTION PROPERTIES

HOT FINISHED CIRCULAR HOLLOW SECTIONS

Celsius® CHS

Dimensions and properties



Hot Finished

Section Designation: Outside Diameter d (mm)	Section Designation: Thickness t (mm)	Mass per Metre (kg/m)	Area of Section A (cm^2)	Ratio for Local Buckling d/t	Second Moment of Area I (cm^4)	Radius of Gyration i (cm)	Elastic Modulus W_{el} (cm^3)	Plastic Modulus W_{pl} (cm^3)	Torsional Constants I_T (cm^4)	Torsional Constants W_t (cm^3)	Surface Area Per Metre (m^2)	Surface Area Per Tonne (m^2)
273.0	5.0 #	33.0	42.1	54.6	3780	9.48	277	359	7560	554	0.858	26.0
	5.6 #	36.9	47.0	48.8	4210	9.46	308	400	8410	616	0.858	23.3
	6.3 #	41.4	52.8	43.3	4700	9.43	344	448	9390	688	0.858	20.7
	8.0 #	52.3	66.6	34.1	5850	9.37	429	562	11700	857	0.858	16.4
	10.0	64.9	82.6	27.3	7150	9.31	524	692	14300	1050	0.858	13.2
	12.5	80.3	102	21.8	8700	9.22	637	849	17400	1270	0.858	10.7
	14.2 #	90.6	115	19.2	9700	9.16	710	952	19400	1420	0.858	9.44
	16.0	101	129	17.1	10700	9.10	784	1060	21400	1570	0.858	8.46
323.9	5.0 #	39.3	50.1	64.8	6370	11.3	393	509	12700	787	1.02	25.9
	5.6 #	44.0	56.0	57.8	7090	11.3	438	567	14200	876	1.02	23.2
	6.3 #	49.3	62.9	51.4	7930	11.2	490	636	15900	979	1.02	20.7
	8.0 #	62.3	79.4	40.5	9910	11.2	612	799	19800	1220	1.02	16.3
	10.0	77.4	98.6	32.4	12200	11.1	751	986	24300	1500	1.02	13.2
	12.5	96.0	122	25.9	14800	11.0	917	1210	29700	1830	1.02	10.6
	14.2 #	108	138	22.8	16600	11.0	1030	1360	33200	2050	1.02	9.40
	16.0	121	155	20.2	18400	10.9	1140	1520	36800	2270	1.02	8.39
355.6	6.3 #	54.3	69.1	56.4	10500	12.4	593	769	21100	1190	1.12	20.6
	8.0 #	68.6	87.4	44.5	13200	12.3	742	967	26400	1490	1.12	16.4
	10.0 #	85.2	109	35.6	16200	12.2	912	1200	32400	1830	1.12	13.1
	12.5 #	106	135	28.4	19900	12.1	1120	1470	39700	2230	1.12	10.6
	14.2 #	120	152	25.0	22200	12.1	1250	1660	44500	2500	1.12	9.36
	16.0	134	171	22.2	24700	12.0	1390	1850	49300	2770	1.12	8.36
406.4	6.3 #	62.2	79.2	64.5	15800	14.1	780	1010	31700	1560	1.28	20.6
	8.0 #	78.6	100	50.8	19900	14.1	978	1270	39700	1960	1.28	16.3
	10.0	97.8	125	40.6	24500	14.0	1210	1570	49000	2410	1.28	13.1
	12.5 #	121	155	32.5	30000	13.9	1480	1940	60100	2960	1.28	10.5
	14.2 #	137	175	28.6	33700	13.9	1660	2190	67400	3320	1.28	9.32
	16.0	154	196	25.4	37400	13.8	1840	2440	74900	3690	1.28	8.31
457.0	6.3 #	70.0	89.2	72.5	22700	15.9	991	1280	45300	1980	1.44	20.6
	8.0 #	88.6	113	57.1	28400	15.9	1250	1610	56900	2490	1.44	16.3
	10.0	110	140	45.7	35100	15.8	1540	2000	70200	3070	1.44	13.1
	12.5 #	137	175	36.6	43100	15.7	1890	2470	86300	3780	1.44	10.5
	14.2 #	155	198	32.2	48500	15.7	2120	2790	96900	4240	1.44	9.29
	16.0	174	222	28.6	54000	15.6	2360	3110	108000	4720	1.44	8.28
508.0	6.3 #	77.9	99.3	80.6	31200	17.7	1230	1590	62500	2460	1.60	20.5
	8.0 #	98.6	126	63.5	39300	17.7	1550	2000	78600	3090	1.60	16.2
	10.0 #	123	156	50.8	48500	17.6	1910	2480	97000	3820	1.60	13.0
	12.5	153	195	40.6	59800	17.5	2350	3070	120000	4710	1.60	10.5
	14.2 #	173	220	35.8	67200	17.5	2650	3460	134000	5290	1.60	9.25
	16.0	194	247	31.8	74900	17.4	2950	3870	150000	5900	1.60	8.24

Table 2.8.1.4. Celsius® CHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

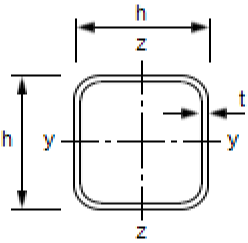
Table 2.8.2.1

SECTION PROPERTIES

HOT FINISHED
SQUARE HOLLOW SECTIONS

Celsius® SHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
Size	Thickness										Per Metre	Per Tonne
h x h	t		A	c/t (1)	I	i	W_{el}	W_{pl}	I_T	W_t		
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
40 x 40	3.0 #	3.41	4.34	10.3	9.78	1.50	4.89	5.97	15.7	7.10	0.152	44.5
	3.2	3.61	4.60	9.50	10.2	1.49	5.11	6.28	16.5	7.42	0.152	42.1
	3.6 #	4.01	5.10	8.11	11.1	1.47	5.54	6.88	18.1	8.01	0.151	37.8
	4.0	4.39	5.59	7.00	11.8	1.45	5.91	7.44	19.5	8.54	0.150	34.2
	5.0	5.28	6.73	5.00	13.4	1.41	6.68	8.66	22.5	9.60	0.147	27.8
50 x 50	3.0 #	4.35	5.54	13.7	20.2	1.91	8.08	9.70	32.1	11.8	0.192	44.2
	3.2	4.62	5.88	12.6	21.2	1.90	8.49	10.2	33.8	12.4	0.192	41.7
	3.6 #	5.14	6.54	10.9	23.2	1.88	9.27	11.3	37.2	13.5	0.191	37.2
	4.0	5.64	7.19	9.50	25.0	1.86	9.99	12.3	40.4	14.5	0.190	33.6
	5.0	6.85	8.73	7.00	28.9	1.82	11.6	14.5	47.6	16.7	0.187	27.3
	6.3	8.31	10.6	4.94	32.8	1.76	13.1	17.0	55.2	18.8	0.184	22.1
	7.1 #	9.14	11.6	4.04	34.5	1.72	13.8	18.3	58.9	19.8	0.182	19.8
	8.0 #	10.0	12.8	3.25	36.0	1.68	14.4	19.5	62.3	20.6	0.179	17.9
60 x 60	3.0 #	5.29	6.74	17.0	36.2	2.32	12.1	14.3	56.9	17.7	0.232	43.8
	3.2	5.62	7.16	15.8	38.2	2.31	12.7	15.2	60.2	18.6	0.232	41.3
	3.6 #	6.27	7.98	13.7	41.9	2.29	14.0	16.8	66.5	20.4	0.231	37.0
	4.0	6.90	8.79	12.0	45.4	2.27	15.1	18.3	72.5	22.0	0.230	33.4
	5.0	8.42	10.7	9.00	53.3	2.23	17.8	21.9	86.4	25.7	0.227	27.0
	6.3	10.3	13.1	6.52	61.6	2.17	20.5	26.0	102	29.6	0.224	21.8
	7.1 #	11.4	14.5	5.45	65.8	2.13	21.9	28.2	110	31.6	0.222	19.5
	8.0	12.5	16.0	4.50	69.7	2.09	23.2	30.4	118	33.4	0.219	17.5
70 x 70	3.0 #	6.24	7.94	20.3	59.0	2.73	16.9	19.9	92.2	24.8	0.272	43.5
	3.2	6.63	8.44	18.9	62.3	2.72	17.8	21.0	97.6	26.1	0.272	41.1
	3.6 #	7.40	9.42	16.4	68.6	2.70	19.6	23.3	108	28.7	0.271	36.6
	4.0	8.15	10.4	14.5	74.7	2.68	21.3	25.5	118	31.2	0.270	33.2
	5.0	9.99	12.7	11.0	88.5	2.64	25.3	30.8	142	36.8	0.267	26.7
	6.3	12.3	15.6	8.11	104	2.58	29.7	36.9	169	42.9	0.264	21.5
	7.1 #	13.6	17.3	6.86	112	2.54	32.0	40.3	185	46.1	0.262	19.3
	8.0	15.0	19.2	5.75	120	2.50	34.2	43.8	200	49.2	0.259	17.2
	8.8 #	16.3	20.7	4.95	126	2.46	35.9	46.6	212	51.6	0.257	15.8
80 x 80	3.0 #	7.18	9.14	23.7	89.8	3.13	22.5	26.3	140	33.0	0.312	43.4
	3.2	7.63	9.72	22.0	95.0	3.13	23.7	27.9	148	34.9	0.312	40.9
	3.6 #	8.53	10.9	19.2	105	3.11	26.2	31.0	164	38.5	0.311	36.4
	4.0	9.41	12.0	17.0	114	3.09	28.6	34.0	180	41.9	0.310	32.9
	5.0	11.6	14.7	13.0	137	3.05	34.2	41.1	217	49.8	0.307	26.6
	6.3	14.2	18.1	9.70	162	2.99	40.5	49.7	262	58.7	0.304	21.3
	7.1 #	15.8	20.2	8.27	176	2.95	43.9	54.5	286	63.5	0.302	19.1
	8.0	17.5	22.4	7.00	189	2.91	47.3	59.5	312	68.3	0.299	17.0
	8.8 #	19.0	24.2	6.09	200	2.87	50.0	63.7	332	72.0	0.297	15.6
	10.0 #	21.1	26.9	5.00	214	2.82	53.5	69.3	360	76.8	0.294	13.9
	12.5 #	25.2	32.1	3.40	234	2.70	58.6	78.9	404	83.8	0.288	11.4

Table 2.8.2.1. Celsius® SHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

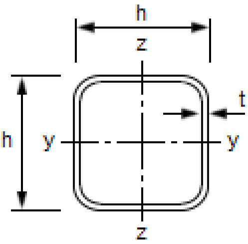
Table 2.8.2.2

SECTION PROPERTIES

HOT FINISHED SQUARE HOLLOW SECTIONS

Celsius® SHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
Size h x h	Thickness t		A	c/t (1)	I	i	W_{el}	W_{pl}	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
90 x 90	3.6 #	9.66	12.3	22.0	152	3.52	33.8	39.7	237	49.7	0.351	36.5
	4.0	10.7	13.6	19.5	166	3.50	37.0	43.6	260	54.2	0.350	32.8
	5.0	13.1	16.7	15.0	200	3.45	44.4	53.0	316	64.8	0.347	26.4
	6.3	16.2	20.7	11.3	238	3.40	53.0	64.3	382	77.0	0.344	21.2
	7.1 #	18.1	23.0	9.68	260	3.36	57.7	70.8	419	83.7	0.342	18.9
	8.0	20.1	25.6	8.25	281	3.32	62.6	77.6	459	90.5	0.339	16.9
	8.8 #	21.8	27.8	7.23	299	3.28	66.5	83.4	492	96.0	0.337	15.5
	10.0 #	24.3	30.9	6.00	322	3.23	71.6	91.3	536	103	0.334	13.8
	12.5 #	29.1	37.1	4.20	359	3.11	79.8	105	612	114	0.328	11.3
100 x 100	3.6	10.8	13.7	24.8	212	3.92	42.3	49.5	328	62.3	0.391	36.2
	4.0	11.9	15.2	22.0	232	3.91	46.4	54.4	361	68.2	0.390	32.7
	5.0	14.7	18.7	17.0	279	3.86	55.9	66.4	439	81.8	0.387	26.3
	6.3	18.2	23.2	12.9	336	3.80	67.1	80.9	534	97.8	0.384	21.1
	7.1 #	20.3	25.8	11.1	367	3.77	73.4	89.2	589	107	0.382	18.8
	8.0	22.6	28.8	9.50	400	3.73	79.9	98.2	646	116	0.379	16.8
	8.8 #	24.5	31.3	8.36	426	3.69	85.2	106	694	123	0.377	15.3
	10.0	27.4	34.9	7.00	462	3.64	92.4	116	761	133	0.374	13.7
	12.5 #	33.0	42.1	5.00	522	3.52	104	135	879	150	0.368	11.2
120 x 120	4.0 #	14.4	18.4	27.0	410	4.72	68.4	79.7	635	101	0.470	32.6
	5.0	17.8	22.7	21.0	498	4.68	83.0	97.6	777	122	0.467	26.2
	6.3	22.2	28.2	16.0	603	4.62	100	120	950	147	0.464	20.9
	7.1 #	24.7	31.5	13.9	663	4.59	110	133	1050	161	0.462	18.7
	8.0	27.6	35.2	12.0	726	4.55	121	146	1160	176	0.459	16.6
	8.8 #	30.1	38.3	10.6	779	4.51	130	158	1250	189	0.457	15.2
	10.0	33.7	42.9	9.00	852	4.46	142	175	1380	206	0.454	13.5
	12.5	40.9	52.1	6.60	982	4.34	164	207	1620	236	0.448	11.0
140 x 140	5.0	21.0	26.7	25.0	807	5.50	115	135	1250	170	0.547	26.1
	6.3	26.1	33.3	19.2	984	5.44	141	166	1540	206	0.544	20.8
	7.1 #	29.2	37.2	16.7	1090	5.40	155	184	1710	227	0.542	18.5
	8.0	32.6	41.6	14.5	1200	5.36	171	204	1890	249	0.539	16.5
	8.8 #	35.6	45.4	12.9	1290	5.33	184	221	2050	268	0.537	15.1
	10.0	40.0	50.9	11.0	1420	5.27	202	246	2270	294	0.534	13.4
	12.5	48.7	62.1	8.20	1650	5.16	236	293	2700	342	0.528	10.8

Table 2.8.2.2. Celsius® SHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

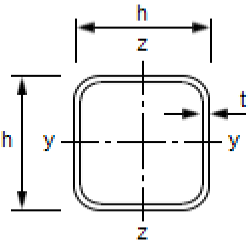
Table 2.8.2.3

SECTION PROPERTIES

HOT FINISHED SQUARE HOLLOW SECTIONS

Celsius® SHS

Dimensions and properties



Hot Finished

Section Designation: Size	Section Designation: Thickness	Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area: Per Metre	Surface Area: Per Tonne
h x h	t		A	c/t (1)	I	i	W_{el}	W_{pl}	I_T	W_t		
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
150 x 150	5.0	22.6	28.7	27.0	1000	5.90	134	156	1550	197	0.587	26.0
	6.3	28.1	35.8	20.8	1220	5.85	163	192	1910	240	0.584	20.8
	7.1 #	31.4	40.0	18.1	1350	5.81	180	213	2120	264	0.582	18.5
	8.0	35.1	44.8	15.8	1490	5.77	199	237	2350	291	0.579	16.5
	8.8 #	38.4	48.9	14.0	1610	5.74	214	257	2550	313	0.577	15.1
	10.0	43.1	54.9	12.0	1770	5.68	236	286	2830	344	0.574	13.3
	12.5	52.7	67.1	9.00	2080	5.57	277	342	3380	402	0.568	10.8
	14.2 #	58.9	75.0	7.56	2260	5.49	302	377	3710	436	0.563	9.57
	16.0 # r	65.2	83.0	6.38	2430	5.41	324	411	4030	467	0.559	8.55
160 x 160	5.0 #	24.1	30.7	29.0	1230	6.31	153	178	1890	226	0.627	26.0
	6.3	30.1	38.3	22.4	1500	6.26	187	220	2330	275	0.624	20.8
	7.1 #	33.7	42.9	19.5	1660	6.22	207	245	2600	304	0.622	18.5
	8.0	37.6	48.0	17.0	1830	6.18	229	272	2880	335	0.619	16.5
	8.8 #	41.1	52.4	15.2	1980	6.14	247	295	3130	361	0.617	15.0
	10.0	46.3	58.9	13.0	2190	6.09	273	329	3480	398	0.614	13.3
	12.5	56.6	72.1	9.80	2580	5.98	322	395	4160	467	0.608	10.8
	14.2 #	63.3	80.7	8.27	2810	5.90	351	436	4580	508	0.603	9.53
	16.0 #	70.2	89.4	7.00	3030	5.82	379	476	4990	546	0.599	8.51
180 x 180	5.0 #	27.3	34.7	33.0	1770	7.13	196	227	2720	290	0.707	25.9
	6.3	34.0	43.3	25.6	2170	7.07	241	281	3360	355	0.704	20.7
	7.1 #	38.1	48.6	22.4	2400	7.04	267	314	3740	393	0.702	18.4
	8.0	42.7	54.4	19.5	2660	7.00	296	349	4160	434	0.699	16.4
	8.8 #	46.7	59.4	17.5	2880	6.96	320	379	4520	469	0.697	14.9
	10.0	52.5	66.9	15.0	3190	6.91	355	424	5050	518	0.694	13.2
	12.5	64.4	82.1	11.4	3790	6.80	421	511	6070	613	0.688	10.7
	14.2 #	72.2	92.0	9.68	4150	6.72	462	566	6710	670	0.683	9.43
	16.0	80.2	102	8.25	4500	6.64	500	621	7340	724	0.679	8.49
200 x 200	5.0	30.4	38.7	37.0	2450	7.95	245	283	3760	362	0.787	25.9
	6.3	38.0	48.4	28.7	3010	7.89	301	350	4650	444	0.784	20.6
	7.1 #	42.6	54.2	25.2	3350	7.85	335	391	5190	493	0.782	18.4
	8.0	47.7	60.8	22.0	3710	7.81	371	436	5780	545	0.779	16.4
	8.8 #	52.2	66.5	19.7	4020	7.78	402	474	6290	590	0.777	14.9
	10.0	58.8	74.9	17.0	4470	7.72	447	531	7030	655	0.774	13.2
	12.5	72.3	92.1	13.0	5340	7.61	534	643	8490	778	0.768	10.6
	14.2 #	81.1	103	11.1	5870	7.54	587	714	9420	854	0.763	9.38
	16.0	90.3	115	9.50	6390	7.46	639	785	10300	927	0.759	8.42

Table 2.8.2.3. Celsius® SHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

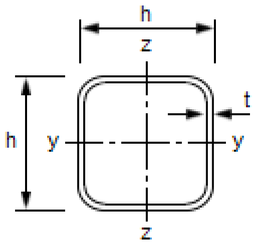
Table 2.8.2.4

SECTION PROPERTIES

HOT FINISHED SQUARE HOLLOW SECTIONS

Celsius® SHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
Size	Thickness										Per Metre	Per Tonne
h x h	t		A	c/t (1)	I	i	W_{el}	W_{pl}	I_T	W_t		
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
250 x 250	5.0 #	38.3	48.7	47.0	4860	9.99	389	447	7430	577	0.987	25.8
	6.3	47.9	61.0	36.7	6010	9.93	481	556	9240	712	0.984	20.6
	7.1 #	53.7	68.4	32.2	6700	9.90	536	622	10300	792	0.982	18.3
	8.0	60.3	76.8	28.3	7460	9.86	596	694	11500	880	0.979	16.3
	8.8 #	66.0	84.1	25.4	8110	9.82	649	758	12600	955	0.977	14.9
	10.0	74.5	94.9	22.0	9060	9.77	724	851	14100	1070	0.974	13.1
	12.5	91.9	117	17.0	10900	9.66	873	1040	17200	1280	0.968	10.6
	14.2 #	103	132	14.6	12100	9.58	967	1160	19100	1410	0.963	9.31
	16.0	115	147	12.6	13300	9.50	1060	1280	21100	1550	0.959	8.31
260 x 260	6.3 #	49.9	63.5	38.3	6790	10.3	522	603	10400	773	1.02	20.5
	7.1 #	56.0	71.3	33.6	7570	10.3	582	674	11600	861	1.02	18.3
	8.0 #	62.8	80.0	29.5	8420	10.3	648	753	13000	956	1.02	16.2
	8.8 #	68.8	87.6	26.5	9160	10.2	705	822	14200	1040	1.02	14.8
	10.0 #	77.7	98.9	23.0	10200	10.2	788	924	15900	1160	1.01	13.0
	12.5 #	95.8	122	17.8	12400	10.1	951	1130	19400	1390	1.01	10.5
	14.2 #	108	137	15.3	13700	9.99	1060	1260	21700	1540	1.00	9.27
	16.0 #	120	153	13.3	15100	9.91	1160	1390	23900	1690	0.999	8.29
300 x 300	6.3 #	57.8	73.6	44.6	10500	12.0	703	809	16100	1040	1.18	20.4
	7.1 #	64.9	82.6	39.3	11800	11.9	785	906	18100	1160	1.18	18.2
	8.0	72.8	92.8	34.5	13100	11.9	875	1010	20200	1290	1.18	16.2
	8.8 #	79.8	102	31.1	14300	11.9	954	1110	22100	1410	1.18	14.8
	10.0	90.2	115	27.0	16000	11.8	1070	1250	24800	1580	1.17	13.0
	12.5	112	142	21.0	19400	11.7	1300	1530	30300	1900	1.17	10.5
	14.2 #	126	160	18.1	21600	11.6	1440	1710	33900	2110	1.16	9.22
	16.0	141	179	15.8	23900	11.5	1590	1900	37600	2330	1.16	8.26
350 x 350	8.0	85.4	109	40.8	21100	13.9	1210	1390	32400	1790	1.38	16.1
	8.8 #	93.6	119	36.8	23100	13.9	1320	1520	35400	1950	1.38	14.8
	10.0	106	135	32.0	25900	13.9	1480	1720	39900	2190	1.37	12.9
	12.5	131	167	25.0	31500	13.7	1800	2110	48900	2650	1.37	10.4
	14.2 #	148	189	21.6	35200	13.7	2010	2360	54900	2960	1.36	9.19
	16.0	166	211	18.9	38900	13.6	2230	2630	61000	3260	1.36	8.21
400 x 400	8.0 #	97.9	125	47.0	31900	16.0	1590	1830	48700	2360	1.58	16.1
	8.8 #	107	137	42.5	34800	15.9	1740	2000	53300	2580	1.58	14.7
	10.0	122	155	37.0	39100	15.9	1960	2260	60100	2900	1.57	12.9
	12.5	151	192	29.0	47800	15.8	2390	2780	73900	3530	1.57	10.4
	14.2 #	170	217	25.2	53500	15.7	2680	3130	83000	3940	1.56	9.16
	16.0	191	243	22.0	59300	15.6	2970	3480	92400	4360	1.56	8.17
	20.0 ^	235	300	17.0	71500	15.4	3580	4250	112000	5240	1.55	6.59

Table 2.8.2.4. Celsius® SHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

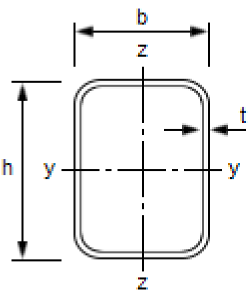
Table 2.8.3.1

SECTION PROPERTIES

HOT FINISHED RECTANGULAR HOLLOW SECTIONS

Celsius® RHS

Dimensions and properties



Hot Finished

Section Designation		Mass per	Area of	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size	Thickness	Metre	Section			Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z			Per Metre	Per Tonne
h x b			A	c_w/t (1)	c_f/t (1)									I_T	W_t		
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
50 x 30	3.0 #	3.41	4.34	13.7	7.00	13.6	5.94	1.77	1.17	5.43	3.96	6.88	4.76	13.5	6.51	0.152	44.5
	3.2	3.61	4.60	12.6	6.38	14.2	6.20	1.76	1.16	5.68	4.13	7.25	5.00	14.2	6.80	0.152	42.1
	3.6 #	4.01	5.10	10.9	5.33	15.4	6.67	1.74	1.14	6.16	4.45	7.94	5.46	15.4	7.31	0.151	37.8
	4.0	4.39	5.59	9.50	4.50	16.5	7.08	1.72	1.13	6.60	4.72	8.59	5.88	16.6	7.77	0.150	34.2
	5.0	5.28	6.73	7.00	3.00	18.7	7.89	1.67	1.08	7.49	5.26	10.0	6.80	19.0	8.67	0.147	27.8
60 x 40	3.0 #	4.35	5.54	17.0	10.3	26.5	13.9	2.18	1.58	8.82	6.95	10.9	8.19	29.2	11.2	0.192	44.2
	3.2	4.62	5.88	15.8	9.50	27.8	14.6	2.18	1.57	9.27	7.29	11.5	8.64	30.8	11.7	0.192	41.7
	3.6 #	5.14	6.54	13.7	8.11	30.4	15.9	2.16	1.56	10.1	7.93	12.7	9.50	33.8	12.8	0.191	37.2
	4.0	5.64	7.19	12.0	7.00	32.8	17.0	2.14	1.54	10.9	8.52	13.8	10.3	36.7	13.7	0.190	33.6
	5.0	6.85	8.73	9.00	5.00	38.1	19.5	2.09	1.50	12.7	9.77	16.4	12.2	43.0	15.7	0.187	27.3
	6.3	8.31	10.6	6.52	3.35	43.4	21.9	2.02	1.44	14.5	11.0	19.2	14.2	49.5	17.6	0.184	22.1
80 x 40	3.0 #	5.29	6.74	23.7	10.3	54.2	18.0	2.84	1.63	13.6	9.00	17.1	10.4	43.8	15.3	0.232	43.8
	3.2	5.62	7.16	22.0	9.50	57.2	18.9	2.83	1.63	14.3	9.46	18.0	11.0	46.2	16.1	0.232	41.3
	3.6 #	6.27	7.98	19.2	8.11	62.8	20.6	2.81	1.61	15.7	10.3	20.0	12.1	50.8	17.5	0.231	37.0
	4.0	6.90	8.79	17.0	7.00	68.2	22.2	2.79	1.59	17.1	11.1	21.8	13.2	55.2	18.9	0.230	33.4
	5.0	8.42	10.7	13.0	5.00	80.3	25.7	2.74	1.55	20.1	12.9	26.1	15.7	65.1	21.9	0.227	27.0
	6.3	10.3	13.1	9.70	3.35	93.3	29.2	2.67	1.49	23.3	14.6	31.1	18.4	75.6	24.8	0.224	21.8
	7.1 #	11.4	14.5	8.27	2.63	99.8	30.7	2.63	1.46	25.0	15.4	33.8	19.8	80.9	26.2	0.222	19.5
	8.0	12.5	16.0	7.00	2.00	106	32.1	2.58	1.42	26.5	16.1	36.5	21.2	85.8	27.4	0.219	17.5
90 x 50	3.0 #	6.24	7.94	27.0	13.7	84.4	33.5	3.26	2.05	18.8	13.4	23.2	15.3	76.5	22.4	0.272	43.5
	3.2	6.63	8.44	25.1	12.6	89.1	35.3	3.25	2.04	19.8	14.1	24.6	16.2	80.9	23.6	0.272	41.1
	3.6 #	7.40	9.42	22.0	10.9	98.3	38.7	3.23	2.03	21.8	15.5	27.2	18.0	89.4	25.9	0.271	36.6
	4.0	8.15	10.4	19.5	9.50	107	41.9	3.21	2.01	23.8	16.8	29.8	19.6	97.5	28.0	0.270	33.2
	5.0	9.99	12.7	15.0	7.00	127	49.2	3.16	1.97	28.3	19.7	36.0	23.5	116	32.9	0.267	26.7
	6.3	12.3	15.6	11.3	4.94	150	57.0	3.10	1.91	33.3	22.8	43.2	28.0	138	38.1	0.264	21.5
	7.1 #	13.6	17.3	9.68	4.04	162	60.9	3.06	1.88	36.0	24.4	47.2	30.5	149	40.7	0.262	19.3
	8.0	15.0	19.2	8.25	3.25	174	64.6	3.01	1.84	38.6	25.8	51.4	32.9	160	43.2	0.259	17.2
100 x 50	3.0 #	6.71	8.54	30.3	13.7	110	36.8	3.58	2.08	21.9	14.7	27.3	16.8	88.4	25.0	0.292	43.5
	3.2	7.13	9.08	28.3	12.6	116	38.8	3.57	2.07	23.2	15.5	28.9	17.7	93.4	26.4	0.292	40.9
	3.6 #	7.96	10.1	24.8	10.9	128	42.6	3.55	2.05	25.6	17.0	32.1	19.6	103	29.0	0.291	36.7
	4.0	8.78	11.2	22.0	9.50	140	46.2	3.53	2.03	27.9	18.5	35.2	21.5	113	31.4	0.290	33.1
	5.0	10.8	13.7	17.0	7.00	167	54.3	3.48	1.99	33.3	21.7	42.6	25.8	135	36.9	0.287	26.6
	6.3	13.3	16.9	12.9	4.94	197	63.0	3.42	1.93	39.4	25.2	51.3	30.8	160	42.9	0.284	21.4
	7.1 #	14.7	18.7	11.1	4.04	214	67.5	3.38	1.90	42.7	27.0	56.3	33.5	173	46.0	0.282	19.2
	8.0	16.3	20.8	9.50	3.25	230	71.7	3.33	1.86	46.0	28.7	61.4	36.3	186	48.9	0.279	17.1
	8.8 #	17.6	22.5	8.36	2.68	243	74.8	3.29	1.82	48.5	29.9	65.6	38.5	197	51.1	0.277	15.7
	10.0 #	19.6	24.9	7.00	2.00	259	78.4	3.22	1.77	51.8	31.4	71.2	41.4	209	53.6	0.274	14.0

Table 2.8.3.1. Celsius® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

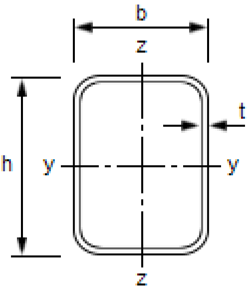
Table 2.8.3.2

SECTION PROPERTIES

HOT FINISHED
RECTANGULAR HOLLOW SECTIONS

Celsius® RHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size h x b	Thickness		A	c_w/t (1)	c_f/t (1)	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
100 x 60	3.0 #	7.18	9.14	30.3	17.0	124	55.7	3.68	2.47	24.7	18.6	30.2	21.2	121	30.7	0.312	43.4
	3.2	7.63	9.72	28.3	15.8	131	58.8	3.67	2.46	26.2	19.6	32.0	22.4	129	32.4	0.312	40.9
	3.6 #	8.53	10.9	24.8	13.7	145	64.8	3.65	2.44	28.9	21.6	35.6	24.9	142	35.6	0.311	36.4
	4.0	9.41	12.0	22.0	12.0	158	70.5	3.63	2.43	31.6	23.5	39.1	27.3	156	38.7	0.310	32.9
	5.0	11.6	14.7	17.0	9.00	189	83.6	3.58	2.38	37.8	27.9	47.4	32.9	188	45.9	0.307	26.6
	6.3	14.2	18.1	12.9	6.52	225	98.1	3.52	2.33	45.0	32.7	57.3	39.5	224	53.8	0.304	21.3
	7.1 #	15.8	20.2	11.1	5.45	244	106	3.48	2.29	48.8	35.3	62.9	43.2	245	58.0	0.302	19.1
	8.0	17.5	22.4	9.50	4.50	264	113	3.44	2.25	52.8	37.8	68.7	47.1	265	62.2	0.299	17.0
	8.8 #	19.0	24.2	8.36	3.82	279	119	3.40	2.22	55.9	39.7	73.6	50.2	282	65.4	0.297	15.6
	10.0 #	21.1	26.9	7.00	3.00	299	126	3.33	2.16	59.9	42.1	80.2	54.4	304	69.3	0.294	13.9
120 x 60	3.0 #	8.12	10.3	37.0	17.0	194	65.5	4.33	2.52	32.3	21.8	40.0	24.6	156	37.2	0.352	43.3
	3.2 #	8.64	11.0	34.5	15.8	205	69.2	4.32	2.51	34.2	23.1	42.4	26.1	165	39.2	0.352	40.8
	3.6 #	9.66	12.3	30.3	13.7	227	76.3	4.30	2.49	37.9	25.4	47.2	28.9	183	43.3	0.351	36.5
	4.0	10.7	13.6	27.0	12.0	249	83.1	4.28	2.47	41.5	27.7	51.9	31.7	201	47.1	0.350	32.8
	5.0	13.1	16.7	21.0	9.00	299	98.8	4.23	2.43	49.9	32.9	63.1	38.4	242	56.0	0.347	26.4
	6.3	16.2	20.7	16.0	6.52	358	116	4.16	2.37	59.7	38.8	76.7	46.3	290	65.9	0.344	21.2
	7.1 #	18.1	23.0	13.9	5.45	391	126	4.12	2.34	65.2	41.9	84.4	50.8	317	71.3	0.342	18.9
	8.0	20.1	25.6	12.0	4.50	425	135	4.08	2.30	70.8	45.0	92.7	55.4	344	76.6	0.339	16.9
	8.8 #	21.8	27.8	10.6	3.82	452	142	4.04	2.27	75.3	47.5	99.6	59.2	366	80.8	0.337	15.5
	10.0 #	24.3	30.9	9.00	3.00	488	152	3.97	2.21	81.4	50.5	109	64.4	396	86.1	0.334	13.8
	12.5 #	29.1	37.1	6.60	1.80	546	165	3.84	2.11	91.1	54.9	126	73.1	442	93.8	0.328	11.3
120 x 80	3.6 #	10.8	13.7	30.3	19.2	276	147	4.48	3.27	46.0	36.7	55.6	42.0	301	59.5	0.391	36.2
	4.0	11.9	15.2	27.0	17.0	303	161	4.46	3.25	50.4	40.2	61.2	46.1	330	65.0	0.390	32.7
	5.0	14.7	18.7	21.0	13.0	365	193	4.42	3.21	60.9	48.2	74.6	56.1	401	77.9	0.387	26.3
	6.3	18.2	23.2	16.0	9.70	440	230	4.36	3.15	73.3	57.6	91.0	68.2	487	92.9	0.384	21.1
	7.1 #	20.3	25.8	13.9	8.27	482	251	4.32	3.12	80.3	62.8	100	75.2	535	101	0.382	18.8
	8.0	22.6	28.8	12.0	7.00	525	273	4.27	3.08	87.5	68.1	111	82.6	587	110	0.379	16.8
	8.8 #	24.5	31.3	10.6	6.09	561	290	4.24	3.04	93.5	72.4	119	88.7	629	117	0.377	15.3
	10.0	27.4	34.9	9.00	5.00	609	313	4.18	2.99	102	78.1	131	97.3	688	126	0.374	13.7
	12.5 #	33.0	42.1	6.60	3.40	692	349	4.05	2.88	115	87.4	153	113	789	141	0.368	11.2
150 x 100	4.0 #	15.1	19.2	34.5	22.0	607	324	5.63	4.11	81.0	64.8	97.4	73.6	660	105	0.490	32.5
	5.0	18.6	23.7	27.0	17.0	739	392	5.58	4.07	98.5	78.5	119	90.1	807	127	0.487	26.2
	6.3	23.1	29.5	20.8	12.9	898	474	5.52	4.01	120	94.8	147	110	986	153	0.484	20.9
	7.1 #	25.9	32.9	18.1	11.1	990	520	5.48	3.97	132	104	163	122	1090	168	0.482	18.7
	8.0	28.9	36.8	15.8	9.50	1090	569	5.44	3.94	145	114	180	135	1200	183	0.479	16.6
	8.8 #	31.5	40.1	14.0	8.36	1170	610	5.40	3.90	156	122	195	146	1300	196	0.477	15.2
	10.0	35.3	44.9	12.0	7.00	1280	665	5.34	3.85	171	133	216	161	1430	214	0.474	13.5
	12.5	42.8	54.6	9.00	5.00	1490	763	5.22	3.74	198	153	256	190	1680	246	0.468	10.9

Table 2.8.3.2. Celsius® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

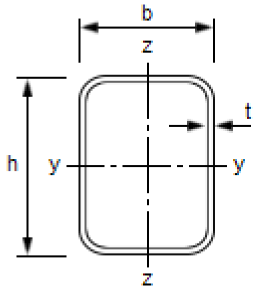
Table 2.8.3.3

SECTION PROPERTIES

HOT FINISHED
RECTANGULAR HOLLOW SECTIONS

Celsius® RHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size	Thickness					Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z			Per Metre	Per Tonne
h x b			A	c_w/t (1)	c_f/t (1)									I_T	W_t		
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
160 x 80	4.0 #	14.4	18.4	37.0	17.0	612	207	5.77	3.35	76.5	51.7	94.7	58.3	493	88.1	0.470	32.6
	5.0	17.8	22.7	29.0	13.0	744	249	5.72	3.31	93.0	62.3	116	71.1	600	106	0.467	26.2
	6.3	22.2	28.2	22.4	9.70	903	299	5.66	3.26	113	74.8	142	86.8	730	127	0.464	20.9
	7.1 #	24.7	31.5	19.5	8.27	994	327	5.62	3.22	124	81.7	158	95.9	804	139	0.462	18.7
	8.0	27.6	35.2	17.0	7.00	1090	356	5.57	3.18	136	89.0	175	106	883	151	0.459	16.6
	8.8 #	30.1	38.3	15.2	6.09	1170	379	5.53	3.15	147	94.9	189	114	949	161	0.457	15.2
	10.0	33.7	42.9	13.0	5.00	1280	411	5.47	3.10	161	103	209	125	1040	175	0.454	13.5
	12.5	40.9	52.1	9.80	3.40	1490	465	5.34	2.99	186	116	247	146	1200	198	0.448	11.0
180 x 60	4.0 #	14.4	18.4	42.0	12.0	697	121	6.16	2.56	77.4	40.3	99.8	45.2	341	72.2	0.470	32.6
	5.0 #	17.8	22.7	33.0	9.00	846	144	6.10	2.52	94.0	48.1	122	54.9	411	86.3	0.467	26.2
	6.3 #	22.2	28.2	25.6	6.52	1030	171	6.03	2.46	114	57.0	150	66.6	495	102	0.464	20.9
	7.1 #	24.7	31.5	22.4	5.45	1130	186	5.99	2.43	126	61.9	166	73.3	542	111	0.462	18.7
	8.0 #	27.6	35.2	19.5	4.50	1240	201	5.94	2.39	138	66.9	184	80.4	590	120	0.459	16.6
	8.8 #	30.1	38.3	17.5	3.82	1330	212	5.89	2.35	148	70.8	199	86.2	630	127	0.457	15.2
	10.0 #	33.7	42.9	15.0	3.00	1460	228	5.83	2.30	162	75.8	220	94.4	683	137	0.454	13.5
	12.5 #	40.9	52.1	11.4	1.80	1680	251	5.68	2.20	187	83.7	260	109	770	151	0.448	11.0
180 x 100	4.0 #	16.9	21.6	42.0	22.0	945	379	6.61	4.19	105	75.9	128	85.2	852	127	0.550	32.5
	5.0 #	21.0	26.7	33.0	17.0	1150	460	6.57	4.15	128	92.0	157	104	1040	154	0.547	26.1
	6.3 #	26.1	33.3	25.6	12.9	1410	557	6.50	4.09	156	111	194	128	1280	186	0.544	20.8
	7.1 #	29.2	37.2	22.4	11.1	1560	613	6.47	4.06	173	123	215	142	1410	205	0.542	18.5
	8.0 #	32.6	41.6	19.5	9.50	1710	671	6.42	4.02	190	134	239	157	1560	224	0.539	16.5
	8.8 #	35.6	45.4	17.5	8.36	1850	720	6.38	3.98	205	144	259	170	1690	240	0.537	15.1
	10.0 #	40.0	50.9	15.0	7.00	2040	787	6.32	3.93	226	157	288	188	1860	263	0.534	13.4
	12.5 #	48.7	62.1	11.4	5.00	2390	908	6.20	3.82	265	182	344	223	2190	303	0.528	10.8
200 x 100	4.0 #	18.2	23.2	47.0	22.0	1220	416	7.26	4.24	122	83.2	150	92.8	983	142	0.590	32.4
	5.0	22.6	28.7	37.0	17.0	1500	505	7.21	4.19	149	101	185	114	1200	172	0.587	26.0
	6.3	28.1	35.8	28.7	12.9	1830	613	7.15	4.14	183	123	228	140	1480	208	0.584	20.8
	7.1 #	31.4	40.0	25.2	11.1	2020	674	7.11	4.10	202	135	254	155	1630	229	0.582	18.5
	8.0	35.1	44.8	22.0	9.50	2230	739	7.06	4.06	223	148	282	172	1800	251	0.579	16.5
	8.8 #	38.4	48.9	19.7	8.36	2410	793	7.02	4.03	241	159	306	186	1950	270	0.577	15.1
	10.0	43.1	54.9	17.0	7.00	2660	869	6.96	3.98	266	174	341	206	2160	295	0.574	13.3
	12.5	52.7	67.1	13.0	5.00	3140	1000	6.84	3.87	314	201	408	245	2540	341	0.568	10.8
	14.2 #	58.9	75.0	11.1	4.04	3420	1080	6.75	3.80	342	216	450	268	2770	368	0.563	9.57
	16.0 # r	65.2	83.0	9.50	3.25	3680	1150	6.66	3.72	368	229	491	290	2980	391	0.559	8.55

Table 2.8.3.3. Celsius® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

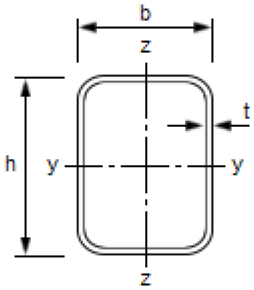
Table 2.8.3.4

SECTION PROPERTIES

HOT FINISHED
RECTANGULAR HOLLOW SECTIONS

Celsius® RHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size	Thickness					Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z			Per Metre	Per Tonne
h x b			A	c_w/t (1)	c_f/t (1)									I_T	W_t		
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
200 x 120	5.0 #	24.1	30.7	37.0	21.0	1690	762	7.40	4.98	168	127	205	144	1650	210	0.627	26.0
	6.3	30.1	38.3	28.7	16.0	2070	929	7.34	4.92	207	155	253	177	2030	255	0.624	20.8
	7.1 #	33.7	42.9	25.2	13.9	2290	1030	7.30	4.89	229	171	281	197	2250	282	0.622	18.5
	8.0	37.6	48.0	22.0	12.0	2530	1130	7.26	4.85	253	188	313	218	2500	310	0.619	16.5
	8.8 #	41.1	52.4	19.7	10.6	2730	1220	7.22	4.82	273	203	340	237	2700	334	0.617	15.0
	10.0	46.3	58.9	17.0	9.00	3030	1340	7.17	4.76	303	223	379	263	3000	367	0.614	13.3
	12.5 #	56.6	72.1	13.0	6.60	3580	1560	7.04	4.66	358	260	455	314	3570	428	0.608	10.8
	14.2 #	63.3	80.7	11.1	5.45	3910	1690	6.96	4.58	391	282	503	346	3920	464	0.603	9.53
	16.0 #	70.2	89.4	9.50	4.50	4220	1810	6.87	4.50	422	302	550	377	4250	497	0.599	8.51
200 x 150	5.0 #	26.5	33.7	37.0	27.0	1970	1270	7.64	6.12	197	169	234	192	2390	267	0.687	26.0
	6.3 #	33.0	42.1	28.7	20.8	2420	1550	7.58	6.07	242	207	289	237	2950	326	0.684	20.7
	7.1 #	37.0	47.1	25.2	18.1	2690	1720	7.55	6.03	268	229	322	264	3280	361	0.682	18.4
	8.0	41.4	52.8	22.0	15.8	2970	1890	7.50	5.99	297	253	359	294	3640	398	0.679	16.4
	8.8 #	45.3	57.7	19.7	14.0	3220	2050	7.47	5.96	322	273	390	319	3960	430	0.677	15.0
	10.0	51.0	64.9	17.0	12.0	3570	2260	7.41	5.91	357	302	436	356	4410	475	0.674	13.2
	12.5 #	62.5	79.6	13.0	9.00	4240	2670	7.30	5.80	424	356	525	428	5290	559	0.668	10.7
	14.2 #	70.0	89.2	11.1	7.56	4640	2920	7.22	5.72	464	389	582	473	5830	610	0.663	9.48
	16.0 #	77.7	99.0	9.50	6.38	5040	3150	7.13	5.64	504	420	638	518	6370	658	0.659	8.50
220 x 120	5.0 #	25.7	32.7	41.0	21.0	2130	829	8.06	5.03	193	138	236	155	1880	232	0.667	25.9
	6.3 #	32.0	40.8	31.9	16.0	2610	1010	8.00	4.98	237	168	292	191	2320	283	0.664	20.7
	7.1 #	35.9	45.7	28.0	13.9	2900	1120	7.96	4.94	263	186	326	213	2570	312	0.662	18.5
	8.0 #	40.2	51.2	24.5	12.0	3200	1230	7.91	4.90	291	205	362	236	2850	343	0.659	16.4
	8.8 #	43.9	55.9	22.0	10.6	3470	1320	7.87	4.87	315	221	394	256	3090	370	0.657	15.0
	10.0 #	49.4	62.9	19.0	9.00	3840	1460	7.82	4.81	349	243	440	285	3430	407	0.654	13.2
	12.5 #	60.5	77.1	14.6	6.60	4560	1710	7.69	4.71	415	285	530	341	4090	476	0.648	10.7
	14.2 #	67.8	86.3	12.5	5.45	5000	1850	7.61	4.63	454	309	586	376	4490	517	0.643	9.52
	16.0 #	75.2	95.8	10.8	4.50	5410	1990	7.52	4.55	492	331	643	410	4870	555	0.639	8.50
250 x 100	5.0 #	26.5	33.7	47.0	17.0	2610	618	8.80	4.28	209	124	263	138	1620	217	0.687	26.0
	6.3 #	33.0	42.1	36.7	12.9	3210	751	8.73	4.22	257	150	326	169	1980	264	0.684	20.7
	7.1 #	37.0	47.1	32.2	11.1	3560	827	8.69	4.19	285	165	363	188	2200	291	0.682	18.4
	8.0 #	41.4	52.8	28.3	9.50	3940	909	8.64	4.15	315	182	404	209	2430	319	0.679	16.4
	8.8 #	45.3	57.7	25.4	8.36	4270	977	8.60	4.12	341	195	439	226	2630	343	0.677	15.0
	10.0 #	51.0	64.9	22.0	7.00	4730	1070	8.54	4.06	379	214	491	251	2910	376	0.674	13.2
	12.5 #	62.5	79.6	17.0	5.00	5620	1250	8.41	3.96	450	249	592	299	3440	438	0.668	10.7
	14.2 #	70.0	89.2	14.6	4.04	6170	1340	8.31	3.88	493	269	655	329	3750	473	0.663	9.48
	16.0 #	77.7	99.0	12.6	3.25	6690	1430	8.22	3.80	535	287	719	358	4050	505	0.659	8.50

Table 2.8.3.4. Celsius® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

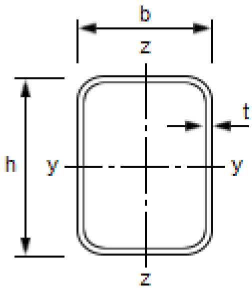
Table 2.8.3.5

SECTION PROPERTIES

HOT FINISHED
RECTANGULAR HOLLOW SECTIONS

Celsius® RHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size h x b	Thickness		A	c_w/t (1)	c_f/t (1)	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
250 x 150	5.0 #	30.4	38.7	47.0	27.0	3360	1530	9.31	6.28	269	204	324	228	3280	337	0.787	25.9
	6.3	38.0	48.4	36.7	20.8	4140	1870	9.25	6.22	331	250	402	283	4050	413	0.784	20.6
	7.1 #	42.6	54.2	32.2	18.1	4610	2080	9.22	6.19	368	277	449	315	4520	457	0.782	18.4
	8.0	47.7	60.8	28.3	15.8	5110	2300	9.17	6.15	409	306	501	350	5020	506	0.779	16.4
	8.8 #	52.2	66.5	25.4	14.0	5550	2490	9.13	6.12	444	331	545	381	5460	547	0.777	14.9
	10.0	58.8	74.9	22.0	12.0	6170	2760	9.08	6.06	494	367	611	426	6090	605	0.774	13.2
	12.5	72.3	92.1	17.0	9.00	7390	3270	8.96	5.96	591	435	740	514	7330	717	0.768	10.6
	14.2 #	81.1	103	14.6	7.56	8140	3580	8.87	5.88	651	477	823	570	8100	784	0.763	9.38
	16.0	90.3	115	12.6	6.38	8880	3870	8.79	5.80	710	516	906	625	8870	849	0.759	8.42
260 x 140	5.0 #	30.4	38.7	49.0	25.0	3530	1350	9.55	5.91	272	193	331	216	3080	326	0.787	25.9
	6.3 #	38.0	48.4	38.3	19.2	4360	1660	9.49	5.86	335	237	411	267	3800	399	0.784	20.6
	7.1 #	42.6	54.2	33.6	16.7	4840	1840	9.45	5.82	372	263	459	298	4230	442	0.782	18.4
	8.0 #	47.7	60.8	29.5	14.5	5370	2030	9.40	5.78	413	290	511	331	4700	488	0.779	16.4
	8.8 #	52.2	66.5	26.5	12.9	5830	2200	9.37	5.75	449	314	557	360	5110	527	0.777	14.9
	10.0 #	58.8	74.9	23.0	11.0	6490	2430	9.31	5.70	499	347	624	402	5700	584	0.774	13.2
	12.5 #	72.3	92.1	17.8	8.20	7770	2880	9.18	5.59	597	411	756	485	6840	690	0.768	10.6
	14.2 #	81.1	103	15.3	6.86	8560	3140	9.10	5.52	658	449	840	537	7560	754	0.763	9.38
	16.0 #	90.3	115	13.3	5.75	9340	3400	9.01	5.44	718	486	925	588	8260	815	0.759	8.42
300 x 100	5.0 #	30.4	38.7	57.0	17.0	4150	731	10.3	4.34	276	146	354	161	2040	262	0.787	25.9
	6.3 #	38.0	48.4	44.6	12.9	5110	890	10.3	4.29	341	178	439	199	2500	319	0.784	20.6
	7.1 #	42.6	54.2	39.3	11.1	5680	981	10.2	4.25	379	196	490	221	2780	352	0.782	18.4
	8.0	47.7	60.8	34.5	9.50	6310	1080	10.2	4.21	420	216	546	245	3070	387	0.779	16.4
	8.8 #	52.2	66.5	31.1	8.36	6840	1160	10.1	4.18	456	232	594	266	3320	416	0.777	14.9
	10.0	58.8	74.9	27.0	7.00	7610	1280	10.1	4.13	508	255	666	296	3680	458	0.774	13.2
	12.5 #	72.3	92.1	21.0	5.00	9100	1490	9.94	4.02	607	297	806	354	4350	534	0.768	10.6
	14.2 #	81.1	103	18.1	4.04	10000	1610	9.85	3.94	669	321	896	390	4760	578	0.763	9.38
	16.0 #	90.3	115	15.8	3.25	10900	1720	9.75	3.87	729	344	986	425	5140	619	0.759	8.42
300 x 150	8.0 # rr	54.0	68.8	34.5	15.8	8010	2700	10.8	6.27	534	360	663	407	6450	613	0.879	16.3
	8.8 # rr	59.1	75.3	31.1	14.0	8710	2930	10.8	6.23	580	390	723	443	7020	664	0.877	14.8
	10.0 # rr	66.7	84.9	27.0	12.0	9720	3250	10.7	6.18	648	433	811	496	7840	736	0.874	13.1
	12.5 # rr	82.1	105	21.0	9.00	11700	3860	10.6	6.07	779	514	986	600	9450	874	0.868	10.6
	14.2 # rr	92.3	118	18.1	7.56	12900	4230	10.5	6.00	862	564	1100	666	10500	959	0.863	9.32
	16.0 # rr	103	131	15.8	6.38	14200	4600	10.4	5.92	944	613	1210	732	11500	1040	0.859	8.35

Table 2.8.3.5. Celsius® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

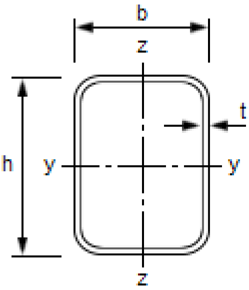
Table 2.8.3.6

SECTION PROPERTIES

HOT FINISHED RECTANGULAR HOLLOW SECTIONS

Celsius® RHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size h x b	Thickness		A	c_w/t (1)	c_f/t (1)	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
300 x 200	5.0 #	38.3	48.7	57.0	37.0	6320	3400	11.4	8.35	421	340	501	380	6820	552	0.987	25.8
	6.3	47.9	61.0	44.6	28.7	7830	4190	11.3	8.29	522	419	624	472	8480	681	0.984	20.6
	7.1 #	53.7	68.4	39.3	25.2	8730	4670	11.3	8.26	582	467	698	528	9470	757	0.982	18.3
	8.0	60.3	76.8	34.5	22.0	9720	5180	11.3	8.22	648	518	779	589	10600	840	0.979	16.3
	8.8 #	66.0	84.1	31.1	19.7	10600	5630	11.2	8.18	705	563	851	643	11500	912	0.977	14.9
	10.0	74.5	94.9	27.0	17.0	11800	6280	11.2	8.13	788	628	956	721	12900	1020	0.974	13.1
	12.5	91.9	117	21.0	13.0	14300	7540	11.0	8.02	952	754	1170	877	15700	1220	0.968	10.6
	14.2 #	103	132	18.1	11.1	15800	8330	11.0	7.95	1060	833	1300	978	17500	1340	0.963	9.31
	16.0	115	147	15.8	9.50	17400	9110	10.9	7.87	1160	911	1440	1080	19300	1470	0.959	8.31
300 x 250	5.0 #	42.2	53.7	57.0	47.0	7410	5610	11.7	10.2	494	449	575	508	9770	697	1.09	25.8
	6.3 #	52.8	67.3	44.6	36.7	9190	6950	11.7	10.2	613	556	716	633	12200	862	1.08	20.4
	7.1 #	59.3	75.5	39.3	32.2	10300	7750	11.6	10.1	683	620	802	708	13600	960	1.08	18.3
	8.0	66.5	84.8	34.5	28.3	11400	8630	11.6	10.1	761	690	896	791	15200	1070	1.08	16.2
	8.8 #	72.9	92.9	31.1	25.4	12400	9390	11.6	10.1	829	751	979	864	16600	1160	1.08	14.8
	10.0 #	82.4	105	27.0	22.0	13900	10500	11.5	10.0	928	840	1100	971	18600	1300	1.07	12.9
	12.5 #	102	130	21.0	17.0	16900	12700	11.4	9.89	1120	1010	1350	1190	22700	1560	1.07	10.5
	14.2 #	115	146	18.1	14.6	18700	14100	11.3	9.82	1250	1130	1510	1330	25400	1730	1.06	9.25
	16.0 #	128	163	15.8	12.6	20600	15500	11.2	9.74	1380	1240	1670	1470	28100	1900	1.06	8.28
340 x 100	10.0	65.1	82.9	31.0	7.00	10600	1440	11.3	4.16	623	288	823	332	4300	523	0.854	13.2
350 x 150	5.0 #	38.3	48.7	67.0	27.0	7660	2050	12.5	6.49	437	274	543	301	5160	477	0.987	25.8
	6.3 #	47.9	61.0	52.6	20.8	9480	2530	12.5	6.43	542	337	676	373	6390	586	0.984	20.6
	7.1 #	53.7	68.4	46.3	18.1	10600	2800	12.4	6.40	604	374	756	416	7120	651	0.982	18.3
	8.0 #	60.3	76.8	40.8	15.8	11800	3110	12.4	6.36	673	414	844	464	7930	721	0.979	16.3
	8.8 #	66.0	84.1	36.8	14.0	12800	3360	12.3	6.33	732	449	922	506	8620	781	0.977	14.9
	10.0 #	74.5	94.9	32.0	12.0	14300	3740	12.3	6.27	818	498	1040	566	9630	867	0.974	13.1
	12.5 #	91.9	117	25.0	9.00	17300	4450	12.2	6.17	988	593	1260	686	11600	1030	0.968	10.6
	14.2 #	103	132	21.6	7.56	19200	4890	12.1	6.09	1100	652	1410	763	12900	1130	0.963	9.31
	16.0 #	115	147	18.9	6.38	21100	5320	12.0	6.01	1210	709	1560	840	14100	1230	0.959	8.31
350 x 250	6.3 #	57.8	73.6	52.6	36.7	13200	7890	13.4	10.4	754	631	892	709	15200	1010	1.18	20.4
	7.1 #	64.9	82.6	46.3	32.2	14700	8800	13.4	10.3	843	704	999	794	17000	1130	1.18	18.2
	8.0 #	72.8	92.8	40.8	28.3	16400	9800	13.3	10.3	940	784	1120	888	19000	1250	1.18	16.2
	8.8 #	79.8	102	36.8	25.4	17900	10700	13.3	10.2	1030	853	1220	970	20800	1370	1.18	14.8
	10.0 #	90.2	115	32.0	22.0	20100	11900	13.2	10.2	1150	955	1380	1090	23400	1530	1.17	13.0
	12.5 #	112	142	25.0	17.0	24400	14400	13.1	10.1	1400	1160	1690	1330	28500	1840	1.17	10.5
	14.2 #	126	160	21.6	14.6	27200	16000	13.0	10.0	1550	1280	1890	1490	31900	2040	1.16	9.22
	16.0 #	141	179	18.9	12.6	30000	17700	12.9	9.93	1720	1410	2100	1660	35300	2250	1.16	8.26

Table 2.8.3.6. Celsius® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

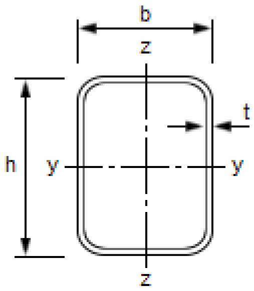
Table 2.8.3.7

SECTION PROPERTIES

HOT FINISHED RECTANGULAR HOLLOW SECTIONS

Celsius® RHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size h x b	Thickness		A	c_w/t (1)	c_f/t (1)	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
400 x 150	6.3 #	52.8	67.3	60.5	20.8	13300	2850	14.0	6.51	663	380	836	418	7600	673	1.08	20.4
	7.1 #	59.3	75.5	53.3	18.1	14800	3170	14.0	6.47	740	422	936	467	8470	748	1.08	18.3
	8.0 #	66.5	84.8	47.0	15.8	16500	3510	13.9	6.43	824	468	1050	521	9420	828	1.08	16.2
	8.8 #	72.9	92.9	42.5	14.0	18000	3800	13.9	6.40	898	507	1140	568	10300	898	1.08	14.8
	10.0 #	82.4	105	37.0	12.0	20100	4230	13.8	6.35	1010	564	1290	636	11500	998	1.07	12.9
	12.5 #	102	130	29.0	9.00	24400	5040	13.7	6.24	1220	672	1570	772	13800	1190	1.07	10.5
	14.2 #	115	146	25.2	7.56	27100	5550	13.6	6.16	1360	740	1760	859	15300	1310	1.06	9.25
	16.0	128	163	22.0	6.38	29800	6040	13.5	6.09	1490	805	1950	947	16800	1430	1.06	8.28
400 x 200	6.3 #	57.8	73.6	60.5	28.7	15700	5380	14.6	8.55	785	538	960	594	12600	917	1.18	20.4
	7.1 #	64.9	82.6	53.3	25.2	17500	5990	14.6	8.51	877	599	1080	665	14100	1020	1.18	18.2
	8.0	72.8	92.8	47.0	22.0	19600	6660	14.5	8.47	978	666	1200	743	15700	1140	1.18	16.2
	8.8 #	79.8	102	42.5	19.7	21300	7240	14.5	8.44	1070	724	1320	811	17200	1230	1.18	14.8
	10.0	90.2	115	37.0	17.0	23900	8080	14.4	8.39	1200	808	1480	911	19300	1380	1.17	13.0
	12.5	112	142	29.0	13.0	29100	9740	14.3	8.28	1450	974	1810	1110	23400	1660	1.17	10.5
	14.2 #	126	160	25.2	11.1	32400	10800	14.2	8.21	1620	1080	2030	1240	26100	1830	1.16	9.22
	16.0	141	179	22.0	9.50	35700	11800	14.1	8.13	1790	1180	2260	1370	28900	2010	1.16	8.26
400 x 300	8.0 #	85.4	109	47.0	34.5	25700	16500	15.4	12.3	1290	1100	1520	1250	31000	1750	1.38	16.1
	8.8 #	93.6	119	42.5	31.1	28100	18000	15.3	12.3	1400	1200	1660	1360	33900	1910	1.38	14.8
	10.0 #	106	135	37.0	27.0	31500	20200	15.3	12.2	1580	1350	1870	1540	38200	2140	1.37	12.9
	12.5 #	131	167	29.0	21.0	38500	24600	15.2	12.1	1920	1640	2300	1880	46800	2590	1.37	10.4
	14.2 #	148	189	25.2	18.1	43000	27400	15.1	12.1	2150	1830	2580	2110	52500	2890	1.36	9.19
	16.0 #	166	211	22.0	15.8	47500	30300	15.0	12.0	2380	2020	2870	2350	58300	3180	1.36	8.21
450 x 250	8.0	85.4	109	53.3	28.3	30100	12100	16.6	10.6	1340	971	1620	1080	27100	1630	1.38	16.1
	8.8 #	93.6	119	48.1	25.4	32800	13200	16.6	10.5	1460	1060	1770	1180	29600	1770	1.38	14.8
	10.0	106	135	42.0	22.0	36900	14800	16.5	10.5	1640	1190	2000	1330	33300	1990	1.37	12.9
	12.5	131	167	33.0	17.0	45000	18000	16.4	10.4	2000	1440	2460	1630	40700	2410	1.37	10.4
	14.2 #	148	189	28.7	14.6	50300	20000	16.3	10.3	2240	1600	2760	1830	45600	2680	1.36	9.19
	16.0	166	211	25.1	12.6	55700	22000	16.2	10.2	2480	1760	3070	2030	50500	2950	1.36	8.21
500 x 200	8.0 #	85.4	109	59.5	22.0	34000	8140	17.7	8.65	1360	814	1710	896	21100	1430	1.38	16.1
	8.8 #	93.6	119	53.8	19.7	37200	8850	17.7	8.61	1490	885	1870	979	23000	1560	1.38	14.8
	10.0 #	106	135	47.0	17.0	41800	9890	17.6	8.56	1670	989	2110	1100	25900	1740	1.37	12.9
	12.5 #	131	167	37.0	13.0	51000	11900	17.5	8.45	2040	1190	2590	1350	31500	2100	1.37	10.4
	14.2 #	148	189	32.2	11.1	56900	13200	17.4	8.38	2280	1320	2900	1510	35200	2320	1.36	9.19
	16.0 #	166	211	28.3	9.50	63000	14500	17.3	8.30	2520	1450	3230	1670	38900	2550	1.36	8.21
500 x 300	8.0 #	97.9	125	59.5	34.5	43700	20000	18.7	12.6	1750	1330	2100	1480	42600	2200	1.58	16.1
	8.8 #	107	137	53.8	31.1	47800	21800	18.7	12.6	1910	1450	2300	1620	46600	2400	1.58	14.7
	10.0	122	155	47.0	27.0	53800	24400	18.6	12.6	2150	1630	2600	1830	52500	2700	1.57	12.9
	12.5 #	151	192	37.0	21.0	65800	29800	18.5	12.5	2630	1990	3200	2240	64400	3280	1.57	10.4
	14.2 #	170	217	32.2	18.1	73700	33200	18.4	12.4	2950	2220	3590	2520	72200	3660	1.56	9.16
	16.0	191	243	28.3	15.8	81800	36800	18.3	12.3	3270	2450	4010	2800	80300	4040	1.56	8.17
	20.0 ^	235	300	22.0	12.0	98800	44100	18.2	12.1	3950	2940	4890	3410	97400	4840	1.55	6.59

Table 2.8.3.7. Celsius® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10210-2: 2006

UK EUROCODES

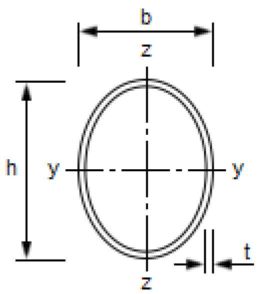
Table 2.8.4.1

SECTION PROPERTIES

HOT FINISHED
ELLIPTICAL HOLLOW SECTIONS

Celsius® OHS

Dimensions and properties



Hot Finished

Section Designation		Mass per Metre	Area of Section	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size h x b	Thickness t		A	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
150 x 75	4.0 #	10.7	13.6	301	101	4.70	2.72	40.1	26.9	56.1	34.4	303	60.1	0.363	33.9
	5.0 #	13.3	16.9	367	122	4.66	2.69	48.9	32.5	68.9	42.0	367	72.2	0.363	27.4
	6.3 #	16.5	21.0	448	147	4.62	2.64	59.7	39.1	84.9	51.5	443	86.3	0.363	22.0
200 x 100	5.0 #	17.9	22.8	897	302	6.27	3.64	89.7	60.4	125	76.8	905	135	0.484	27.1
	6.3 #	22.3	28.4	1100	368	6.23	3.60	110	73.5	155	94.7	1110	163	0.484	21.7
	8.0 #	28.0	35.7	1360	446	6.17	3.54	136	89.3	193	117	1350	197	0.484	17.3
	10.0 #	34.5	44.0	1640	529	6.10	3.47	164	106	235	141	1610	232	0.484	14.0
	12.5 #	42.4	54.0	1950	619	6.02	3.39	195	124	284	169	1890	269	0.484	11.4
250 x 125	6.3 #	28.2	35.9	2210	742	7.84	4.55	176	119	246	151	2220	265	0.605	21.5
	8.0 #	35.4	45.1	2730	909	7.78	4.49	219	145	307	188	2730	323	0.605	17.1
	10.0 #	43.8	55.8	3320	1090	7.71	4.42	265	174	376	228	3290	385	0.605	13.8
	12.5 #	53.9	68.7	4000	1290	7.63	4.34	320	207	458	276	3920	453	0.605	11.2
300 x 150	8.0 #	42.8	54.5	4810	1620	9.39	5.44	321	215	449	275	4850	481	0.726	17.0
	10.0 #	53.0	67.5	5870	1950	9.32	5.37	391	260	551	336	5870	577	0.726	13.7
	12.5	65.5	83.4	7120	2330	9.24	5.29	475	311	674	409	7050	686	0.726	11.1
	16.0 #	82.5	105	8730	2810	9.12	5.17	582	374	837	503	8530	818	0.726	8.78
400 x 200	8.0 #	57.6	73.4	11700	3970	12.6	7.35	584	397	811	500	11900	890	0.969	16.9
	10.0 #	71.5	91.1	14300	4830	12.5	7.28	717	483	1000	615	14500	1080	0.969	13.6
	12.5	88.6	113	17500	5840	12.5	7.19	877	584	1230	753	17600	1300	0.969	10.9
	16.0	112	143	21700	7140	12.3	7.07	1090	714	1540	936	21600	1580	0.969	8.64
500 x 250	10.0 #	90.0	115	28500	9680	15.8	9.19	1140	775	1590	976	29000	1740	1.21	13.4
	12.5 #	112	142	35000	11800	15.7	9.10	1400	943	1960	1200	35300	2110	1.21	10.8
	16.0 #	142	180	43700	14500	15.6	8.98	1750	1160	2460	1500	43700	2590	1.21	8.54

Table 2.8.4.1. Celsius® OHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

UK EUROCODES

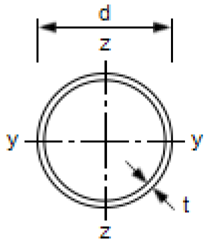
Table 2.8.5.1

SECTION PROPERTIES

COLD FORMED CIRCULAR HOLLOW SECTIONS

Hybox® CHS

Dimensions and properties



Cold Formed

Section Designation: Outside Diameter d (mm)	Section Designation: Thickness t (mm)	Mass per Metre (kg/m)	Area of Section A (cm^2)	Ratio for Local Buckling d/t	Second Moment of Area I (cm^4)	Radius of Gyration i (cm)	Elastic Modulus W_{el} (cm^3)	Plastic Modulus W_{pl} (cm^3)	Torsional Constants I_T (cm^4)	Torsional Constants W_t (cm^3)	Surface Area Per Metre (m^2)	Surface Area Per Tonne (m^2)
33.7	3.0	2.27	2.89	11.2	3.44	1.09	2.04	2.84	6.88	4.08	0.106	46.6
42.4	3.0	2.91	3.71	14.1	7.25	1.40	3.42	4.67	14.5	6.84	0.133	45.6
48.3	3.0	3.35	4.27	16.1	11.0	1.61	4.55	6.17	22.0	9.11	0.152	45.3
	4.0 #	4.37	5.57	12.1	13.8	1.57	5.70	7.87	27.5	11.4	0.152	34.8
60.3	3.0 #	4.24	5.40	20.1	22.2	2.03	7.37	9.86	44.4	14.7	0.189	44.6
	4.0	5.55	7.07	15.1	28.2	2.00	9.34	12.7	56.3	18.7	0.189	34.0
76.1	3.0	5.41	6.89	25.4	46.1	2.59	12.1	16.0	92.2	24.2	0.239	44.2
	4.0	7.11	9.06	19.0	59.1	2.55	15.5	20.8	118	31.0	0.239	33.7
88.9	3.0	6.36	8.10	29.6	74.8	3.04	16.8	22.1	150	33.6	0.279	43.8
	3.5 #	7.37	9.39	25.4	85.7	3.02	19.3	25.5	171	38.6	0.279	37.9
	4.0	8.38	10.7	22.2	96.3	3.00	21.7	28.9	193	43.3	0.279	33.2
	5.0	10.3	13.2	17.8	116	2.97	26.2	35.2	233	52.4	0.279	27.0
	6.3	12.8	16.3	14.1	140	2.93	31.5	43.1	280	63.1	0.279	21.7
114.3	3.0 #	8.23	10.5	38.1	163	3.94	28.4	37.2	325	56.9	0.359	43.4
	3.5	9.56	12.2	32.7	187	3.92	32.7	43.0	374	65.5	0.359	37.7
	4.0 #	10.9	13.9	28.6	211	3.90	36.9	48.7	422	73.9	0.359	33.0
	5.0	13.5	17.2	22.9	257	3.87	45.0	59.8	514	89.9	0.359	26.6
	6.0	16.0	20.4	19.1	300	3.83	52.5	70.4	600	105	0.359	22.4
	6.3	16.8	21.4	18.1	313	3.82	54.7	73.6	625	109	0.359	21.4
139.7	3.0 #	10.1	12.9	46.6	301	4.83	43.1	56.1	602	86.2	0.439	43.4
	4.0 #	13.4	17.1	34.9	393	4.80	56.2	73.7	786	112	0.439	32.8
	5.0	16.6	21.2	27.9	481	4.77	68.8	90.8	961	138	0.439	26.4
	6.0	19.8	25.2	23.3	564	4.73	80.8	107	1130	162	0.439	22.2
	6.3	20.7	26.4	22.2	589	4.72	84.3	112	1180	169	0.439	21.2
	8.0	26.0	33.1	17.5	720	4.66	103	139	1440	206	0.439	16.9
	10.0	32.0	40.7	14.0	862	4.60	123	169	1720	247	0.439	13.7
168.3	4.0	16.2	20.6	42.1	697	5.81	82.8	108	1390	166	0.529	32.6
	4.5 #	18.2	23.2	37.4	777	5.79	92.4	121	1550	185	0.529	29.1
	5.0	20.1	25.7	33.7	856	5.78	102	133	1710	203	0.529	26.3
	6.0	24.0	30.6	28.1	1010	5.74	120	158	2020	240	0.529	22.0
	6.3	25.2	32.1	26.7	1050	5.73	125	165	2110	250	0.529	21.0
	8.0	31.6	40.3	21.0	1300	5.67	154	206	2600	308	0.529	16.7
	10.0	39.0	49.7	16.8	1560	5.61	186	251	3130	372	0.529	13.5
	12.5	48.0	61.2	13.5	1870	5.53	222	304	3740	444	0.529	11.0
193.7	4.0 #	18.7	23.8	48.4	1070	6.71	111	144	2150	222	0.609	32.5
	4.5 #	21.0	26.7	43.0	1200	6.69	124	161	2400	247	0.609	29.0
	5.0	23.3	29.6	38.7	1320	6.67	136	178	2640	273	0.609	26.2
	6.0	27.8	35.4	32.3	1560	6.64	161	211	3120	322	0.609	21.9
	6.3	29.1	37.1	30.7	1630	6.63	168	221	3260	337	0.609	20.9
	8.0	36.6	46.7	24.2	2020	6.57	208	276	4030	416	0.609	16.6
	10.0	45.3	57.7	19.4	2440	6.50	252	338	4880	504	0.609	13.5
	12.5	55.9	71.2	15.5	2930	6.42	303	411	5870	606	0.609	10.9

Table 2.8.5.1. Hybox® CHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

UK EUROCODES

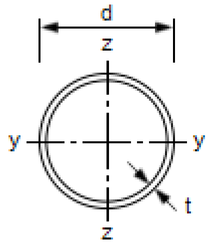
Table 2.8.5.2

SECTION PROPERTIES

COLD FORMED
CIRCULAR HOLLOW SECTIONS

Hybox® CHS

Dimensions and properties



Cold Formed

Section Designation		Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
Outside Diameter d	Thickness t		A	d/t	I	i	W_{el}	W_{pl}	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
219.1	4.5 #	23.8	30.3	48.7	1750	7.59	159	207	3490	319	0.688	28.9
	5.0	26.4	33.6	43.8	1930	7.57	176	229	3860	352	0.688	26.1
	6.0	31.5	40.2	36.5	2280	7.54	208	273	4560	417	0.688	21.8
	6.3	33.1	42.1	34.8	2390	7.53	218	285	4770	436	0.688	20.8
	8.0	41.6	53.1	27.4	2960	7.47	270	357	5920	540	0.688	16.5
	10.0	51.6	65.7	21.9	3600	7.40	328	438	7200	657	0.688	13.3
	12.0 #	61.3	78.1	18.3	4200	7.33	383	515	8400	767	0.688	11.2
	12.5	63.7	81.1	17.5	4350	7.32	397	534	8690	793	0.688	10.8
	16.0	80.1	102	13.7	5300	7.20	483	661	10600	967	0.688	8.60
244.5	5.0 #	29.5	37.6	48.9	2700	8.47	221	287	5400	441	0.768	26.0
	6.0	35.3	45.0	40.8	3200	8.43	262	341	6400	523	0.768	21.7
	6.3	37.0	47.1	38.8	3350	8.42	274	358	6690	547	0.768	20.7
	8.0	46.7	59.4	30.6	4160	8.37	340	448	8320	681	0.768	16.4
	10.0	57.8	73.7	24.5	5070	8.30	415	550	10100	830	0.768	13.3
	12.0 #	68.8	87.7	20.4	5940	8.23	486	649	11900	972	0.768	11.1
	12.5	71.5	91.1	19.6	6150	8.21	503	673	12300	1010	0.768	10.8
	16.0	90.2	115	15.3	7530	8.10	616	837	15100	1230	0.768	8.52
273.0	4.0 #	26.5	33.8	68.3	3060	9.51	224	289	6120	448	0.858	32.3
	4.5 #	29.8	38.0	60.7	3420	9.49	251	324	6840	501	0.858	28.8
	5.0 #	33.0	42.1	54.6	3780	9.48	277	359	7560	554	0.858	26.0
	6.0	39.5	50.3	45.5	4490	9.44	329	428	8970	657	0.858	21.7
	6.3	41.4	52.8	43.3	4700	9.43	344	448	9390	688	0.858	20.7
	8.0	52.3	66.6	34.1	5850	9.37	429	562	11700	857	0.858	16.4
	10.0	64.9	82.6	27.3	7150	9.31	524	692	14300	1050	0.858	13.2
	12.0 #	77.2	98.4	22.8	8400	9.24	615	818	16800	1230	0.858	11.1
	12.5	80.3	102	21.8	8700	9.22	637	849	17400	1270	0.858	10.7
	16.0	101	129	17.1	10700	9.10	784	1060	21400	1570	0.858	8.46
323.9	5.0 #	39.3	50.1	64.8	6370	11.3	393	509	12700	787	1.02	25.9
	6.0	47.0	59.9	54.0	7570	11.2	468	606	15100	935	1.02	21.7
	6.3 #	49.3	62.9	51.4	7930	11.2	490	636	15900	979	1.02	20.7
	8.0	62.3	79.4	40.5	9910	11.2	612	799	19800	1220	1.02	16.3
	10.0	77.4	98.6	32.4	12200	11.1	751	986	24300	1500	1.02	13.2
	12.0 #	92.3	118	27.0	14300	11.0	884	1170	28600	1770	1.02	11.0
	12.5	96.0	122	25.9	14800	11.0	917	1210	29700	1830	1.02	10.6
	16.0	121	155	20.2	18400	10.9	1140	1520	36800	2270	1.02	8.39
355.6	5.0 #	43.2	55.1	71.1	8460	12.4	476	615	16900	952	1.12	25.9
	6.0	51.7	65.9	59.3	10100	12.4	566	733	20100	1130	1.12	21.6
	6.3 #	54.3	69.1	56.4	10500	12.4	593	769	21100	1190	1.12	20.6
	8.0	68.6	87.4	44.5	13200	12.3	742	967	26400	1490	1.12	16.4
	10.0	85.2	109	35.6	16200	12.2	912	1200	32400	1830	1.12	13.1
	12.0 #	102	130	29.6	19100	12.2	1080	1420	38300	2150	1.12	11.0
	12.5	106	135	28.4	19900	12.1	1120	1470	39700	2230	1.12	10.6
	16.0	134	171	22.2	24700	12.0	1390	1850	49300	2770	1.12	8.36

Table 2.8.5.2. Hybox® CHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

UK EUROCODES

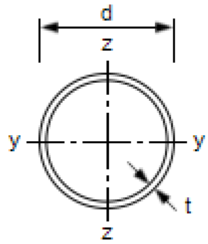
Table 2.8.5.3

SECTION PROPERTIES

COLD FORMED
CIRCULAR HOLLOW SECTIONS

Hybox® CHS

Dimensions and properties



Cold Formed

Section Designation		Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
Outside Diameter d	Thickness t		A	d/t	I	i	W_{el}	W_{pl}	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
406.4	6.0 #	59.2	75.5	67.7	15100	14.2	745	962	30300	1490	1.28	21.6
	6.3 #	62.2	79.2	64.5	15800	14.1	780	1010	31700	1560	1.28	20.6
	8.0	78.6	100	50.8	19900	14.1	978	1270	39700	1960	1.28	16.3
	10.0	97.8	125	40.6	24500	14.0	1210	1570	49000	2410	1.28	13.1
	12.0 #	117	149	33.9	28900	14.0	1420	1870	57900	2850	1.28	11.0
	12.5	121	155	32.5	30000	13.9	1480	1940	60100	2960	1.28	10.5
	16.0	154	196	25.4	37400	13.8	1840	2440	74900	3690	1.28	8.31
457.0	6.0 #	66.7	85.0	76.2	21600	15.9	946	1220	43200	1890	1.44	21.6
	6.3 #	70.0	89.2	72.5	22700	15.9	991	1280	45300	1980	1.44	20.6
	8.0	88.6	113	57.1	28400	15.9	1250	1610	56900	2490	1.44	16.3
	10.0	110	140	45.7	35100	15.8	1540	2000	70200	3070	1.44	13.1
	12.0 #	132	168	38.1	41600	15.7	1820	2380	83100	3640	1.44	10.9
	12.5	137	175	36.6	43100	15.7	1890	2470	86300	3780	1.44	10.5
	16.0	174	222	28.6	54000	15.6	2360	3110	108000	4720	1.44	8.28
508.0	6.0 #	74.3	94.6	84.7	29800	17.7	1170	1510	59600	2350	1.60	21.6
	6.3 #	77.9	99.3	80.6	31200	17.7	1230	1590	62500	2460	1.60	20.5
	8.0 #	98.6	126	63.5	39300	17.7	1550	2000	78600	3090	1.60	16.2
	10.0	123	156	50.8	48500	17.6	1910	2480	97000	3820	1.60	13.0
	12.0 #	147	187	42.3	57500	17.5	2270	2950	115000	4530	1.60	10.9
	12.5	153	195	40.6	59800	17.5	2350	3070	120000	4710	1.60	10.5
	16.0 #	194	247	31.8	74900	17.4	2950	3870	150000	5900	1.60	8.24

Table 2.8.5.3. Hybox® CHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

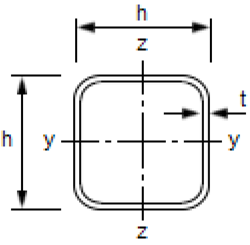
Table 2.8.6.1

SECTION PROPERTIES

COLD FORMED
SQUARE HOLLOW SECTIONS

Hybox® SHS

Dimensions and properties



Cold Formed

Section Designation Size h x h mm	Section Designation Thickness t mm	Mass per Metre kg/m	Area of Section A cm^2	Ratio for Local Buckling c/t (1)	Second Moment of Area I cm^4	Radius of Gyration i cm	Elastic Modulus W_{el} cm^3	Plastic Modulus W_{pl} cm^3	Torsional Constants I_T cm^4	Torsional Constants W_t cm^3	Surface Area Per Metre m^2	Surface Area Per Tonne m^2
25 x 25	2.0 #	1.36	1.74	9.50	1.48	0.924	1.19	1.47	2.53	1.80	0.093	68.2
	2.5	1.64	2.09	7.00	1.69	0.899	1.35	1.71	2.97	2.07	0.091	55.5
30 x 30	2.0 #	1.68	2.14	12.0	2.72	1.13	1.81	2.21	4.54	2.75	0.113	67.3
	2.5 #	2.03	2.59	9.00	3.16	1.10	2.10	2.61	5.40	3.20	0.111	54.6
	3.0	2.36	3.01	7.00	3.50	1.08	2.34	2.96	6.15	3.58	0.110	46.5
40 x 40	2.0 #	2.31	2.94	17.0	6.94	1.54	3.47	4.13	11.3	5.23	0.153	66.4
	2.5	2.82	3.59	13.0	8.22	1.51	4.11	4.97	13.6	6.21	0.151	53.6
	3.0	3.30	4.21	10.3	9.32	1.49	4.66	5.72	15.8	7.07	0.150	45.5
	4.0	4.20	5.35	7.00	11.1	1.44	5.54	7.01	19.4	8.48	0.146	34.7
50 x 50	2.5	3.60	4.59	17.0	16.9	1.92	6.78	8.07	27.5	10.2	0.191	53.1
	3.0	4.25	5.41	13.7	19.5	1.90	7.79	9.39	32.1	11.8	0.190	44.8
	4.0	5.45	6.95	9.50	23.7	1.85	9.49	11.7	40.4	14.4	0.186	34.0
	5.0	6.56	8.36	7.00	27.0	1.80	10.8	13.7	47.5	16.6	0.183	27.8
60 x 60	3.0	5.19	6.61	17.0	35.1	2.31	11.7	14.0	57.1	17.7	0.230	44.4
	4.0	6.71	8.55	12.0	43.6	2.26	14.5	17.6	72.6	22.0	0.226	33.7
	5.0	8.13	10.4	9.00	50.5	2.21	16.8	20.9	86.4	25.6	0.223	27.4
	6.0 #	9.45	12.0	7.00	56.1	2.16	18.7	23.7	98.4	28.6	0.219	23.2
70 x 70	3.0	6.13	7.81	20.3	57.5	2.71	16.4	19.4	92.4	24.7	0.270	44.0
	3.5	7.06	8.99	17.0	65.1	2.69	18.6	22.2	106	28.0	0.268	38.1
	4.0	7.97	10.1	14.5	72.1	2.67	20.6	24.8	119	31.1	0.266	33.5
	5.0	9.70	12.4	11.0	84.6	2.62	24.2	29.6	142	36.7	0.263	27.1
	6.0 #	11.3	14.4	8.67	95.2	2.57	27.2	33.8	163	41.4	0.259	22.9
80 x 80	3.0	7.07	9.01	23.7	87.8	3.12	22.0	25.8	140	33.0	0.310	43.7
	3.5	8.16	10.4	19.9	99.8	3.10	25.0	29.5	161	37.6	0.308	37.9
	4.0	9.22	11.7	17.0	111	3.07	27.8	33.1	180	41.8	0.306	33.0
	5.0	11.3	14.4	13.0	131	3.03	32.9	39.7	218	49.7	0.303	26.9
	6.0	13.2	16.8	10.3	149	2.98	37.3	45.8	252	56.6	0.299	22.6
90 x 90	3.0	8.01	10.2	27.0	127	3.53	28.3	33.0	201	42.5	0.350	43.8
	3.5	9.26	11.8	22.7	145	3.51	32.2	37.9	232	48.5	0.348	37.6
	4.0	10.5	13.3	19.5	162	3.48	36.0	42.6	261	54.2	0.346	33.0
	5.0	12.8	16.4	15.0	193	3.43	42.9	51.4	316	64.7	0.343	26.7
	6.0 #	15.1	19.2	12.0	220	3.39	49.0	59.5	368	74.2	0.339	22.4
100 x 100	3.0	8.96	11.4	30.3	177	3.94	35.4	41.2	279	53.2	0.390	43.7
	4.0	11.7	14.9	22.0	226	3.89	45.3	53.3	362	68.1	0.386	32.9
	5.0	14.4	18.4	17.0	271	3.84	54.2	64.6	441	81.7	0.383	26.6
	6.0	17.0	21.6	13.7	311	3.79	62.3	75.1	514	94.1	0.379	22.3
	8.0	21.4	27.2	9.50	366	3.67	73.2	91.1	645	114	0.366	17.1
120 x 120	3.0 #	10.8	13.8	37.0	312	4.76	52.1	60.2	488	78.2	0.470	43.4
	4.0	14.2	18.1	27.0	402	4.71	67.0	78.3	637	101	0.466	32.7
	5.0	17.5	22.4	21.0	485	4.66	80.9	95.4	778	122	0.463	26.4
	6.0	20.7	26.4	17.0	562	4.61	93.7	112	913	141	0.459	22.1
	8.0	26.4	33.6	12.0	677	4.49	113	138	1160	175	0.446	16.9
	10.0	31.8	40.6	9.00	777	4.38	129	162	1380	203	0.437	13.7

Table 2.8.6.1. Hybox® SHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

UK EUROCODES

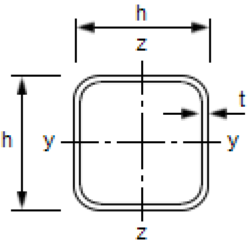
Table 2.8.6.2

SECTION PROPERTIES

COLD FORMED SQUARE HOLLOW SECTIONS

Hybox® SHS

Dimensions and properties



Cold Formed

Section Designation		Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
Size	Thickness										Per Metre	Per Tonne
h x h	t		A	c/t (1)	I	i	W_{el}	W_{pl}	I_T	W_t		
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
140 x 140	4.0	16.8	21.3	32.0	652	5.52	93.1	108	1020	140	0.546	32.6
	5.0	20.7	26.4	25.0	791	5.48	113	132	1260	170	0.543	26.2
	6.0	24.5	31.2	20.3	920	5.43	131	155	1480	198	0.539	22.0
	8.0	31.4	40.0	14.5	1130	5.30	161	194	1900	248	0.526	16.7
	10.0	38.1	48.6	11.0	1310	5.20	187	230	2270	291	0.517	13.5
150 x 150	4.0 #	18.0	22.9	34.5	808	5.93	108	125	1270	162	0.586	32.5
	5.0	22.3	28.4	27.0	982	5.89	131	153	1550	197	0.583	26.2
	6.0	26.4	33.6	22.0	1150	5.84	153	180	1830	230	0.579	21.9
	8.0	33.9	43.2	15.8	1410	5.71	188	226	2360	289	0.566	16.7
	10.0	41.3	52.6	12.0	1650	5.61	220	269	2840	341	0.557	13.5
160 x 160	4.0 #	19.3	24.5	37.0	987	6.34	123	143	1540	185	0.626	32.5
	5.0	23.8	30.4	29.0	1200	6.29	150	175	1900	226	0.623	26.2
	6.0	28.3	36.0	23.7	1410	6.25	176	206	2240	264	0.619	21.9
	8.0	36.5	46.4	17.0	1740	6.12	218	260	2900	334	0.606	16.6
	10.0	44.4	56.6	13.0	2050	6.02	256	311	3490	395	0.597	13.4
180 x 180	5.0	27.0	34.4	33.0	1740	7.11	193	224	2720	290	0.703	26.1
	6.0	32.1	40.8	27.0	2040	7.06	226	264	3220	340	0.699	21.8
	6.3 #	33.3	42.4	25.6	2100	7.03	233	273	3380	354	0.693	20.8
	8.0	41.5	52.8	19.5	2550	6.94	283	336	4190	432	0.686	16.5
	10.0	50.7	64.6	15.0	3020	6.84	335	404	5070	515	0.677	13.3
	12.0 #	58.5	74.5	12.0	3320	6.68	369	454	5870	584	0.658	11.3
	12.5	60.5	77.0	11.4	3410	6.65	378	467	6050	600	0.656	10.8
200 x 200	5.0	30.1	38.4	37.0	2410	7.93	241	279	3760	362	0.783	26.0
	6.0	35.8	45.6	30.3	2830	7.88	283	330	4460	426	0.779	21.7
	6.3 #	37.2	47.4	28.7	2920	7.85	292	341	4680	444	0.773	20.7
	8.0	46.5	59.2	22.0	3570	7.76	357	421	5820	544	0.766	16.5
	10.0	57.0	72.6	17.0	4250	7.65	425	508	7070	651	0.757	13.3
	12.0 #	66.0	84.1	13.7	4730	7.50	473	576	8230	743	0.738	11.2
	12.5	68.3	87.0	13.0	4860	7.47	486	594	8500	765	0.736	10.7
250 x 250	6.0	45.2	57.6	38.7	5670	9.92	454	524	8840	681	0.979	21.6
	6.3 #	47.1	60.0	36.7	5870	9.89	470	544	9290	711	0.973	20.6
	8.0	59.1	75.2	28.3	7230	9.80	578	676	11600	878	0.966	16.3
	10.0	72.7	92.6	22.0	8710	9.70	697	822	14200	1060	0.957	13.2
	12.0 #	84.8	108	17.8	9860	9.55	789	944	16700	1230	0.938	11.1
	12.5	88.0	112	17.0	10200	9.52	813	975	17300	1270	0.936	10.7
300 x 300	6.0	54.7	69.6	47.0	9960	12.0	664	764	15400	997	1.18	21.6
	6.3 #	57.0	72.6	44.6	10300	11.9	689	795	16200	1040	1.17	20.5
	8.0	71.6	91.2	34.5	12800	11.8	853	991	20300	1290	1.17	16.4
	10.0	88.4	113	27.0	15500	11.7	1040	1210	25000	1570	1.16	13.1
	12.0 #	104	132	22.0	17800	11.6	1180	1400	29500	1830	1.14	11.0
	12.5	108	137	21.0	18300	11.6	1220	1450	30600	1890	1.14	10.6

Table 2.8.6.2. Hybox® SHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

UK EUROCODES

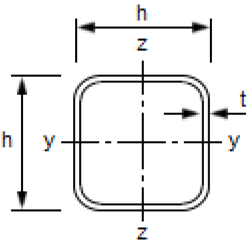
Table 2.8.6.3

SECTION PROPERTIES

COLD FORMED SQUARE HOLLOW SECTIONS

Hybox® SHS

Dimensions and properties



Cold Formed

Section Designation		Mass per Metre	Area of Section	Ratio for Local Buckling	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
Size	Thickness										Per Metre	Per Tonne
h x h	t		A	c/t (1)	I	i	W_{el}	W_{pl}	I_T	W_t		
mm	mm	kg/m	cm^2		cm^4	cm	cm^3	cm^3	cm^4	cm^3	m^2	m^2
350 x 350	6.0 #	64.1	81.6	55.3	16000	14.0	915	1050	24700	1370	1.38	21.5
	6.3 #	66.9	85.2	52.6	16600	14.0	951	1090	25900	1440	1.37	20.4
	8.0	84.2	107	40.8	20700	13.9	1180	1370	32600	1790	1.37	16.3
	10.0	104	133	32.0	25200	13.8	1440	1680	40100	2180	1.36	13.1
	12.0 #	123	156	26.2	29100	13.6	1660	1950	47600	2550	1.34	10.9
	12.5	127	162	25.0	30000	13.6	1720	2020	49400	2640	1.34	10.5
400 x 400	6.0 #	73.5	93.6	63.7	24100	16.0	1210	1380	37000	1810	1.58	21.5
	6.3 #	76.8	97.8	60.5	25100	16.0	1260	1440	38900	1890	1.57	20.4
	8.0	96.7	123	47.0	31300	15.9	1560	1800	48900	2360	1.57	16.2
	10.0	120	153	37.0	38200	15.8	1910	2210	60400	2890	1.56	13.0
	12.0 #	141	180	30.3	44300	15.7	2220	2590	71800	3400	1.54	10.9
	12.5	147	187	29.0	45900	15.7	2290	2680	74600	3520	1.54	10.5

Table 2.8.6.3. Hybox® SHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

UK EUROCODES

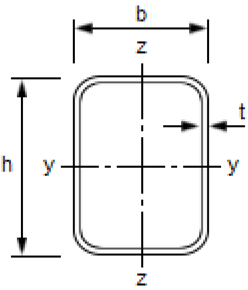
Table 2.8.7.1

SECTION PROPERTIES

COLD FORMED
RECTANGULAR HOLLOW SECTIONS

Hybox® RHS

Dimensions and properties



Cold Formed

Section Designation		Mass per	Area of	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size	Thickness	Metre	Section			Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z			Per Metre	Per Tonne
h x b			A	c_w/t (1)	c_f/t (1)									I_T	W_t		
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
50 x 25	2.0 #	2.15	2.74	22.0	9.50	8.38	2.81	1.75	1.01	3.35	2.25	4.26	2.62	7.06	3.92	0.143	66.5
	2.5	2.62	3.34	17.0	7.00	9.89	3.28	1.72	0.991	3.95	2.62	5.11	3.12	8.43	4.60	0.141	53.9
	3.0	3.07	3.91	13.7	5.33	11.2	3.67	1.69	0.969	4.47	2.93	5.86	3.56	9.64	5.18	0.140	45.6
50 x 30	2.0 #	2.31	2.94	22.0	12.0	9.54	4.29	1.80	1.21	3.81	2.86	4.74	3.33	9.77	4.84	0.153	66.4
	2.5	2.82	3.59	17.0	9.00	11.3	5.05	1.77	1.19	4.52	3.37	5.70	3.98	11.7	5.72	0.151	53.6
	3.0	3.30	4.21	13.7	7.00	12.8	5.70	1.75	1.16	5.13	3.80	6.57	4.58	13.5	6.49	0.150	45.5
	4.0	4.20	5.35	9.50	4.50	15.3	6.69	1.69	1.12	6.10	4.46	8.05	5.58	16.5	7.71	0.146	34.7
60 x 40	2.5 #	3.60	4.59	21.0	13.0	22.1	11.7	2.19	1.60	7.36	5.87	9.06	6.84	25.1	9.72	0.191	53.1
	3.0	4.25	5.41	17.0	10.3	25.4	13.4	2.17	1.58	8.46	6.72	10.5	7.94	29.3	11.2	0.190	44.8
	4.0	5.45	6.95	12.0	7.00	31.0	16.3	2.11	1.53	10.3	8.14	13.2	9.89	36.7	13.7	0.186	34.0
	5.0	6.56	8.36	9.00	5.00	35.3	18.4	2.06	1.48	11.8	9.21	15.4	11.5	42.8	15.6	0.183	27.8
70 x 40	3.0	4.72	6.01	20.3	10.3	37.3	15.5	2.49	1.61	10.7	7.75	13.4	9.05	36.5	13.2	0.210	44.5
	4.0	6.08	7.75	14.5	7.00	46.0	18.9	2.44	1.56	13.1	9.44	16.8	11.3	45.8	16.2	0.206	33.8
	5.0	7.34	9.36	11.0	5.00	52.9	21.5	2.38	1.52	15.1	10.8	19.8	13.3	53.8	18.7	0.203	27.6
70 x 50	3.0 #	5.19	6.61	20.3	13.7	44.1	26.1	2.58	1.99	12.6	10.4	15.4	12.2	53.6	17.1	0.230	44.4
	4.0	6.71	8.55	14.5	9.50	54.7	32.2	2.53	1.94	15.6	12.9	19.5	15.4	68.1	21.2	0.226	33.7
	5.0	8.13	10.4	11.0	7.00	63.5	37.2	2.48	1.90	18.1	14.9	23.1	18.2	80.8	24.6	0.223	27.4
80 x 40	3.0	5.19	6.61	23.7	10.3	52.3	17.6	2.81	1.63	13.1	8.78	16.5	10.2	43.9	15.3	0.230	44.4
	4.0	6.71	8.55	17.0	7.00	64.8	21.5	2.75	1.59	16.2	10.7	20.9	12.8	55.2	18.8	0.226	33.7
	5.0	8.13	10.4	13.0	5.00	75.1	24.6	2.69	1.54	18.8	12.3	24.7	15.0	65.0	21.7	0.223	27.4
80 x 50	3.0	5.66	7.21	23.7	13.7	61.1	29.4	2.91	2.02	15.3	11.8	18.8	13.6	65.0	19.7	0.250	44.3
	4.0	7.34	9.35	17.0	9.50	76.4	36.5	2.86	1.98	19.1	14.6	24.0	17.2	82.7	24.6	0.246	33.5
	5.0	8.91	11.4	13.0	7.00	89.2	42.3	2.80	1.93	22.3	16.9	28.5	20.5	98.4	28.7	0.243	27.2
80 x 60	3.0	6.13	7.81	23.7	17.0	70.0	44.9	3.00	2.40	17.5	15.0	21.2	17.4	88.3	24.1	0.270	44.0
	3.5	7.06	8.99	19.9	14.1	79.3	50.7	2.97	2.37	19.8	16.9	24.1	19.8	101	27.3	0.268	38.1
	4.0	7.97	10.1	17.0	12.0	87.9	56.1	2.94	2.35	22.0	18.7	27.0	22.1	113	30.3	0.266	33.5
	5.0	9.70	12.4	13.0	9.00	103	65.7	2.89	2.31	25.8	21.9	32.2	26.4	136	35.7	0.263	27.1
90 x 50	3.0 #	6.13	7.81	27.0	13.7	81.9	32.7	3.24	2.05	18.2	13.1	22.6	15.0	76.7	22.4	0.270	44.0
	4.0 #	7.97	10.1	19.5	9.50	103	40.7	3.18	2.00	22.8	16.3	28.8	19.1	97.7	28.0	0.266	33.5
	5.0	9.70	12.4	15.0	7.00	121	47.4	3.12	1.96	26.8	18.9	34.4	22.7	116	32.7	0.263	27.1

Table 2.8.7.1. Hybox® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

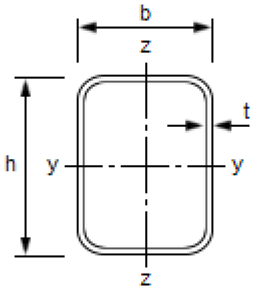
Table 2.8.7.2

SECTION PROPERTIES

COLD FORMED RECTANGULAR HOLLOW SECTIONS

Hybox® RHS

Dimensions and properties



Cold Formed

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size h x b	Thickness		A	c_w/t (1)	c_f/t (1)	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
100 x 40	3.0	6.13	7.81	30.3	10.3	92.3	21.7	3.44	1.67	18.5	10.8	23.7	12.4	59.0	19.4	0.270	44.0
	4.0	7.97	10.1	22.0	7.00	116	26.7	3.38	1.62	23.1	13.3	30.3	15.7	74.5	24.0	0.266	33.5
	5.0 #	9.70	12.4	17.0	5.00	136	30.8	3.31	1.58	27.1	15.4	36.1	18.5	87.9	27.9	0.263	27.1
100 x 50	3.0	6.60	8.41	30.3	13.7	106	36.1	3.56	2.07	21.3	14.4	26.7	16.4	88.6	25.0	0.290	44.1
	4.0	8.59	10.9	22.0	9.50	134	44.9	3.50	2.03	26.8	18.0	34.1	20.9	113	31.3	0.286	33.2
	5.0	10.5	13.4	17.0	7.00	158	52.5	3.44	1.98	31.6	21.0	40.8	25.0	135	36.8	0.283	27.0
	6.0	12.3	15.6	13.7	5.33	179	58.7	3.38	1.94	35.8	23.5	46.9	28.5	154	41.4	0.279	22.7
100 x 60	3.0	7.07	9.01	30.3	17.0	121	54.6	3.66	2.46	24.1	18.2	29.6	20.8	122	30.6	0.310	43.7
	3.5	8.16	10.4	25.6	14.1	137	61.9	3.63	2.44	27.4	20.6	33.8	23.8	139	34.8	0.308	37.9
	4.0	9.22	11.7	22.0	12.0	153	68.7	3.60	2.42	30.5	22.9	37.9	26.6	156	38.7	0.306	33.0
	5.0	11.3	14.4	17.0	9.00	181	80.8	3.55	2.37	36.2	26.9	45.6	31.9	188	45.8	0.303	26.9
	6.0	13.2	16.8	13.7	7.00	205	91.2	3.49	2.33	41.1	30.4	52.5	36.6	216	51.9	0.299	22.6
100 x 80	3.0 #	8.01	10.2	30.3	23.7	149	106	3.82	3.22	29.8	26.4	35.4	30.4	196	41.9	0.350	43.8
	4.0	10.5	13.3	22.0	17.0	189	134	3.77	3.17	37.9	33.5	45.6	39.2	254	53.4	0.346	33.0
	5.0	12.8	16.4	17.0	13.0	226	160	3.72	3.12	45.2	39.9	55.1	47.2	308	63.7	0.343	26.7
	6.0	15.1	19.2	13.7	10.3	258	182	3.67	3.08	51.7	45.5	63.8	54.7	357	73.0	0.339	22.4
120 x 40	3.0 #	7.07	9.01	37.0	10.3	148	25.8	4.05	1.69	24.7	12.9	32.2	14.6	74.6	23.5	0.310	43.7
	4.0 #	9.22	11.7	27.0	7.00	187	31.9	3.99	1.65	31.1	15.9	41.2	18.5	94.2	29.2	0.306	33.0
	5.0 #	11.3	14.4	21.0	5.00	221	36.9	3.92	1.60	36.8	18.5	49.4	22.0	111	34.1	0.303	26.9
120 x 60	3.0	8.01	10.2	37.0	17.0	189	64.4	4.30	2.51	31.5	21.5	39.2	24.2	156	37.1	0.350	43.8
	3.5	9.26	11.8	31.3	14.1	216	73.1	4.28	2.49	35.9	24.4	44.9	27.7	179	42.2	0.348	37.6
	4.0	10.5	13.3	27.0	12.0	241	81.2	4.25	2.47	40.1	27.1	50.5	31.1	201	47.0	0.346	33.0
	5.0	12.8	16.4	21.0	9.00	287	96.0	4.19	2.42	47.8	32.0	60.9	37.4	242	55.8	0.343	26.7
	6.0	15.1	19.2	17.0	7.00	328	109	4.13	2.38	54.7	36.3	70.6	43.1	280	63.6	0.339	22.4
120 x 80	3.0	8.96	11.4	37.0	23.7	230	123	4.49	3.29	38.4	30.9	46.2	35.0	255	50.8	0.390	43.7
	4.0	11.7	14.9	27.0	17.0	295	157	4.44	3.24	49.1	39.3	59.8	45.2	331	64.9	0.386	32.9
	5.0	14.4	18.4	21.0	13.0	353	188	4.39	3.20	58.9	46.9	72.4	54.7	402	77.8	0.383	26.6
	6.0	17.0	21.6	17.0	10.3	406	215	4.33	3.15	67.7	53.8	84.3	63.5	469	89.4	0.379	22.3
	8.0	21.4	27.2	12.0	7.00	476	252	4.18	3.04	79.3	62.9	102	76.9	584	108	0.366	17.1
140 x 80	3.0 #	9.90	12.6	43.7	23.7	334	141	5.15	3.35	47.8	35.3	58.2	39.6	317	59.7	0.430	43.4
	4.0	13.0	16.5	32.0	17.0	430	180	5.10	3.30	61.4	45.1	75.5	51.3	412	76.5	0.426	32.8
	5.0 #	16.0	20.4	25.0	13.0	517	216	5.04	3.26	73.9	54.0	91.8	62.2	501	91.8	0.423	26.5
	6.0	18.9	24.0	20.3	10.3	597	248	4.98	3.21	85.3	62.0	107	72.4	584	106	0.419	22.2
	8.0	23.9	30.4	14.5	7.00	708	293	4.82	3.10	101	73.3	131	88.4	731	129	0.406	17.0
	10.0	28.7	36.6	11.0	5.00	804	330	4.69	3.01	115	82.6	152	103	851	147	0.397	13.8

Table 2.8.7.2. Hybox® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

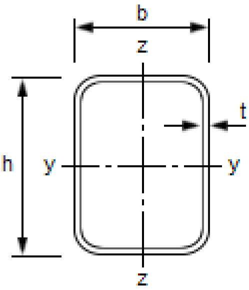
Table 2.8.7.3

SECTION PROPERTIES

COLD FORMED
RECTANGULAR HOLLOW SECTIONS

Hybox® RHS

Dimensions and properties



Cold Formed

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size h x b	Thickness		A	c_w/t (1)	c_f/t (1)	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
150 x 100	3.0 #	11.3	14.4	47.0	30.3	461	248	5.65	4.15	61.4	49.5	73.5	55.8	507	81.4	0.490	43.3
	4.0	14.9	18.9	34.5	22.0	595	319	5.60	4.10	79.3	63.7	95.7	72.5	662	105	0.486	32.7
	5.0	18.3	23.4	27.0	17.0	719	384	5.55	4.05	95.9	76.8	117	88.3	809	127	0.483	26.3
	6.0	21.7	27.6	22.0	13.7	835	444	5.50	4.01	111	88.8	137	103	948	147	0.479	22.1
	8.0	27.7	35.2	15.8	9.50	1010	536	5.35	3.90	134	107	169	128	1210	182	0.466	16.8
	10.0	33.4	42.6	12.0	7.00	1160	614	5.22	3.80	155	123	199	150	1430	211	0.457	13.7
160 x 80	3.0 #	10.8	13.8	50.3	23.7	464	159	5.80	3.39	58.0	39.8	71.4	44.3	380	68.6	0.470	43.4
	4.0	14.2	18.1	37.0	17.0	598	204	5.74	3.35	74.7	50.9	92.9	57.4	494	88.0	0.466	32.7
	5.0	17.5	22.4	29.0	13.0	722	244	5.68	3.30	90.2	61.0	113	69.7	601	106	0.463	26.4
	6.0	20.7	26.4	23.7	10.3	836	281	5.62	3.26	105	70.2	132	81.3	702	122	0.459	22.1
	8.0	26.4	33.6	17.0	7.00	1000	335	5.46	3.16	125	83.7	163	100	882	150	0.446	16.9
	10.0 #	31.8	40.6	13.0	5.00	1150	380	5.32	3.06	143	95.0	191	117	1030	172	0.437	13.7
180 x 80	3.0	11.8	15.0	57.0	23.7	621	177	6.43	3.43	69.0	44.2	85.8	48.9	445	77.5	0.510	43.3
	4.0	15.5	19.7	42.0	17.0	802	227	6.37	3.39	89.1	56.7	112	63.5	578	99.6	0.506	32.6
	5.0	19.1	24.4	33.0	13.0	971	272	6.31	3.34	108	68.1	137	77.2	704	120	0.503	26.3
	6.0 #	22.6	28.8	27.0	10.3	1130	314	6.25	3.30	125	78.5	160	90.2	823	139	0.499	22.1
	8.0	28.9	36.8	19.5	7.00	1360	377	6.08	3.20	151	94.1	198	111	1040	170	0.486	16.8
	10.0 #	35.0	44.6	15.0	5.00	1570	429	5.94	3.10	174	107	234	131	1210	196	0.477	13.6
180 x 100	4.0 #	16.8	21.3	42.0	22.0	926	374	6.59	4.18	103	74.8	126	84.0	854	127	0.546	32.6
	5.0	20.7	26.4	33.0	17.0	1120	452	6.53	4.14	125	90.4	154	103	1050	154	0.543	26.2
	6.0	24.5	31.2	27.0	13.7	1310	524	6.48	4.10	146	105	181	120	1230	179	0.539	22.0
	8.0	31.4	40.0	19.5	9.50	1600	637	6.32	3.99	178	127	226	150	1570	222	0.526	16.7
	10.0	38.1	48.6	15.0	7.00	1860	736	6.19	3.89	207	147	268	177	1860	260	0.517	13.5
200 x 100	4.0	18.0	22.9	47.0	22.0	1200	411	7.23	4.23	120	82.2	148	91.7	985	142	0.586	32.5
	5.0	22.3	28.4	37.0	17.0	1460	497	7.17	4.19	146	99.4	181	112	1210	172	0.583	26.2
	6.0	26.4	33.6	30.3	13.7	1700	577	7.12	4.14	170	115	213	132	1420	200	0.579	21.9
	8.0	33.9	43.2	22.0	9.50	2090	705	6.95	4.04	209	141	267	165	1810	250	0.566	16.7
	10.0	41.3	52.6	17.0	7.00	2440	818	6.82	3.94	244	164	318	195	2150	292	0.557	13.5
200 x 120	4.0	19.3	24.5	47.0	27.0	1350	618	7.43	5.02	135	103	164	115	1350	172	0.626	32.5
	5.0	23.8	30.4	37.0	21.0	1650	750	7.37	4.97	165	125	201	141	1650	210	0.623	26.2
	6.0	28.3	36.0	30.3	17.0	1930	874	7.32	4.93	193	146	237	166	1950	245	0.619	21.9
	8.0	36.5	46.4	22.0	12.0	2390	1080	7.17	4.82	239	180	298	209	2510	308	0.606	16.6
	10.0	44.4	56.6	17.0	9.00	2810	1260	7.04	4.72	281	210	356	250	3010	364	0.597	13.4
200 x 150	4.0 #	21.2	26.9	47.0	34.5	1580	1020	7.67	6.16	158	136	187	154	1940	219	0.686	32.4
	5.0 #	26.2	33.4	37.0	27.0	1940	1250	7.62	6.11	193	166	230	189	2390	267	0.683	26.1
	6.0	31.1	39.6	30.3	22.0	2270	1460	7.56	6.06	227	194	271	223	2830	313	0.679	21.8
	8.0	40.2	51.2	22.0	15.8	2830	1820	7.43	5.95	283	242	344	283	3670	396	0.666	16.6
	10.0	49.1	62.6	17.0	12.0	3350	2140	7.31	5.85	335	286	413	339	4430	471	0.657	13.4

Table 2.8.7.3. Hybox® RHS. Dimensions and properties

BS EN 1993-1-1: 2005
BS EN 10219-2: 2006

UK EUROCODES

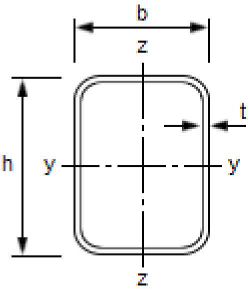
Table 2.8.7.4

SECTION PROPERTIES

COLD FORMED RECTANGULAR HOLLOW SECTIONS

Hybox® RHS

Dimensions and properties



Cold Formed

Section Designation		Mass per Metre	Area of Section	Ratios for Local Buckling		Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface Area	
Size h x b	Thickness		A	c_w/t (1)	c_f/t (1)	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	I_T	W_t	Per Metre	Per Tonne
mm	mm	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
250 x 150	5.0	30.1	38.4	47.0	27.0	3300	1510	9.28	6.27	264	201	320	225	3290	337	0.783	26.0
	6.0	35.8	45.6	38.7	22.0	3890	1770	9.23	6.23	311	236	378	266	3890	396	0.779	21.7
	6.3 #	37.2	47.4	36.7	20.8	4000	1830	9.18	6.20	320	243	391	276	4080	412	0.773	20.7
	8.0	46.5	59.2	28.3	15.8	4890	2220	9.08	6.12	391	296	482	340	5050	504	0.766	16.5
	10.0	57.0	72.6	22.0	12.0	5830	2630	8.96	6.02	466	351	582	409	6120	602	0.757	13.3
	12.0	66.0	84.1	17.8	9.50	6460	2930	8.77	5.90	517	390	658	463	7090	684	0.738	11.2
	12.5	68.3	87.0	17.0	9.00	6630	3000	8.73	5.87	531	400	678	477	7320	704	0.736	10.7
300 x 100	8.0	46.5	59.2	34.5	9.50	5980	1050	10.0	4.20	399	209	523	238	3080	385	0.766	16.5
	10.0	57.0	72.6	27.0	7.00	7110	1220	9.90	4.11	474	245	631	285	3680	455	0.757	13.3
300 x 200	6.0	45.2	57.6	47.0	30.3	7370	3960	11.3	8.29	491	396	588	446	8120	651	0.979	21.6
	6.3 #	47.1	60.0	44.6	28.7	7620	4100	11.3	8.27	508	410	610	463	8520	680	0.973	20.6
	8.0	59.1	75.2	34.5	22.0	9390	5040	11.2	8.19	626	504	757	574	10600	838	0.966	16.3
	10.0	72.7	92.6	27.0	17.0	11300	6060	11.1	8.09	754	606	921	698	13000	1010	0.957	13.2
	12.0 #	84.8	108	22.0	13.7	12800	6850	10.9	7.96	853	685	1060	801	15200	1170	0.938	11.1
	12.5	88.0	112	21.0	13.0	13200	7060	10.8	7.94	879	706	1090	828	15800	1200	0.936	10.7
400 x 200	6.0 #	54.7	69.6	63.7	30.3	14800	5090	14.6	8.55	739	509	906	562	12100	877	1.18	21.6
	6.3 #	57.0	72.6	60.5	28.7	15300	5290	14.5	8.53	766	529	942	585	12700	916	1.17	20.5
	8.0	71.6	91.2	47.0	22.0	19000	6520	14.4	8.45	949	652	1170	728	15800	1130	1.17	16.4
	10.0	88.4	113	37.0	17.0	23000	7860	14.3	8.36	1150	786	1430	888	19400	1370	1.16	13.1
	12.0 #	104	132	30.3	13.7	26200	8980	14.1	8.24	1310	898	1660	1030	22800	1590	1.14	11.0
	12.5	108	137	29.0	13.0	27100	9260	14.1	8.22	1360	926	1710	1060	23600	1640	1.14	10.6
450 x 250	6.0 #	64.1	81.6	72.0	38.7	22700	9250	16.7	10.6	1010	740	1220	817	20700	1250	1.38	21.5
	6.3 #	66.9	85.2	68.4	36.7	23600	9620	16.6	10.6	1050	769	1270	851	21700	1310	1.37	20.4
	8.0 #	84.2	107	53.3	28.3	29300	11900	16.5	10.5	1300	953	1590	1060	27200	1630	1.37	16.3
	10.0 #	104	133	42.0	22.0	35700	14500	16.4	10.4	1590	1160	1950	1300	33500	1980	1.36	13.1
	12.0 #	123	156	34.5	17.8	41100	16700	16.2	10.3	1830	1330	2260	1520	39600	2310	1.34	10.9
	12.5 #	127	162	33.0	17.0	42500	17200	16.2	10.3	1890	1380	2350	1570	41100	2390	1.34	10.5
500 x 300	6.0 #	73.5	93.6	80.3	47.0	33000	15200	18.8	12.7	1320	1010	1580	1120	32400	1690	1.58	21.5
	6.3 #	76.8	97.8	76.4	44.6	34300	15800	18.7	12.7	1370	1050	1650	1170	34100	1770	1.57	20.4
	8.0 #	96.7	123	59.5	34.5	42800	19600	18.6	12.6	1710	1310	2060	1460	42800	2200	1.57	16.2
	10.0 #	120	153	47.0	27.0	52300	23900	18.5	12.5	2090	1600	2540	1790	52700	2690	1.56	13.0
	12.0 #	141	180	38.7	22.0	60600	27700	18.3	12.4	2420	1850	2960	2090	62600	3160	1.54	10.9
	12.5 #	147	187	37.0	21.0	62700	28700	18.3	12.4	2510	1910	3070	2170	65000	3270	1.54	10.5

Table 2.8.7.4. Hybox® RHS. Dimensions and properties

BS EN 1993-1-8: 2005
BS EN ISO 4016
BS EN ISO 4018

UK EUROCODES

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 4.6 Countersunk Bolts

S275

C-305

Table 2.14.4.1

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	17.0	13.8	27.5	1.5
16	157	31.7	30.1	60.3	2.2
20	245	49.4	47.0	94.1	2.7
24	353	71.2	67.8	136	3.3
30	561	113	108	215	4.1

Table 2.14.4.1. Bolt Resistances.
Non-preloaded Class 4.6 countersunk bolts in S275

Table 2.14.4.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	**10.3**	15.5	20.7	25.9	*31.0*	*36.2*	*46.6*	*62.1*	*87.9*	*114*	*140*
16	25	35	50	50	**6.81**	**13.6**	**20.4**	**27.2**	34.0	40.8	54.5	*74.9*	*109*	*143*	*177*
20	30	40	60	60	**0**	**8.42**	**16.8**	**25.3**	**33.7**	**42.1**	58.9	84.2	*126*	*168*	*211*
24	35	50	70	70	**0**	**0**	**10.0**	**20.0**	**30.1**	**40.1**	**60.1**	90.2	*140*	*190*	*241*
30	45	60	85	90	**0**	**0**	**0**	**6.32**	**18.9**	**31.6**	**56.8**	**94.7**	158	*221*	*284*

Table 2.14.4.1. Bolt Resistances.
Non-preloaded Class 4.6 countersunk bolts in S275

BS EN 1993-1-8: 2005
BS EN ISO 4014
BS EN ISO 4017

UK EUROCODES

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 8.8 Countersunk Bolts

S275

C-306

Table 2.14.4.3

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	34.0	27.5	55.0	3.0
16	157	63.3	60.3	121	4.4
20	245	98.8	94.1	188	5.5
24	353	142	136	271	6.6
30	561	226	215	431	8.1

Table 2.14.4.5. Bolt Resistances.
Non-preloaded Class 8.8 countersunk bolts in S275

Table 2.14.4.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	**10.3**	**15.5**	**20.7**	**25.9**	31.0	36.2	46.6	*62.1*	*87.9*	*114*	*140*
16	25	35	50	50	**6.81**	**13.6**	**20.4**	**27.2**	**34.0**	**40.8**	**54.5**	74.9	109	*143*	*177*
20	30	40	60	60	**0**	**8.42**	**16.8**	**25.3**	**33.7**	**42.1**	**58.9**	**84.2**	126	168	*211*
24	35	50	70	70	**0**	**0**	**10.0**	**20.0**	**30.1**	**40.1**	**60.1**	**90.2**	140	190	241
30	45	60	85	90	**0**	**0**	**0**	**6.32**	**18.9**	**31.6**	**56.8**	**94.7**	**158**	221	284

Table 2.14.4.4. Bolt Resistances.
Non-preloaded Class 8.8 countersunk bolts in S275

Table 2.14.4.5

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	25	45	55	45	**19.7**	29.5	39.4	49.2	*59.0*	*68.9*	*88.6*	*118*	*167*	*216*	*266*
16	30	55	70	55	**13.1**	**26.2**	**39.4**	**52.5**	65.6	78.7	105	*144*	*210*	*276*	*341*
20	35	70	85	70	**0**	**16.4**	**32.8**	**49.2**	**65.6**	**82.0**	115	164	*246*	*328*	*410*
24	40	80	100	80	**0**	**0**	**19.7**	**39.4**	**59.0**	**78.7**	**118**	177	*276*	*374*	*472*
30	50	100	125	100	**0**	**0**	**0**	**12.3**	**36.9**	**61.5**	**111**	**185**	308	431	*554*

Table 2.14.4.4. Bolt Resistances.
Non-preloaded Class 8.8 countersunk bolts in S275

BS EN 1993-1-8: 2005
BS EN ISO 4014
BS EN ISO 4017

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 10.9 Countersunk Bolts

S275

C-307

Table 2.14.4.6

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	42.5	28.7	57.3	3.7
16	157	79.1	62.8	126	5.5
20	245	123	98.0	196	6.9
24	353	178	141	282	8.2
30	561	283	224	449	10.2

Table 2.14.4.8. Bolt Resistances.
Non-preloaded Class 10.9 countersunk bolts in S275

Table 2.14.4.7

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	**10.3**	**15.5**	**20.7**	**25.9**	31.0	36.2	46.6	*62.1*	*87.9*	*114*	*140*
16	25	35	50	50	**6.81**	**13.6**	**20.4**	**27.2**	**34.0**	**40.8**	**54.5**	74.9	109	*143*	*177*
20	30	40	60	60	**0**	**8.42**	**16.8**	**25.3**	**33.7**	**42.1**	**58.9**	**84.2**	126	168	*211*
24	35	50	70	70	**0**	**0**	**10.0**	**20.0**	**30.1**	**40.1**	**60.1**	**90.2**	**140**	190	241
30	45	60	85	90	**0**	**0**	**0**	**6.32**	**18.9**	**31.6**	**56.8**	**94.7**	**158**	**221**	284

Table 2.14.4.7. Bolt Resistances.
Non-preloaded Class 10.9 countersunk bolts in S275

Table 2.14.4.8

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	25	45	55	45	**19.7**	29.5	39.4	49.2	*59.0*	*68.9*	*88.6*	*118*	*167*	*216*	*266*
16	30	55	70	55	**13.1**	**26.2**	**39.4**	**52.5**	65.6	78.7	105	*144*	*210*	*276*	*341*
20	35	70	85	70	**0**	**16.4**	**32.8**	**49.2**	**65.6**	**82.0**	115	164	*246*	*328*	*410*
24	40	80	100	80	**0**	**0**	**19.7**	**39.4**	**59.0**	**78.7**	**118**	177	276	*374*	*472*
30	50	100	125	100	**0**	**0**	**0**	**12.3**	**36.9**	**61.5**	**111**	**185**	308	431	*554*

Table 2.14.4.7. Bolt Resistances.
Non-preloaded Class 10.9 countersunk bolts in S275

BS EN 1993-1-8: 2005
BS EN ISO 4016
BS EN ISO 4018

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 4.6 Countersunk Bolts

S355

D-305

Table 2.14.3.1

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	17.0	13.8	27.5	1.3
16	157	31.7	30.1	60.3	1.9
20	245	49.4	47.0	94.1	2.4
24	353	71.2	67.8	136	2.9
30	561	113	108	215	3.6

Table 2.14.3.1. Bolt Resistances.
Non-preloaded Class 4.6 countersunk bolts in S355

Table 2.14.3.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	**11.9**	17.8	23.7	*29.7*	*35.6*	*41.5*	*53.4*	*71.2*	*101*	*130*	*160*
16	25	35	50	50	**7.80**	**15.6**	**23.4**	31.2	39.0	46.8	*62.4*	*85.8*	*125*	*164*	*203*
20	30	40	60	60	**0**	**9.65**	**19.3**	**29.0**	**38.6**	48.3	67.6	*96.5*	*145*	*193*	*241*
24	35	50	70	70	**0**	**0**	**11.5**	**23.0**	**34.5**	**46.0**	68.9	103	*161*	*218*	*276*
30	45	60	85	90	**0**	**0**	**0**	**7.24**	**21.7**	**36.2**	**65.2**	109	181	*253*	*326*

Table 2.14.3.1. Bolt Resistances.
Non-preloaded Class 4.6 countersunk bolts in S355

BS EN 1993-1-8: 2005
BS EN ISO 4014
BS EN ISO 4017

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 8.8 Countersunk Bolts

S355

D-306

Table 2.14.3.3

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	34.0	27.5	55.0	2.6
16	157	63.3	60.3	121	3.9
20	245	98.8	94.1	188	4.8
24	353	142	136	271	5.7
30	561	226	215	431	7.1

Table 2.14.3.5. Bolt Resistances.
Non-preloaded Class 8.8 countersunk bolts in S355

Table 2.14.3.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply, t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	**11.9**	**17.8**	**23.7**	29.7	35.6	41.5	53.4	*71.2*	*101*	*130*	*160*
16	25	35	50	50	**7.80**	**15.6**	**23.4**	**31.2**	**39.0**	**46.8**	62.4	85.8	*125*	*164*	*203*
20	30	40	60	60	**0**	**9.65**	**19.3**	**29.0**	**38.6**	**48.3**	**67.6**	96.5	145	*193*	*241*
24	35	50	70	70	**0**	**0**	**11.5**	**23.0**	**34.5**	**46.0**	**68.9**	**103**	161	218	*276*
30	45	60	85	90	**0**	**0**	**0**	**7.24**	**21.7**	**36.2**	**65.2**	**109**	**181**	253	326

Table 2.14.3.4. Bolt Resistances.
Non-preloaded Class 8.8 countersunk bolts in S355

Table 2.14.3.5

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply, t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	25	45	55	45	**22.6**	33.8	45.1	*56.4*	*67.7*	*79.0*	*102*	*135*	*192*	*248*	*305*
16	30	55	70	55	**15.0**	**30.1**	**45.1**	**60.2**	75.2	90.2	120	*165*	*241*	*316*	*391*
20	35	70	85	70	**0**	**18.8**	**37.6**	**56.4**	**75.2**	**94.0**	132	188	*282*	*376*	*470*
24	40	80	100	80	**0**	**0**	**22.6**	**45.1**	**67.7**	**90.2**	**135**	203	*316*	*429*	*541*
30	50	100	125	100	**0**	**0**	**0**	**14.1**	**42.3**	**70.5**	**127**	**212**	353	*494*	*635*

Table 2.14.3.4. Bolt Resistances.
Non-preloaded Class 8.8 countersunk bolts in S355

BS EN 1993-1-8: 2005
BS EN ISO 4014
BS EN ISO 4017

UK EUROCODES

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 10.9 Countersunk Bolts

S355

D-307

Table 2.14.3.6

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	42.5	28.7	57.3	3.2
16	157	79.1	62.8	126	4.8
20	245	123	98.0	196	6.0
24	353	178	141	282	7.2
30	561	283	224	449	8.9

Table 2.14.3.8. Bolt Resistances.
Non-preloaded Class 10.9 countersunk bolts in S355

Table 2.14.3.7

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	**11.9**	**17.8**	**23.7**	29.7	35.6	41.5	53.4	*71.2*	*101*	*130*	*160*
16	25	35	50	50	**7.80**	**15.6**	**23.4**	**31.2**	**39.0**	**46.8**	**62.4**	85.8	125	*164*	*203*
20	30	40	60	60	**0**	**9.65**	**19.3**	**29.0**	**38.6**	**48.3**	**67.6**	**96.5**	145	193	*241*
24	35	50	70	70	**0**	**0**	**11.5**	**23.0**	**34.5**	**46.0**	**68.9**	**103**	161	218	276
30	45	60	85	90	**0**	**0**	**0**	**7.24**	**21.7**	**36.2**	**65.2**	**109**	**181**	253	326

Table 2.14.3.7. Bolt Resistances.
Non-preloaded Class 10.9 countersunk bolts in S355

Table 2.14.3.8

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	25	45	55	45	**22.6**	33.8	45.1	56.4	*67.7*	*79.0*	*102*	*135*	*192*	*248*	*305*
16	30	55	70	55	**15.0**	**30.1**	**45.1**	**60.2**	75.2	90.2	120	*165*	*241*	*316*	*391*
20	35	70	85	70	**0**	**18.8**	**37.6**	**56.4**	**75.2**	**94.0**	132	188	*282*	*376*	*470*
24	40	80	100	80	**0**	**0**	**22.6**	**45.1**	**67.7**	**90.2**	**135**	203	*316*	*429*	*541*
30	50	100	125	100	**0**	**0**	**0**	**14.1**	**42.3**	**70.5**	**127**	**212**	353	*494*	*635*

Table 2.14.3.7. Bolt Resistances.
Non-preloaded Class 10.9 countersunk bolts in S355

BS EN 1993-1-8: 2005
BS EN ISO 4016
BS EN ISO 4018

UK EUROCODES

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 4.6 Hexagon Head Bolts

S275

C-302

Table 2.14.2.1

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	24.3	13.8	27.5	2.1
16	157	45.2	30.1	60.3	3.2
20	245	70.6	47.0	94.1	3.9
24	353	102	67.8	136	4.7
30	561	162	108	215	5.8

Table 2.14.2.1. Bolt Resistances.
Non-preloaded Class 4.6 hexagon head bolts in S275

Table 2.14.2.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	25.9	*31.0*	*36.2*	*41.4*	*46.6*	*51.7*	*62.1*	*77.6*	*103*	*129*	*155*
16	25	35	50	50	34.0	40.8	47.7	54.5	*61.3*	*68.1*	*81.7*	*102*	*136*	*170*	*204*
20	30	40	60	60	**42.1**	50.5	58.9	67.4	75.8	84.2	*101*	*126*	*168*	*211*	*253*
24	35	50	70	70	**50.1**	**60.1**	70.2	80.2	90.2	100	120	*150*	*200*	*251*	*301*
30	45	60	85	90	**63.2**	**75.8**	**88.4**	**101**	114	126	152	189	*253*	*316*	*379*

Table 2.14.2.1. Bolt Resistances.
Non-preloaded Class 4.6 hexagon head bolts in S275

BS EN 1993-1-8: 2005
BS EN ISO 4014
BS EN ISO 4017

UK EUROCODES

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 8.8 Hexagon Head Bolts

S275

C-303

Table 2.14.2.3

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	48.6	27.5	55.0	4.3
16	157	90.4	60.3	121	6.3
20	245	141	94.1	188	7.8
24	353	203	136	271	9.4
30	561	323	215	431	11.6

Table 2.14.2.5. Bolt Resistances.
Non-preloaded Class 8.8 hexagon head bolts in S275

Table 2.14.2.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	**25.9**	31.0	36.2	41.4	46.6	51.7	*62.1*	*77.6*	*103*	*129*	*155*
16	25	35	50	50	**34.0**	**40.8**	**47.7**	**54.5**	61.3	68.1	81.7	102	*136*	*170*	*204*
20	30	40	60	60	**42.1**	**50.5**	**58.9**	**67.4**	**75.8**	**84.2**	101	126	168	*211*	*253*
24	35	50	70	70	**50.1**	**60.1**	**70.2**	**80.2**	**90.2**	**100**	**120**	150	200	251	*301*
30	45	60	85	90	**63.2**	**75.8**	**88.4**	**101**	**114**	**126**	**152**	**189**	253	316	379

Table 2.14.2.4. Bolt Resistances.
Non-preloaded Class 8.8 hexagon head bolts in S275

Table 2.14.2.5

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	25	40	50	45	42.2	50.6	*59.0*	*67.5*	*75.9*	*84.3*	*101*	*127*	*169*	*211*	*253*
16	30	50	65	55	**58.3**	70.0	81.6	93.3	105	117	*140*	*175*	*233*	*292*	*350*
20	35	60	80	70	**74.5**	**89.5**	104	119	134	149	179	*224*	*298*	*373*	*447*
24	40	75	95	80	**90.8**	**109**	**127**	145	163	182	218	*272*	*363*	*454*	*545*
30	50	90	115	100	**112**	**134**	**157**	**179**	**201**	224	268	335	*447*	*559*	*671*

Table 2.14.2.4. Bolt Resistances.
Non-preloaded Class 8.8 hexagon head bolts in S275

BS EN 1993-1-8: 2005
BS EN ISO 4014
BS EN ISO 4017

UK
EUROCODES

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 10.9 Hexagon Head Bolts

S275

C-304

Table 2.14.2.6

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance: Single Shear	Shear Resistance: Double Shear	Bolts in Tension: Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	60.7	28.7	57.3	5.3
16	157	113	62.8	126	7.9
20	245	176	98.0	196	9.8
24	353	254	141	282	11.7
30	561	404	224	449	14.5

Table 2.14.2.8. Bolt Resistances.
Non-preloaded Class 10.9 hexagon head bolts in S275

Table 2.14.2.7

Diameter of Bolt	Minimum Edge Distance	Minimum End Distance	Minimum Pitch	Minimum Gauge	Bearing Resistance (kN)										
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	**25.9**	31.0	36.2	41.4	46.6	51.7	*62.1*	*77.6*	*103*	*129*	*155*
16	25	35	50	50	**34.0**	**40.8**	**47.7**	**54.5**	**61.3**	68.1	81.7	102	*136*	*170*	*204*
20	30	40	60	60	**42.1**	**50.5**	**58.9**	**67.4**	**75.8**	**84.2**	101	126	168	*211*	*253*
24	35	50	70	70	**50.1**	**60.1**	**70.2**	**80.2**	**90.2**	**100**	**120**	150	200	251	*301*
30	45	60	85	90	**63.2**	**75.8**	**88.4**	**101**	**114**	**126**	**152**	**189**	253	316	379

Table 2.14.2.7. Bolt Resistances.
Non-preloaded Class 10.9 hexagon head bolts in S275

Table 2.14.2.8

Diameter of Bolt	Minimum Edge Distance	Minimum End Distance	Minimum Pitch	Minimum Gauge	Bearing Resistance (kN)										
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	25	40	50	45	42.2	50.6	*59.0*	*67.5*	*75.9*	*84.3*	*101*	*127*	*169*	*211*	*253*
16	30	50	65	55	**58.3**	70.0	81.6	93.3	105	117	*140*	*175*	*233*	*292*	*350*
20	35	60	80	70	**74.5**	**89.5**	104	119	134	149	179	*224*	*298*	*373*	*447*
24	40	75	95	80	**90.8**	**109**	**127**	145	163	182	218	272	*363*	*454*	*545*
30	50	90	115	100	**112**	**134**	**157**	**179**	**201**	**224**	268	335	447	*559*	*671*

Table 2.14.2.7. Bolt Resistances.
Non-preloaded Class 10.9 hexagon head bolts in S275

BS EN 1993-1-8: 2005
BS EN ISO 4016
BS EN ISO 4018

UK
EUROCODES

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 4.6 Hexagon Head Bolts

S355

D-302

Table 2.14.1.1

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	24.3	13.8	27.5	1.9
16	157	45.2	30.1	60.3	2.8
20	245	70.6	47.0	94.1	3.4
24	353	102	67.8	136	4.1
30	561	162	108	215	5.1

Table 2.14.1.1. Bolt Resistances.
Non-preloaded Class 4.6 hexagon head bolts in S355

Table 2.14.1.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	*29.7*	*35.6*	*41.5*	*47.4*	*53.4*	*59.3*	*71.2*	*89.0*	*119*	*148*	*178*
16	25	35	50	50	39.0	46.8	54.6	*62.4*	*70.2*	*78.0*	*93.6*	*117*	*156*	*195*	*234*
20	30	40	60	60	48.3	57.9	67.6	77.2	86.9	*96.5*	*116*	*145*	*193*	*241*	*290*
24	35	50	70	70	**57.5**	68.9	80.4	91.9	103	115	*138*	*172*	*230*	*287*	*345*
30	45	60	85	90	**72.4**	**86.9**	**101**	116	130	145	174	*217*	*290*	*362*	*434*

Table 2.14.1.1. Bolt Resistances.
Non-preloaded Class 4.6 hexagon head bolts in S355

BS EN 1993-1-8: 2005
BS EN ISO 4014
BS EN ISO 4017

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 8.8 Hexagon Head Bolts

S355

D-303

Table 2.14.1.3

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	48.6	27.5	55.0	3.7
16	157	90.4	60.3	121	5.5
20	245	141	94.1	188	6.8
24	353	203	136	271	8.2
30	561	323	215	431	10.1

Table 2.14.1.5. Bolt Resistances.
Non-preloaded Class 8.8 hexagon head bolts in S355

Table 2.14.1.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	29.7	35.6	41.5	47.4	53.4	*59.3*	*71.2*	*89.0*	*119*	*148*	*178*
16	25	35	50	50	**39.0**	**46.8**	**54.6**	62.4	70.2	78.0	93.6	117	*156*	*195*	*234*
20	30	40	60	60	**48.3**	**57.9**	**67.6**	**77.2**	**86.9**	96.5	116	145	*193*	*241*	*290*
24	35	50	70	70	**57.5**	**68.9**	**80.4**	**91.9**	**103**	**115**	138	172	230	*287*	*345*
30	45	60	85	90	**72.4**	**86.9**	**101**	**116**	**130**	**145**	**174**	217	290	362	*434*

Table 2.14.1.4. Bolt Resistances.
Non-preloaded Class 8.8 hexagon head bolts in S355

Table 2.14.1.5

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	25	40	50	45	48.3	*58.0*	*67.7*	*77.3*	*87.0*	*96.7*	*116*	*145*	*193*	*242*	*290*
16	30	50	65	55	66.8	80.2	93.6	107	120	*134*	*160*	*201*	*267*	*334*	*401*
20	35	60	80	70	**85.5**	103	120	137	154	171	*205*	*256*	*342*	*427*	*513*
24	40	75	95	80	**104**	**125**	146	167	187	208	250	*312*	*416*	*521*	*625*
30	50	90	115	100	**128**	**154**	**179**	**205**	231	256	308	385	*513*	*641*	*769*

Table 2.14.1.4. Bolt Resistances.
Non-preloaded Class 8.8 hexagon head bolts in S355

BS EN 1993-1-8: 2005
BS EN ISO 4014
BS EN ISO 4017

UK EUROCODES

BOLT RESISTANCES

NON-PRELOADED BOLTS

Class 10.9 Hexagon Head Bolts

S355

D-304

Table 2.14.1.6

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension
			Single Shear	Double Shear	Min Thickness for Punching Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}
mm	mm^2	kN	kN	kN	mm
12	84.3	60.7	28.7	57.3	4.6
16	157	113	62.8	126	6.9
20	245	176	98.0	196	8.5
24	353	254	141	282	10.2
30	561	404	224	449	12.7

Table 2.14.1.8. Bolt Resistances.
Non-preloaded Class 10.9 hexagon head bolts in S355

Table 2.14.1.7

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	25	35	40	29.7	35.6	41.5	47.4	53.4	*59.3*	*71.2*	*89.0*	*119*	*148*	*178*
16	25	35	50	50	**39.0**	**46.8**	**54.6**	**62.4**	70.2	78.0	93.6	117	*156*	*195*	*234*
20	30	40	60	60	**48.3**	**57.9**	**67.6**	**77.2**	**86.9**	**96.5**	116	145	193	*241*	*290*
24	35	50	70	70	**57.5**	**68.9**	**80.4**	**91.9**	**103**	**115**	**138**	172	230	*287*	*345*
30	45	60	85	90	**72.4**	**86.9**	**101**	**116**	**130**	**145**	**174**	**217**	290	362	434

Table 2.14.1.7. Bolt Resistances.
Non-preloaded Class 10.9 hexagon head bolts in S355

Table 2.14.1.8

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	25	40	50	45	48.3	*58.0*	*67.7*	*77.3*	*87.0*	*96.7*	*116*	*145*	*193*	*242*	*290*
16	30	50	65	55	66.8	80.2	93.6	107	120	*134*	*160*	*201*	*267*	*334*	*401*
20	35	60	80	70	**85.5**	103	120	137	154	171	*205*	*256*	*342*	*427*	*513*
24	40	75	95	80	**104**	**125**	146	167	187	208	250	*312*	*416*	*521*	*625*
30	50	90	115	100	**128**	**154**	**179**	**205**	231	256	308	385	*513*	*641*	*769*

Table 2.14.1.7. Bolt Resistances.
Non-preloaded Class 10.9 hexagon head bolts in S355

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT SERVICEABILITY LIMIT STATE

Class 8.8 countersunk bolts

S275

C-312

Table 2.14.12.1

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension	Slip Resistance $\mu = 0.5$	
			Single Shear	Double Shear	Min Thickness for Punching Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}		
mm	mm^2	kN	kN	kN	mm	kN	kN
12	84.3	34.0	27.5	55.0	2.60	21.5	42.9
16	157	63.3	60.3	121	3.91	40.0	79.9
20	245	98.8	94.1	188	5.15	62.4	125
24	353	142	136	271	5.76	89.9	180
30	561	226	215	431	7.47	143	286

Table 2.14.12.1. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 8.8 countersunk bolts in S275

Table 2.14.12.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	40	50	40	**15.5**	**23.3**	31.0	38.8	46.6	54.3	*69.8*	*93.1*	*132*	*171*	*210*
16	25	50	65	50	**10.2**	**20.4**	**30.6**	**40.8**	**51.1**	61.3	81.7	112	*163*	*214*	*265*
20	30	60	80	60	**0**	**12.6**	**25.3**	**37.9**	**50.5**	**63.2**	**88.4**	126	*189*	*253*	*316*
24	35	75	95	70	**0**	**0**	**15.0**	**30.1**	**45.1**	**60.1**	**90.2**	**135**	211	*286*	*361*
30	45	90	115	90	**0**	**0**	**0**	**9.47**	**28.4**	**47.4**	**85.3**	**142**	237	332	426

Table 2.14.12.1. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 8.8 countersunk bolts in S275

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT SERVICEABILITY LIMIT STATE

Class 10.9 countersunk bolts

S275

C-313

Table 2.14.12.3

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension	Slip Resistance $\mu = 0.5$	
			Single Shear	Double Shear	Min Thickness for Punching Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}		
mm	mm^2	kN	kN	kN	mm	kN	kN
16	157	79.1	62.8	126	4.89	50.0	99.9
20	245	123	98.0	196	6.44	78.0	156
24	353	178	141	282	7.19	112	225
30	561	283	224	449	9.33	179	357

Table 2.14.12.3. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 10.9 countersunk bolts in S275

Table 2.14.12.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
16	25	50	65	50	**10.2**	**20.4**	**30.6**	**40.8**	**51.1**	**61.3**	81.7	112	*163*	*214*	*265*
20	30	60	80	60	**0**	**12.6**	**25.3**	**37.9**	**50.5**	**63.2**	**88.4**	126	189	*253*	*316*
24	35	75	95	70	**0**	**0**	**15.0**	**30.1**	**45.1**	**60.1**	**90.2**	**135**	211	*286*	*361*
30	45	90	115	90	**0**	**0**	**0**	**9.47**	**28.4**	**47.4**	**85.3**	**142**	237	332	426

Table 2.14.12.3. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 10.9 countersunk bolts in S275

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT SERVICEABILITY LIMIT STATE

Class 8.8 countersunk bolts

S355

D-312

Table 2.14.11.1

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension	Slip Resistance μ = 0.5	
			Single Shear	Double Shear	Min Thickness for Punching Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}		
mm	mm^2	kN	kN	kN	mm	kN	kN
12	84.3	34.0	27.5	55.0	2.27	21.5	42.9
16	157	63.3	60.3	121	3.41	40.0	79.9
20	245	98.8	94.1	188	4.50	62.4	125
24	353	142	136	271	5.02	89.9	180
30	561	226	215	431	6.51	143	286

Table 2.14.11.1. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 8.8 countersunk bolts in S355

Table 2.14.11.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	40	50	40	**17.8**	**26.7**	35.6	44.5	53.4	*62.3*	*80.1*	*107*	*151*	*196*	*240*
16	25	50	65	50	**11.7**	**23.4**	**35.1**	**46.8**	**58.5**	70.2	93.6	*129*	*187*	*246*	*304*
20	30	60	80	60	**0**	**14.5**	**29.0**	**43.4**	**57.9**	**72.4**	101	145	*217*	*290*	*362*
24	35	75	95	70	**0**	**0**	**17.2**	**34.5**	**51.7**	**68.9**	**103**	155	241	*327*	*414*
30	45	90	115	90	**0**	**0**	**0**	**10.9**	**32.6**	**54.3**	**97.7**	**163**	272	380	*489*

Table 2.14.11.1. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 8.8 countersunk bolts in S355
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BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

UK EUROCODES

BOLT RESISTANCES

PRELOADED BOLTS AT SERVICEABILITY LIMIT STATE

Class 10.9 countersunk bolts

S355

D-313

Table 2.14.11.3

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension	Slip Resistance $\mu = 0.5$	
			Single Shear	Double Shear	Min Thickness for Punching Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}		
mm	mm^2	kN	kN	kN	mm	kN	kN
16	157	79.1	62.8	126	4.27	50.0	99.9
20	245	123	98.0	196	5.62	78.0	156
24	353	178	141	282	6.28	112	225
30	561	283	224	449	8.14	179	357

Table 2.14.11.3. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 10.9 countersunk bolts in S355

Table 2.14.11.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
16	25	50	65	50	**11.7**	**23.4**	**35.1**	**46.8**	**58.5**	70.2	93.6	*129*	*187*	*246*	*304*
20	30	60	80	60	**0**	**14.5**	**29.0**	**43.4**	**57.9**	**72.4**	101	145	*217*	*290*	*362*
24	35	75	95	70	**0**	**0**	**17.2**	**34.5**	**51.7**	**68.9**	**103**	155	241	*327*	*414*
30	45	90	115	90	**0**	**0**	**0**	**10.9**	**32.6**	**54.3**	**97.7**	**163**	272	380	*489*

Table 2.14.11.3. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 10.9 countersunk bolts in S355

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

UK EUROCODES

BOLT RESISTANCES

PRELOADED BOLTS AT ULTIMATE LIMIT STATE

Class 8.8 countersunk bolts

S275

C-314

Table 2.14.14.1

Diameter of Bolt	Tensile Stress Area	Bolts in Tension		Slip Resistance							
		Tension Resistance	Min Thickness for Punching Shear	μ = 0.2		μ = 0.3		μ = 0.4		μ = 0.5	
				Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	t_{min}								
mm	mm^2	kN	mm	kN	kN	kN	kN	kN	kN	kN	kN
12	84.3	34.0	2.60	7.55	15.1	11.3	22.7	15.1	30.2	18.9	37.8
16	157	63.3	3.91	14.1	28.1	21.1	42.2	28.1	56.3	35.2	70.3
20	245	98.8	5.15	22.0	43.9	32.9	65.9	43.9	87.8	54.9	110
24	353	142	5.76	31.6	63.3	47.4	94.9	63.3	127	79.1	158
30	561	226	7.47	50.3	101	75.4	151	101	201	126	251

Table 2.14.14.1. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 8.8 countersunk bolts in S275

Table 2.14.14.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	40	50	40	**15.5**	**23.3**	31.0	38.8	46.6	54.3	*69.8*	*93.1*	*132*	*171*	*210*
16	25	50	65	50	**10.2**	**20.4**	**30.6**	**40.8**	**51.1**	61.3	81.7	112	*163*	*214*	*265*
20	30	60	80	60	**0**	**12.6**	**25.3**	**37.9**	**50.5**	**63.2**	**88.4**	126	*189*	*253*	*316*
24	35	75	95	70	**0**	**0**	**15.0**	**30.1**	**45.1**	**60.1**	**90.2**	**135**	211	*286*	*361*
30	45	90	115	90	**0**	**0**	**0**	**9.47**	**28.4**	**47.4**	**85.3**	**142**	237	332	426

Table 2.14.14.1. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 8.8 countersunk bolts in S275

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

UK EUROCODES

BOLT RESISTANCES

PRELOADED BOLTS AT ULTIMATE LIMIT STATE

Class 10.9 countersunk bolts

S275

C-315

Table 2.14.14.3

Diameter of Bolt	Tensile Stress Area	Bolts in Tension		Slip Resistance							
		Tension Resistance	Min Thickness for Punching Shear	μ = 0.2		μ = 0.3		μ = 0.4		μ = 0.5	
				Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	t_{min}								
mm	mm^2	kN	mm	kN	kN	kN	kN	kN	kN	kN	kN
16	157	79.1	4.89	17.6	35.2	26.4	52.8	35.2	70.3	44.0	87.9
20	245	123	6.44	27.4	54.9	41.2	82.3	54.9	110	68.6	137
24	353	178	7.19	39.5	79.1	59.3	119	79.1	158	98.8	198
30	561	283	9.33	62.8	126	94.2	188	126	251	157	314

Table 2.14.14.3. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 10.9 countersunk bolts in S275

Table 2.14.14.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
16	25	50	65	50	**10.2**	**20.4**	**30.6**	**40.8**	**51.1**	**61.3**	81.7	112	*163*	*214*	*265*
20	30	60	80	60	**0**	**12.6**	**25.3**	**37.9**	**50.5**	**63.2**	**88.4**	126	189	*253*	*316*
24	35	75	95	70	**0**	**0**	**15.0**	**30.1**	**45.1**	**60.1**	**90.2**	**135**	211	*286*	*361*
30	45	90	115	90	**0**	**0**	**0**	**9.47**	**28.4**	**47.4**	**85.3**	**142**	237	332	426

Table 2.14.14.3. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 10.9 countersunk bolts in S275

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT ULTIMATE LIMIT STATE

Class 8.8 countersunk bolts

S355

D-314

Table 2.14.13.1

Diameter of Bolt	Tensile Stress Area	Bolts in Tension		Slip Resistance							
		Tension Resistance	Min Thickness for Punching Shear	μ = 0.2		μ = 0.3		μ = 0.4		μ = 0.5	
				Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear
d	A_s	$F_{t,Rd}$	t_{min}								
mm	mm^2	kN	mm	kN	kN	kN	kN	kN	kN	kN	kN
12	84.3	34.0	2.27	7.55	15.1	11.3	22.7	15.1	30.2	18.9	37.8
16	157	63.3	3.41	14.1	28.1	21.1	42.2	28.1	56.3	35.2	70.3
20	245	98.8	4.50	22.0	43.9	32.9	65.9	43.9	87.8	54.9	110
24	353	142	5.02	31.6	63.3	47.4	94.9	63.3	127	79.1	158
30	561	226	6.51	50.3	101	75.4	151	101	201	126	251

Table 2.14.13.1. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 8.8 countersunk bolts in S355

Table 2.14.13.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	40	50	40	**17.8**	**26.7**	35.6	44.5	53.4	*62.3*	*80.1*	*107*	*151*	*196*	*240*
16	25	50	65	50	**11.7**	**23.4**	**35.1**	**46.8**	**58.5**	70.2	93.6	*129*	*187*	*246*	*304*
20	30	60	80	60	**0**	**14.5**	**29.0**	**43.4**	**57.9**	**72.4**	101	145	*217*	*290*	*362*
24	35	75	95	70	**0**	**0**	**17.2**	**34.5**	**51.7**	**68.9**	**103**	155	241	*327*	*414*
30	45	90	115	90	**0**	**0**	**0**	**10.9**	**32.6**	**54.3**	**97.7**	**163**	272	380	*489*

Table 2.14.13.1. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 8.8 countersunk bolts in S355

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

UK EUROCODES

BOLT RESISTANCES

PRELOADED BOLTS AT ULTIMATE LIMIT STATE

Class 10.9 countersunk bolts

S355

D-315

Table 2.14.13.3

Diameter of Bolt	Tensile Stress Area	Bolts in Tension		Slip Resistance							
		Tension Resistance	Min Thickness for Punching Shear	μ = 0.2		μ = 0.3		μ = 0.4		μ = 0.5	
				Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear
d	A_s	$F_{t,Rd}$	t_{min}								
mm	mm^2	kN	mm	kN	kN	kN	kN	kN	kN	kN	kN
16	157	79.1	4.27	17.6	35.2	26.4	52.8	35.2	70.3	44.0	87.9
20	245	123	5.62	27.4	54.9	41.2	82.3	54.9	110	68.6	137
24	353	178	6.28	39.5	79.1	59.3	119	79.1	158	98.8	198
30	561	283	8.14	62.8	126	94.2	188	126	251	157	314

Table 2.14.13.3. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 10.9 countersunk bolts in S355

Table 2.14.13.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
16	25	50	65	50	**11.7**	**23.4**	**35.1**	**46.8**	**58.5**	70.2	93.6	*129*	*187*	*246*	*304*
20	30	60	80	60	**0**	**14.5**	**29.0**	**43.4**	**57.9**	**72.4**	101	145	*217*	*290*	*362*
24	35	75	95	70	**0**	**0**	**17.2**	**34.5**	**51.7**	**68.9**	**103**	155	241	*327*	*414*
30	45	90	115	90	**0**	**0**	**0**	**10.9**	**32.6**	**54.3**	**97.7**	**163**	272	380	*489*

Table 2.14.13.3. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 10.9 countersunk bolts in S355

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT SERVICEABILITY LIMIT STATE

Class 8.8 hexagon head bolts

S275

Table 2.14.8.1

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension	Slip Resistance $\mu = 0.5$	
			Single Shear	Double Shear	Min Thickness for Punching Shear	Single Shear	Double Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}		
mm	mm^2	kN	kN	kN	mm	kN	kN
12	84.3	48.6	27.5	55.0	3.71	21.5	42.9
16	157	90.4	60.3	121	5.59	40.0	79.9
20	245	141	94.1	188	7.36	62.4	125
24	353	203	136	271	8.22	89.9	180
30	561	323	215	431	10.7	143	286

Table 2.14.8.1. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 8.8 hexagon head bolts in S275

Table 2.14.8.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	40	50	40	38.8	46.6	54.3	*62.1*	*69.8*	*77.6*	*93.1*	*116*	*155*	*194*	*233*
16	25	50	65	50	**51.1**	61.3	71.5	81.7	91.9	102	*123*	*153*	*204*	*255*	*306*
20	30	60	80	60	**63.2**	**75.8**	**88.4**	101	114	126	152	*189*	*253*	*316*	*379*
24	35	75	95	70	**75.2**	**90.2**	**105**	**120**	**135**	150	180	226	*301*	*376*	*451*
30	45	90	115	90	**94.7**	**114**	**133**	**152**	**171**	**189**	227	284	379	*474*	*568*

Table 2.14.8.1. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 8.8 hexagon head bolts in S275

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT SERVICEABILITY LIMIT STATE

Class 10.9 hexagon head bolts

S275

C-309

Table 2.14.8.3

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension	Slip Resistance $\mu = 0.5$	
			Single Shear	Double Shear	Min Thickness for Punching Shear	Single Shear	Double Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}		
mm	mm^2	kN	kN	kN	mm	kN	kN
16	157	113	62.8	126	6.99	50.0	99.9
20	245	176	98.0	196	9.20	78.0	156
24	353	254	141	282	10.3	112	225
30	561	404	224	449	13.3	179	357

Table 2.14.8.3. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 10.9 hexagon head bolts in S275

Table 2.14.8.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
16	25	50	65	50	**51.1**	**61.3**	71.5	81.7	91.9	102	123	*153*	*204*	*255*	*306*
20	30	60	80	60	**63.2**	**75.8**	**88.4**	101	114	126	152	189	*253*	*316*	*379*
24	35	75	95	70	**75.2**	**90.2**	**105**	**120**	**135**	150	180	226	*301*	*376*	*451*
30	45	90	115	90	**94.7**	**114**	**133**	**152**	**171**	**189**	227	284	379	*474*	*568*

Table 2.14.8.3. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 10.9 hexagon head bolts in S275

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT SERVICEABILITY LIMIT STATE

Class 8.8 hexagon head bolts

S355

D-308

Table 2.14.7.1

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension	Slip Resistance $\mu = 0.5$	
			Single Shear	Double Shear	Min Thickness for Punching Shear	Single Shear	Double Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}		
mm	mm^2	kN	kN	kN	mm	kN	kN
12	84.3	48.6	27.5	55.0	3.24	21.5	42.9
16	157	90.4	60.3	121	4.88	40.0	79.9
20	245	141	94.1	188	6.42	62.4	125
24	353	203	136	271	7.17	89.9	180
30	561	323	215	431	9.30	143	286

Table 2.14.7.1. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 8.8 hexagon head bolts in S355

Table 2.14.7.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	40	50	40	44.5	53.4	*62.3*	*71.2*	*80.1*	*89.0*	*107*	*133*	*178*	*222*	*267*
16	25	50	65	50	**58.5**	70.2	81.9	93.6	105	117	*140*	*176*	*234*	*293*	*351*
20	30	60	80	60	**72.4**	**86.9**	101	116	130	145	174	*217*	*290*	*362*	*434*
24	35	75	95	70	**86.2**	**103**	**121**	138	155	172	207	259	*345*	*431*	*517*
30	45	90	115	90	**109**	**130**	**152**	**174**	**195**	217	261	326	*434*	*543*	*652*

Table 2.14.7.1. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 8.8 hexagon head bolts in S355

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

UK EUROCODES

BOLT RESISTANCES

PRELOADED BOLTS AT SERVICEABILITY LIMIT STATE

Class 10.9 hexagon head bolts

S355

D-309

Table 2.14.7.3

Diameter of Bolt	Tensile Stress Area	Tension Resistance	Shear Resistance		Bolts in Tension	Slip Resistance $\mu = 0.5$	
			Single Shear	Double Shear	Min Thickness for Punching Shear	Single Shear	Double Shear
d	A_s	$F_{t,Rd}$	$F_{v,Rd}$	$2 \times F_{v,Rd}$	t_{min}		
mm	mm^2	kN	kN	kN	mm	kN	kN
16	157	113	62.8	126	6.10	50.0	99.9
20	245	176	98.0	196	8.03	78.0	156
24	353	254	141	282	8.97	112	225
30	561	404	224	449	11.6	179	357

Table 2.14.7.3. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 10.9 hexagon head bolts in S355

Table 2.14.7.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
16	25	50	65	50	**58.5**	70.2	81.9	93.6	105	117	*140*	*176*	*234*	*293*	*351*
20	30	60	80	60	**72.4**	**86.9**	101	116	130	145	174	*217*	*290*	*362*	*434*
24	35	75	95	70	**86.2**	**103**	**121**	**138**	155	172	207	259	*345*	*431*	*517*
30	45	90	115	90	**109**	**130**	**152**	**174**	**195**	**217**	261	326	434	*543*	*652*

Table 2.14.7.3. Bolt Resistances. Preloaded bolts at serviceability limit state.
Class 10.9 hexagon head bolts in S355
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BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT ULTIMATE LIMIT STATE

Class 8.8 hexagon head bolts

S275

C-310

Table 2.14.10.1

Diameter of Bolt	Tensile Stress Area	Bolts in Tension		Slip Resistance							
		Tension Resistance	Min Thickness for Punching Shear	μ = 0.2		μ = 0.3		μ = 0.4		μ = 0.5	
				Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	t_{min}								
mm	mm^2	kN	mm	kN	kN	kN	kN	kN	kN	kN	kN
12	84.3	48.6	3.71	7.55	15.1	11.3	22.7	15.1	30.2	18.9	37.8
16	157	90.4	5.59	14.1	28.1	21.1	42.2	28.1	56.3	35.2	70.3
20	245	141	7.36	22.0	43.9	32.9	65.9	43.9	87.8	54.9	110
24	353	203	8.22	31.6	63.3	47.4	94.9	63.3	127	79.1	158
30	561	323	10.7	50.3	101	75.4	151	101	201	126	251

Table 2.14.10.1. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 8.8 hexagon head bolts in S275

Table 2.14.10.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	40	50	40	38.8	46.6	54.3	*62.1*	*69.8*	*77.6*	*93.1*	*116*	*155*	*194*	*233*
16	25	50	65	50	**51.1**	61.3	71.5	81.7	91.9	102	*123*	*153*	*204*	*255*	*306*
20	30	60	80	60	**63.2**	**75.8**	**88.4**	101	114	126	152	*189*	*253*	*316*	*379*
24	35	75	95	70	**75.2**	**90.2**	**105**	**120**	**135**	150	180	226	*301*	*376*	*451*
30	45	90	115	90	**94.7**	**114**	**133**	**152**	**171**	**189**	227	284	379	*474*	*568*

Table 2.14.10.1. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 8.8 hexagon head bolts in S275

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT ULTIMATE LIMIT STATE

Class 10.9 hexagon head bolts

S275

C-311

Table 2.14.10.3

Diameter of Bolt	Tensile Stress Area	Bolts in Tension		Slip Resistance							
		Tension Resistance	Min Thickness for Punching Shear	μ = 0.2		μ = 0.3		μ = 0.4		μ = 0.5	
				Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	t_{min}								
mm	mm^2	kN	mm	kN	kN	kN	kN	kN	kN	kN	kN
16	157	113	6.99	17.6	35.2	26.4	52.8	35.2	70.3	44.0	87.9
20	245	176	9.20	27.4	54.9	41.2	82.3	54.9	110	68.6	137
24	353	254	10.3	39.5	79.1	59.3	119	79.1	158	98.8	198
30	561	404	13.3	62.8	126	94.2	188	126	251	157	314

Table 2.14.10.3. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 10.9 hexagon head bolts in S275

Table 2.14.10.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
16	25	50	65	50	**51.1**	**61.3**	71.5	81.7	91.9	102	123	*153*	*204*	*255*	*306*
20	30	60	80	60	**63.2**	**75.8**	**88.4**	101	114	126	152	189	*253*	*316*	*379*
24	35	75	95	70	**75.2**	**90.2**	**105**	**120**	**135**	150	180	226	*301*	*376*	*451*
30	45	90	115	90	**94.7**	**114**	**133**	**152**	**171**	**189**	227	284	379	*474*	*568*

Table 2.14.10.3. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 10.9 hexagon head bolts in S275

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT ULTIMATE LIMIT STATE

Class 8.8 hexagon head bolts

S355

D-310

Table 2.14.9.1

Diameter of Bolt	Tensile Stress Area	Bolts in Tension		Slip Resistance							
		Tension Resistance	Min Thickness for Punching Shear	μ = 0.2		μ = 0.3		μ = 0.4		μ = 0.5	
				Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	t_{min}								
mm	mm^2	kN	mm	kN	kN	kN	kN	kN	kN	kN	kN
12	84.3	48.6	3.24	7.55	15.1	11.3	22.7	15.1	30.2	18.9	37.8
16	157	90.4	4.88	14.1	28.1	21.1	42.2	28.1	56.3	35.2	70.3
20	245	141	6.42	22.0	43.9	32.9	65.9	43.9	87.8	54.9	110
24	353	203	7.17	31.6	63.3	47.4	94.9	63.3	127	79.1	158
30	561	323	9.30	50.3	101	75.4	151	101	201	126	251

Table 2.14.9.1. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 8.8 hexagon head bolts in S355

Table 2.14.9.2

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
12	20	40	50	40	44.5	53.4	*62.3*	*71.2*	*80.1*	*89.0*	*107*	*133*	*178*	*222*	*267*
16	25	50	65	50	**58.5**	70.2	81.9	93.6	105	117	*140*	*176*	*234*	*293*	*351*
20	30	60	80	60	**72.4**	**86.9**	101	116	130	145	174	*217*	*290*	*362*	*434*
24	35	75	95	70	**86.2**	**103**	**121**	138	155	172	207	259	*345*	*431*	*517*
30	45	90	115	90	**109**	**130**	**152**	**174**	**195**	217	261	326	*434*	*543*	*652*

Table 2.14.9.1. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 8.8 hexagon head bolts in S355

BS EN 1993-1-8: 2005
BS EN 14399: 2005
EN 1090: 2008

BOLT RESISTANCES

PRELOADED BOLTS AT ULTIMATE LIMIT STATE

Class 10.9 hexagon head bolts

S355

D-311

Table 2.14.9.3

Diameter of Bolt	Tensile Stress Area	Bolts in Tension		Slip Resistance							
		Tension Resistance	Min Thickness for Punching Shear	μ = 0.2		μ = 0.3		μ = 0.4		μ = 0.5	
				Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear	Single Shear	Double Shear
	A_s	$F_{t,Rd}$	t_{min}								
mm	mm^2	kN	mm	kN	kN	kN	kN	kN	kN	kN	kN
16	157	113	6.10	17.6	35.2	26.4	52.8	35.2	70.3	44.0	87.9
20	245	176	8.03	27.4	54.9	41.2	82.3	54.9	110	68.6	137
24	353	254	8.97	39.5	79.1	59.3	119	79.1	158	98.8	198
30	561	404	11.6	62.8	126	94.2	188	126	251	157	314

Table 2.14.9.3. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 10.9 hexagon head bolts in S355

Table 2.14.9.4

Diameter of Bolt	Minimum				Bearing Resistance (kN)										
	Edge Distance	End Distance	Pitch	Gauge											
d	e_2	e_1	p_1	p_2	Thickness in mm of ply,t										
mm	mm	mm	mm	mm	5	6	7	8	9	10	12	15	20	25	30
16	25	50	65	50	**58.5**	70.2	81.9	93.6	105	117	*140*	*176*	*234*	*293*	*351*
20	30	60	80	60	**72.4**	**86.9**	101	116	130	145	174	*217*	*290*	*362*	*434*
24	35	75	95	70	**86.2**	**103**	**121**	**138**	155	172	207	259	*345*	*431*	*517*
30	45	90	115	90	**109**	**130**	**152**	**174**	**195**	**217**	261	326	434	*543*	*652*

Table 2.14.9.3. Bolt Resistances. Preloaded bolts at ultimate limit state.
Class 10.9 hexagon head bolts in S355

BS EN 1993-1-8

UK EUROCODES

FILLET WELDS

DESIGN WELD RESISTANCES

S275

C-316

Table 2.14.16.1

Leg Length s mm	Throat Thickness a mm	Longitudinal Resistance $F_{w,L,Rd}$ kN/mm	Transverse Resistance $F_{w,T,Rd}$ kN/mm
3.0	2.1	0.47	0.57
4.0	2.8	0.62	0.76
5.0	3.5	0.78	0.96
6.0	4.2	0.94	1.15
8.0	5.6	1.25	1.53
10.0	7.0	1.56	1.91
12.0	8.4	1.87	2.29
15.0	10.5	2.34	2.87
18.0	12.6	2.81	3.44
20.0	14.0	3.12	3.82
22.0	15.4	3.43	4.20
25.0	17.5	3.90	4.78

Table 2.14.16.1. Fillet Welds. Design weld resistances. S275

BS EN 1993-1-8

UK EUROCODES

FILLET WELDS

DESIGN WELD RESISTANCES

S355

D-316

Table 2.14.15.1

Leg Length s mm	Throat Thickness a mm	Longitudinal Resistance $F_{w,L,Rd}$ kN/mm	Transverse Resistance $F_{w,T,Rd}$ kN/mm
3.0	2.1	0.51	0.62
4.0	2.8	0.68	0.83
5.0	3.5	0.84	1.03
6.0	4.2	1.01	1.24
8.0	5.6	1.35	1.65
10.0	7.0	1.69	2.07
12.0	8.4	2.03	2.48
15.0	10.5	2.53	3.10
18.0	12.6	3.04	3.72
20.0	14.0	3.38	4.14
22.0	15.4	3.71	4.55
25.0	17.5	4.22	5.17

Table 2.14.15.1. Fillet Welds. Design weld resistances. S355

A EXPLANATORY NOTES

1 GENERAL

This publication presents design data in tabular formats as assistance to engineers who are designing buildings in accordance with BS EN 1993-1-1: 2005[1], BS EN 1993-1-5: 2006[1] and BS EN 1993-1-8: 2005[1], and their respective National Annexes. Where these Parts do not give all the necessary expressions for the evaluation of data, reference is made to other published sources.

The symbols used are generally the same as those in these standards or the referred product standards. Where a symbol does not appear in the standards, a symbol has been chosen following the designation convention as closely as possible.

1.1 Material, section dimensions and tolerances

The structural sections referred to in this design guide are of weldable structural steels conforming to the relevant British Standards given in the table below:

Table – Structural steel products

Product	Technical delivery requirements		Dimensions	Tolerances
	Non alloy steels	Fine grain steels		
Universal beams, Universal columns, and universal bearing piles	BS EN 10025-2[2]	BS EN 10025-3[2] BS EN 10025-4[2]	BS 4-1[3]	BS EN 10034[4]
Joists			BS 4-1	BS 4-1 BS EN 10024[5]
Parallel flange channels			BS 4-1	BS EN 10279[6]
Angles			BS EN 10056-1[7]	BS EN 10056-2[7]
Structural tees cut from universal beams and universal columns			BS 4-1	—
ASB (asymmetric beams) *Slimflor*® beam	Generally BS EN 10025, but see note b)		See note a)	Generally BS EN 10034[4], but also see note b)
Hot finished structural hollow sections	BS EN 10210-1[8]		BS EN 10210-2[8]	BS EN 10210-2[8]
Cold formed hollow sections	BS EN 10219-1[9]		BS EN 10219-2[9]	BS EN 10219-2[9]

Notes:

For full details of the British Standards, see the reference list at the end of the Explanatory Notes.

a) See Corus publication, *Advance™ Sections: CE marked structural sections* [11].

b) For further details, consult Corus.

Note that EN 1993 refers to the product standards by their CEN designation, e.g. EN 10025-2. The CEN standards are published in the UK by BSI with their prefix to the designation, e.g. BS EN 10025-2.

1.2 Dimensional units

The dimensions of sections are given in millimetres (mm).

1.3 Property units

Generally, the centimetre (cm) is used for the calculated properties but for surface areas and for the warping constant (I_w), the metre (m) and the decimetre (dm) respectively are used.

Note: 1 dm = 0.1 m = 100 mm

$1\ dm^6 = 1 \times 10^{-6}\ m^6 = 1 \times 10^{12}\ mm^6$

1.4 Mass and force units

The units used are the kilogram (kg), the Newton (N) and the metre per second squared (m/s^2), so that 1 N = 1 kg × 1 m/s^2. For convenience, a standard value of the acceleration due to gravity has been accepted as 9.80665 m/s^2. Thus, the force exerted by 1 kg under the action of gravity is 9.80665 N and the force exerted by 1 tonne (1000 kg) is 9.80665 kiloNewtons (kN).

1.5 Axis convention

The axis system used in BS EN 1993 is:

x along the member

y major axis, or axis perpendicular to web

z minor axis, or axis parallel to web

This system is convenient for structural analysis using computer programs. However, it is different from the axis system previously used in UK standards such as BS 5950.

2 DIMENSIONS OF SECTIONS

2.1 Masses

The masses per metre have been calculated assuming that the density of steel is 7850 kg/m^3.

In all cases, including compound sections, the tabulated masses are for the steel section alone and no allowance has been made for connecting material or fittings.

2.2 Ratios for local buckling

The ratios of the flange outstand to thickness (c_f / t_f) and the web depth to thickness (c_w / t_w) are given for I, H and channel sections.

$$c_f = \frac{1}{2}\left[b - \left(t_w + 2r\right)\right] \qquad \text{for I and H sections}$$

$$c_f = \left[b - \left(t_w + r\right)\right] \qquad \text{for channels}$$

$$c_w = d = \left[h - 2\left(t_f + r\right)\right] \qquad \text{for I, H and channel sections}$$

For circular hollow sections the ratios of the outside diameter to thickness (d / t) are given.

For square and rectangular hollow sections the ratios (c_f / t) and (c_w / t) are given where:

$c_f = b - 3t$ and $c_w = h - 3t$

For square hollow sections c_f and c_w are equal. Note that these relationships for c_f and c_w are applicable to both hot-finished and cold-formed sections.

The dimensions c_f and c_w are not precisely defined in EN 1993-1-1 and the internal profile of the corners is not specified in either EN 10210-2 or EN 10219-2. The above expressions give conservative values of the ratio for both hot-finished and cold-formed sections.

2.3 Dimensions for detailing

The dimensions C, N and n have the meanings given in the figures at the heads of the tables and have been calculated according to the formulae below. The formulae for N and C make allowance for rolling tolerances, whereas the formulae for n make no such allowance.

2.3.1 UB sections, UC sections and bearing piles

$N = (b - t_w)/2 + 10$ mm (rounded to the nearest 2 mm above)

$n = (h - d)/2$ (rounded to the nearest 2 mm above)

$C = t_w/2 + 2$ mm (rounded to the nearest mm)

2.3.2 Joists

$N = (b - t_w)/2 + 6$ mm (rounded to the nearest 2 mm above)

$n = (h - d)/2$ (rounded to the nearest 2 mm above)

$C = t_w/2 + 2$ mm (rounded to the nearest mm)

Note: Flanges of BS 4-1 joists have an 8° taper.

2.3.3 Parallel flange channels

$N = (b - t_w) + 6$ mm (rounded up to the nearest 2 mm above)

$n = (h - d)/2$ (taken to the next higher multiple of 2 mm)

$C = t_w + 2$ mm (rounded up to the nearest mm)

3 SECTION PROPERTIES

3.1 General

All section properties have been accurately calculated and rounded to three significant figures. They have been calculated from the metric dimensions given in the appropriate standards (see Section 1.1). For angles, BS EN 10056-1 assumes that the toe radius equals half the root radius.

3.2 Sections other than hollow sections

3.2.1 Second moment of area (*I*)

The second moment of area has been calculated taking into account all tapers, radii and fillets of the sections. Values are given about both the *y-y* and *z-z* axes.

3.2.2 Radius of gyration (*i*)

The radius of gyration is a parameter used in the calculation of buckling resistance and is derived as follows:

$i \quad = [I / A]^{1/2}$

where:

I is the second moment of area about the relevant axis

A is the area of the cross section.

3.2.3 Elastic section modulus (W_{el})

The elastic section modulus is used to calculate the elastic design resistance for bending or to calculate the stress at the extreme fibre of the section due to a moment. It is derived as follows:

$W_{el,y} \quad = I_y / z$

$W_{el,z} \quad = I_z / y$

where:

z, y are the distances to the extreme fibres of the section from the elastic y-y and z-z axes, respectively.

For parallel flange channels, the elastic section modulus about the minor (z-z) axis is given for the extreme fibre at the toe of the section only.

For angles, the elastic section moduli about both axes are given for the extreme fibres at the toes of the section only. For elastic section moduli about the principal axes u-u and v-v, see AD340.

For asymmetric beams, the elastic section moduli about the y-y axis are given for both top and bottom extreme fibres, and about the z-z axis for the extreme fibre.

3.2.4 Plastic section modulus (W_{pl})

The plastic section moduli about both y-y and z-z axes are tabulated for all sections except angle sections.

3.2.5 Buckling parameter (*U*) and torsional index (*X*)

UB sections, UC sections, joists and parallel flange channels

The buckling parameter (U) and torsional index (X) have been calculated using expressions in Access Steel document SN002 *Determination of non-dimensional slenderness of I and H sections*[20].

$$U = \left(\frac{W_{pl,y}\, g}{A}\right)^{0.5} \times \left(\frac{I_z}{I_w}\right)^{0.25}$$

$$X = \sqrt{\frac{\pi^2 E A I_w}{20 G I_T I_z}}$$

where:

$W_{pl,y}$ is the plastic modulus about the major axis

$g \quad = \sqrt{1 - \frac{I_z}{I_y}}$

I_y is the second moment of area about the major axis

I_z is the second moment of area about the minor axis

E = 210 000 N/mm^2 is the modulus of elasticity

G is the shear modulus where $G = \dfrac{E}{2(1+\nu)}$

ν is Poisson's ratio (= 0.3)

A is the cross–sectional area

I_w is the warping constant

I_T is the torsional constant.

Tee sections and ASB sections

The buckling parameter (U) and the torsional index (X) have been calculated using the following expressions:

$$U = [(4\, W_{pl,y}^{\ 2}\, g^2 \,/\, (A^2\, h^2)]^{1/4}$$

$$X = 0.566\, h\, [A/\, I_T]^{1/2}$$

where:

$W_{pl,y}$ is the plastic modulus about the major axis

$g = \sqrt{1 - \dfrac{I_z}{I_y}}$

I_y is the second moment of area about the major axis

I_z is the second moment of area about the minor axis

A is the cross sectional area

h is the distance between shear centres of flanges (for T sections, h is the distance between the shear centre of the flange and the toe of the web)

I_T is the torsional constant.

3.2.6 Warping constant (I_w) and torsional constant (I_T)

Rolled I sections

The warping constant and St Venant torsional constant for rolled I sections have been calculated using the formulae given in the SCI publication P057 *Design of members subject to combined bending and torsion*[12].

In Eurocode 3 terminology, these formulae are as follows:

$$I_w = \frac{I_z h_s^{\ 2}}{4}$$

where:

I_z is the second moment of area about the minor axis

h_s is the distance between shear centres of flanges (i.e. $h_s = h - t_f$)

$$I_T = \frac{2}{3} b t_f^{\ 3} + \frac{1}{3}(h - 2t_f)t_w^{\ 3} + 2\alpha_1 D_1^{\ 4} - 0.420 t_f^{\ 4}$$

where:

$$\alpha_1 = -0.042 + 0.2204\,\frac{t_w}{t_f} + 0.1355\,\frac{r}{t_f} - 0.0865\,\frac{r t_w}{t_f^{\ 2}} - 0.0725\,\frac{t_w^{\ 2}}{t_f^{\ 2}}$$

$D_1 \quad = \quad \dfrac{(t_f + r)^2 + (r + 0.25\, t_w)\, t_w}{2r + t_f}$

b is the width of the section

h is the depth of the section

t_f is the flange thickness

t_w is the web thickness

r is the root radius.

Tee sections

For Tee sections cut from UB and UC sections, the warping constant (I_w) and torsional constant (I_T) have been derived as given below.

$$I_w = \frac{1}{144}\, t_f^{\,3} b^3 + \frac{1}{36}\left(h - \frac{t_f}{2}\right)^3 t_w^{\,3}$$

$$I_T = \frac{1}{3}\, b t_f^{\,3} + \frac{1}{3}(h - t_f)\, t_w^{\,3} + \alpha_1 D_1^{\,4} - 0.21\, t_f^{\,4} - 0.105\, t_w^{\,4}$$

where:

$$\alpha_1 = -0.042 + 0.2204 \frac{t_w}{t_f} + 0.1355 \frac{r}{t_f} - 0.0865 \frac{t_w\, r}{t_f^{\,2}} - 0.0725 \frac{t_w^{\,2}}{t_f^{\,2}}$$

D_1 is as defined above

Note: These formulae do not apply to tee sections cut from joists, which have tapered flanges. For such sections, expressions are given in SCI Publication 057[12].

Parallel flange channels

For parallel flange channels, the warping constant (I_w) and torsional constant (I_T) have been calculated as follows:

$$I_w = \frac{(h - t_f)^2}{4}\left[I_z - A\left(c_z - \frac{t_w}{2}\right)^2 \left(\frac{(h - t_f)^2 A}{4 I_y} - 1\right)\right]$$

$$I_T = \frac{2}{3} b t_f^{\,3} + \frac{1}{3}(h - 2t_f) t_w^{\,3} + 2\alpha_3 D_3^{\,4} - 0.42\, t_f^{\,4}$$

where:

c_z is the distance from the back of the web to the centroidal axis

$$\alpha_3 = -0.0908 + 0.2621 \frac{t_w}{t_f} + 0.1231 \frac{r}{t_f} - 0.0752 \frac{t_w\, r}{t_f^{\,2}} - 0.0945 \left(\frac{t_w}{t_f}\right)^2$$

$$D_3 = 2\left[(3r + t_w + t_f) - \sqrt{2(2r + t_w)(2r + t_f)}\right]$$

Note: The formula for the torsional constant (I_T) is applicable to parallel flange channels only and does not apply to tapered flange channels.

Angles

For angles, the torsional constant (I_T) is calculated as follows:

$$I_T = \frac{1}{3}bt^3 + \frac{1}{3}(h-t)t^3 + \alpha_3 D_3^4 - 0.21t^4$$

where:

$$\alpha_3 = 0.0768 + 0.0479\frac{r}{t}$$

$$D_3 = 2\left[(3r+2t) - \sqrt{2(2r+t)^2}\right]$$

ASB sections

For ASB sections the warping constant (I_w) and torsional constant (I_T) are as given in Corus brochure, *Advance™ sections* [11].

3.2.7 Equivalent slenderness coefficient (ϕ) and monosymmetry index (ψ)

Angles

The buckling resistance moments for angles have not been included in the bending resistance tables of this publication as angles are predominantly used in compression and tension only. Where the designer wishes to use an angle section in bending, BS EN 1993-1-1, 6.3.2 enables the buckling resistance moment for angles to be determined. The procedure is quite involved.

As an alternative to the procedure in BS EN 1993-1-1, supplementary section properties have been included for angle sections in this publication which enable the designer to adopt a much simplified method for determining the buckling resistance moment. The method is based on that given in BS 5950-1:2000 Annex B.2.9 and makes use of the equivalent slenderness coefficient and the monosymmetry index.

The equivalent slenderness coefficient (ϕ_a) is tabulated for both equal and unequal angles. Two values of the equivalent slenderness coefficient are given for each unequal angle. The larger value is based on the major axis elastic section modulus ($W_{el,u}$) to the toe of the short leg and the lower value is based on the major axis elastic section modulus to the toe of the long leg.

The equivalent slenderness coefficient (ϕ_a) is calculated as follows:

$$\phi_a = \frac{W_{el,u}\, g}{\sqrt{A I_T}}$$

where:

$W_{el,u}$ is the elastic section modulus about the major axis u-u

$$g = \sqrt{1 - \frac{I_v}{I_u}}$$

I_v is the second moment of area about the minor axis

I_u is the second moment of area about the major axis

A is the area of the cross section

I_T is the torsional constant.

The monosymmetry index (ψ_a) is calculated as follows:

$$\psi_a = \left[2v_0 - \frac{\int v_i \left(u_i^2 + v_i^2 \right) dA}{I_u} \right] \frac{1}{t}$$

where:

u_i and v_i are the coordinates of an element of the cross section

v_0 is the coordinate of the shear centre along the v-v axis, relative to the centroid

t is the thickness of the angle.

Tee sections

The monosymmetry index is tabulated for Tee sections cut from UBs and UCs. It has been calculated as:

$$\psi = \left(2z_0 - \frac{z_0 b^3 t_f / 12 + b t_f z_0^3 + \frac{t_w}{4}\left[(c - t_f)^4 - (h - c)^4 \right]}{I_y} \right) \frac{1}{(h - t_f/2)}$$

where:

z_0 $= c - t_f/2$

c is the width of the flange outstand ($= (b - t_w - 2r)/2$)

b is the flange width

t_f is the flange thickness

t_w is the web thickness

h is the depth of the section.

The above expression is based on BS 5950-1, Annex B.2.8.2.

ASB sections

The monosymmetry index is tabulated for ASB sections. It has been calculated using the equation in BS 5950-1, Annex B.2.4.1, re-expressed in BS EN 1993-1-1 nomenclature:

$$\psi = \frac{1}{h_s} \left(\frac{2(I_{zc} h_c - I_{zt} h_t)}{(I_{zc} + I_{zt})} - \frac{(I_{zc} h_c - I_{zt} h_t) + \left(b_c t_c h_c^3 - b_t t_t h_t^3 \right) + \frac{t}{4}\left(d_c^4 - d_t^4 \right)}{I_y} \right)$$

where:

h_s $= \left(h - \frac{t_c + t_t}{2} \right)$

d_c $= h_c - t_c / 2$

d_t $= h_t - t_t / 2$

I_{zc} $= b_c^3 t_c / 12$

I_{zt} $= b_t^3 t_t / 12$

h_c is the distance from the centre of the compression flange to the centroid of the section

h_t is the distance from the centre of the tension flange to the centroid of the section

b_c is the width of the compression flange

b_t is the width of the tension flange

t_c is the thickness of the compression flange

t_t is the thickness of the tension flange.

For ASB sections $t_c = t_t$ and this is shown as t_f in the tables.

3.3 Hollow sections

Section properties are given for both hot-finished and cold-formed hollow sections (but not for cold-formed elliptical hollow sections). For the same overall dimensions and wall thickness, the section properties for square and rectangular hot-finished and cold-formed sections are different because the corner radii are different.

3.3.1 Common properties

For general comment on second moment of area, radius of gyration, elastic and plastic modulus, see Sections 3.2.1, 3.2.2, 3.2.3 and 3.2.4.

For hot-finished square and rectangular hollow sections, the section properties have been calculated using corner radii of $1.5t$ externally and $1.0t$ internally, as specified by BS EN 10210-2[8].

For cold-formed square and rectangular hollow sections, the section properties have been calculated using the external corner radii of $2t$ if $t \leq 6$ mm, $2.5t$ if 6 mm $< t \leq 10$ mm and $3t$ if $t > 10$ mm, as specified by BS EN 10219-2[9]. The internal corner radii used are $1.0t$ if $t \leq 6$ mm, $1.5t$ if 6 mm $< t \leq 10$ mm and $2t$ if $t > 10$ mm, as specified by BS EN 10219-2[9].

3.3.2 Plastic section modulus of hollow sections (W_{pl})

The plastic section moduli (W_{pl}) about both principal axes are given in the tables.

3.3.3 Torsional constant (I_T)

For circular hollow sections:

$$I_T = 2I$$

For square, rectangular and elliptical hollow sections:

$$I_T = \frac{4A_p{}^2 t}{p} + \frac{t^3 p}{3}$$

where:

I is the second moment of area of a CHS

t is the thickness of the section

p is the mean perimeter length

For square and rectangular hollow sections: $p = 2\,[(b - t) + (h - t)] - 2\,R_c\,(4 - \pi)$

For elliptical hollow sections: $p = \dfrac{\pi}{2}(h + b - 2t)\left(1 + 0.25\left(\dfrac{h - b}{h + b - 2t}\right)^2\right)$

A_p is the area enclosed by the mean perimeter

For square and rectangular hollow sections: $A_p = (b - t)\,(h - t) - R_c^2\,(4 - \pi)$

For elliptical hollow sections: $A_p = \frac{\pi(h-t)(b-t)}{4}$

R_c is the average of the internal and external corner radii

3.3.4 Torsional section modulus (W_t)

$W_t = 2W_{el}$ for circular hollow sections

$$W_t = \frac{I_T}{\left(t + \frac{2A_p}{p}\right)}$$ for square, rectangular and elliptical hollow sections

where:

W_{el} is the elastic modulus and I_T, t, A_p and p are as defined in Section 3.3.3.

4 EFFECTIVE SECTION PROPERTIES

4.1 General

In BS EN 1993-1-1:2005, effective section properties are required for the design of members with Class 4 cross sections. In this publication, effective section properties are given for sections subject to compression only and bending only. Effective section properties depend on the grade of steel used and are given for rolled I sections and angles in S275 and S355. Channels are not Class 4 and therefore no effective section properties are provided. For hot-finished and cold-formed hollow sections, effective section properties are only given for S355.

4.2 Effective section properties of members subject to compression

The effective cross section properties of Class 4 cross sections are based on the effective widths of the compression parts.

The effective cross–sectional area A_{eff} of Class 4 sections in compression is calculated in accordance with BS EN 1993-1-1, 6.2.2.5 and BS EN 1993–1–5:2006, 4.3 and 4.4.

The effective section properties tables list the sections that can be Class 4 and the identifier ‘W’, ‘F’ or ‘W, F’ indicates whether the section is Class 4 due to the web, the flange or both. In rectangular hollow sections subject to bending about the major axis, the flanges are the short sides and the webs are the long sides.

The effective area of the section is calculated from:

For UB, UC and joists: $A_{eff} = A - 4\,t_f\,(1-\rho_f)c_f - t_w(1-\rho_w)\,c_w$

For rectangular hollow sections and square hollow sections:

$$A_{eff} = A - 2t_f\,(1-\rho_f)c_f - 2\,t_w(1-\rho_w)\,c_w$$

For parallel flange channels: $A_{eff} = A - 2\,t_f\,(1-\rho_f)c_f - t_w(1-\rho_w)\,c_w$

For equal angles: $A_{eff} = A - 2\,t\,(1-\rho)\,h$

For unequal angles: $A_{eff} = A - \,t\,(1-\rho)(h+b)$

For circular hollow sections: Effective areas are not tabulated for circular hollow sections in this publication. BS EN 1993-1-1 6.2.2.5(5) refers the reader to BS EN 1993-1-6.

For elliptical hollow sections: Effective areas are not tabulated in this publication, but may be calculated from:[14]

$$A_{\text{eff}} = A\left(\frac{90t}{D_{\text{e}}}\frac{235}{f_{\text{y}}}\right)^{0.5}$$

where:

D_{e} is the equivalent diameter $= \dfrac{h^2}{b}$

Expressions for the reduction factors ρ_{f}, ρ_{w} and ρ are given in BS EN 1993-1-5, 4.4.

The ratio of effective area to gross area (A_{eff} / A) is also given in the tables to provide a guide as to how much of the section is effective. Note that although BS EN 1993-1-1 classifies some sections as Class 4, their effective area according to BS EN 1993-1-5 is equal to the gross area.

4.3 Effective section properties of members subject to pure bending

The effective cross section properties of Class 4 cross sections are based on the effective widths of the compression parts. The effective cross–sectional properties for Class 4 sections in bending have been calculated in accordance with BS EN 1993-1-1, 6.2.2.5 and BS EN 1993–1–5:2006, 4.3 and 4.4.

Cross section properties are given for the effective second moment of area I_{eff} and the effective elastic section modulus $W_{\text{el,eff}}$. The identifier 'W' or 'F' indicates whether the web or the flange controls the section Class 4 classification.

Equations for the effective section properties are not shown here because the process for determining these properties requires iteration. Also the equations are dependent on the classification status of each component part.

For the range of sections covered by this publication, only a selection of the hollow sections become Class 4 when subject to bending alone.

For cross sections with a Class 3 web and Class 1 or 2 flanges, an effective plastic modulus $W_{\text{pl,eff}}$ can be calculated, following the recommendations given in BS EN 1993-1-1, 6.2.2.4 (1). This clause is applicable to open sections (UB, UC, joists and channels) and hollow sections.

For the range of sections covered by this publication, only a limited number of the hollow sections can be used with an effective plastic modulus $W_{\text{pl,eff}}$, when subject to bending alone.

Poutrelles I européennes

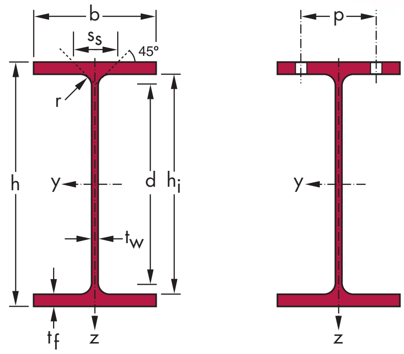
Dimensions: IPE 80 - 600 conformes à l'Euronorme 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Tolérances: EN 10034: 1993
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European I beams

Dimensions: IPE 80 - 600 in accordance with Euronorm 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Tolerances: EN 10034: 1993
Surface condition according to EN 10163-3:1991, class C, subclass 1

Europäische I-Profile

Abmessungen: IPE 80 - 600 gemäß Euronorm 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Toleranzen: EN 10034: 1993
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung	Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm²	h_i mm	d mm	Ø	p_{min} mm	p_{max} mm	A_L m²/m	A_G m²/t
						x 10²							

Désignation	G	h	b	t_w	t_f	r	A	h_i	d	Ø	p_{min}	p_{max}	A_L	A_G
IPE 80 A•/*	5,0	78	46	3,3	4,2	5	6,38	69,6	59,6	-	-	-	0,325	64,90
IPE 80*	6,0	80	46	3,8	5,2	5	7,64	69,6	59,6	-	-	-	0,328	54,64
IPE A 100•/*	6,9	98	55	3,6	4,7	7	8,78	88,6	74,6	-	-	-	0,397	57,57
IPE 100*	8,1	100	55	4,1	5,7	7	10,3	88,6	74,6	-	-	-	0,400	49,33
IPE A 120•	8,7	117,6	64	3,8	5,1	7	11,0	107,4	93,4	-	-	-	0,472	54,47
IPE 120	10,4	120	64	4,4	6,3	7	13,2	107,4	93,4	-	-	-	0,475	45,82
IPE A 140•	10,5	137,4	73	3,8	5,6	7	13,4	126,2	112,2	-	-	-	0,547	52,05
IPE 140	12,9	140	73	4,7	6,9	7	16,4	126,2	112,2	-	-	-	0,551	42,70
IPE A 160•	12,7	157	82	4	5,9	9	16,2	145,2	127,2	-	-	-	0,619	48,70
IPE 160	15,8	160	82	5	7,4	9	20,1	145,2	127,2	-	-	-	0,623	39,47
IPE A 180•	15,4	177	91	4,3	6,5	9	19,6	164	146	M 10	48	48	0,694	45,15
IPE 180	18,8	180	91	5,3	8	9	23,9	164	146	M 10	48	48	0,698	37,13
IPE O 180+	21,3	182	92	6	9	9	27,1	164	146	M 10	50	50	0,705	33,12
IPE A 200•	18,4	197	100	4,5	7	12	23,5	183	159	M 10	54	58	0,764	41,49
IPE 200	22,4	200	100	5,6	8,5	12	28,5	183	159	M 10	54	58	0,768	34,36
IPE O 200+	25,1	202	102	6,2	9,5	12	32,0	183	159	M 10	56	60	0,779	31,05
IPE A 220•	22,2	217	110	5	7,7	12	28,3	201,6	177,6	M 12	60	62	0,843	38,02
IPE 220	26,2	220	110	5,9	9,2	12	33,4	201,6	177,6	M 12	60	62	0,848	32,36
IPE O 220+	29,4	222	112	6,6	10,2	12	37,4	201,6	177,6	M 10	58	66	0,858	29,24

• Commande minimale: pour S 235 JR, cf. conditions de livraison page 216; pour toute autre qualité 40 t ou suivant accord.
+ Commande minimale: 40 t par profilé et qualité ou suivant accord.
* Tonnage minimum et conditions de livraison nécessitent un accord préalable.

• Minimum order: for the S 235 JR grade cf. delivery conditions page 216; for any other grade 40 t or upon agreement.
+ Minimum order: 40 t per section and grade or upon agreement.
* Minimum tonnage and delivery conditions upon agreement.

• Mindestbestellmenge: für S 235 JR gemäß Lieferbedingungen Seite 216; für jede andere Güte 40 t oder nach Vereinbarung.
+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.
* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

IPE

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte												Classification ENV 1993-1-1								
		axe fort y-y strong axis y-y starke Achse y-y					axe faible z-z weak axis z-z schwache Achse z-z							pure bending y-y			pure compression					
	G kg/m	I_y mm^4	$W_{el.y}$ mm^3	$W_{pl.y}$♦ mm^3	i_y mm	A_{vz} mm^2	I_z mm^4	$W_{el.z}$ mm^3	$W_{pl.z}$♦ mm^3	i_z mm	s_s mm	I_t mm^4	I_w mm^6	S 235	S 355	S 460	S 235	S 355	S 460	EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		$x\ 10^4$	$x\ 10^3$	$x\ 10^3$	x 10	$x\ 10^2$	$x\ 10^4$	$x\ 10^3$	$x\ 10^3$	x 10		$x\ 10^4$	$x\ 10^9$									
IPE 80 A	5,0	64,38	16,51	18,98	3,18	3,07	6,85	2,98	4,69	1,04	17,60	0,42	0,09	1	1	-	1	1	-	✔		
IPE 80	6,0	80,14	20,03	23,22	3,24	3,58	8,49	3,69	5,82	1,05	20,10	0,70	0,12	1	1	-	1	1	-	✔		
IPE A 100	6,9	141,2	28,81	32,98	4,01	4,44	13,12	4,77	7,54	1,22	21,20	0,77	0,28	1	1	-	1	1	-	✔		
IPE 100	8,1	171,0	34,20	39,41	4,07	5,08	15,92	5,79	9,15	1,24	23,70	1,20	0,35	1	1	-	1	1	-	✔		
IPE A 120	8,7	257,4	43,77	49,87	4,83	5,41	22,39	7,00	10,98	1,42	22,20	1,04	0,71	1	1	-	1	1	-	✔		
IPE 120	10,4	317,8	52,96	60,73	4,90	6,31	27,67	8,65	13,58	1,45	25,20	1,74	0,89	1	1	-	1	1	-	✔	✔	✔
IPE A 140	10,5	434,9	63,30	71,60	5,70	6,21	36,42	9,98	15,52	1,65	23,20	1,36	1,58	1	1	-	1	2	-	✔	✔	✔
IPE 140	12,9	541,2	77,32	88,34	5,74	7,64	44,92	12,31	19,25	1,65	26,70	2,45	1,98	1	1	-	1	1	-	✔	✔	✔
IPE A 160	12,7	689,3	87,81	99,09	6,53	7,80	54,43	13,27	20,70	1,83	26,34	1,96	3,09	1	1	-	1	3	-	✔	✔	✔
IPE 160	15,8	869,3	108,7	123,9	6,58	9,66	68,31	16,66	26,10	1,84	30,34	3,60	3,96	1	1	-	1	1	-	✔	✔	✔
IPE A 180	15,4	1063	120,1	135,3	7,37	9,20	81,89	18,00	27,96	2,05	27,84	2,70	5,93	1	1	-	2	3	-	✔	✔	✔
IPE 180	18,8	1317	146,3	166,4	7,42	11,25	100,9	22,16	34,60	2,05	31,84	4,79	7,43	1	1	-	1	2	-	✔	✔	✔
IPE O 180	21,3	1505	165,4	189,1	7,45	12,70	117,3	25,50	39,91	2,08	34,54	6,76	8,74	1	1	-	1	1	-	✔	✔	✔
IPE A 200	18,4	1591	161,6	181,7	8,23	11,47	117,2	23,43	36,54	2,23	32,56	4,11	10,53	1	1	-	2	4	-	✔	✔	✔
IPE 200	22,4	1943	194,3	220,6	8,26	14,00	142,4	28,47	44,61	2,24	36,66	6,98	12,99	1	1	-	1	2	-	✔	✔	✔
IPE O 200	25,1	2211	218,9	249,4	8,32	15,45	168,9	33,11	51,89	2,30	39,26	9,45	15,57	1	1	-	1	1	-	✔	✔	✔
IPE A 220	22,2	2317	213,5	240,2	9,05	13,55	171,4	31,17	48,49	2,46	34,46	5,69	18,71	1	1	-	2	4	-	✔	✔	✔
IPE 220	26,2	2772	252,0	285,4	9,11	15,88	204,9	37,25	58,11	2,48	38,36	9,07	22,67	1	1	-	1	2	-	✔	✔	✔
IPE O 220	29,4	3134	282,3	321,1	9,16	17,66	239,8	42,83	66,91	2,53	41,06	12,27	26,79	1	1	-	1	2	-	✔	✔	✔

♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Poutrelles I européennes (suite)

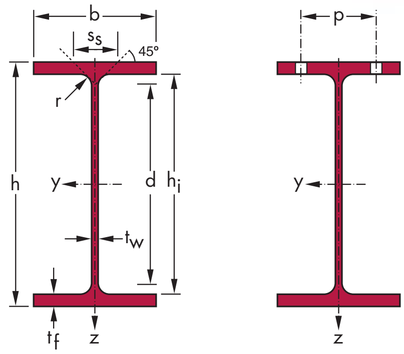
Dimensions: IPE 80 - 600 conformes à l'Euronorme 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Tolérances: EN 10034: 1993
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European I beams (continued)

Dimensions: IPE 80 - 600 in accordance with Euronorm 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Tolerances: EN 10034: 1993
Surface condition according to EN 10163-3:1991, class C, subclass 1

Europäische I-Profile (Fortsetzung)

Abmessungen: IPE 80 - 600 gemäß Euronorm 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Toleranzen: EN 10034: 1993
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung	Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm^2	h_i mm	d mm	Ø	p_{min} mm	p_{max} mm	A_L m^2/m	A_G m^2/t
						x 10^2							
IPE A 240• 26,2	237	120	5,2	8,3	15	33,3	220,4	190,4	M 12	64	68	0,918	35,10
IPE 240 30,7	240	120	6,2	9,8	15	39,1	220,4	190,4	M 12	66	68	0,922	30,02
IPE O 240+ 34,3	242	122	7	10,8	15	43,7	220,4	190,4	M 12	66	70	0,932	27,17
IPE A 270• 30,7	267	135	5,5	8,7	15	39,2	249,6	219,6	M 16	70	72	1,037	33,75
IPE 270 36,1	270	135	6,6	10,2	15	45,9	249,6	219,6	M 16	72	72	1,041	28,86
IPE O 270+ 42,3	274	136	7,5	12,2	15	53,8	249,6	219,6	M 16	72	72	1,051	24,88
IPE A 300• 36,5	297	150	6,1	9,2	15	46,5	278,6	248,6	M 16	72	86	1,156	31,65
IPE 300 42,2	300	150	7,1	10,7	15	53,8	278,6	248,6	M 16	72	86	1,160	27,46
IPE O 300+ 49,3	304	152	8	12,7	15	62,8	278,6	248,6	M 16	74	88	1,174	23,81
IPE A 330• 43,0	327	160	6,5	10	18	54,7	307	271	M 16	78	96	1,250	29,09
IPE 330 49,1	330	160	7,5	11,5	18	62,6	307	271	M 16	78	96	1,254	25,52
IPE O 330+ 57,0	334	162	8,5	13,5	18	72,6	307	271	M 16	80	98	1,268	22,24
IPE A 360• 50,2	357,6	170	6,6	11,5	18	64,0	334,6	298,6	M 22	86	88	1,351	26,91
IPE 360 57,1	360	170	8	12,7	18	72,7	334,6	298,6	M 22	88	88	1,353	23,70
IPE O 360+ 66,0	364	172	9,2	14,7	18	84,1	334,6	298,6	M 22	90	90	1,367	20,69
IPE A 400• 57,4	397	180	7	12	21	73,1	373	331	M 22	94	98	1,464	25,51
IPE 400 66,3	400	180	8,6	13,5	21	84,5	373	331	M 22	96	98	1,467	22,12
IPE O 400+ 75,7	404	182	9,7	15,5	21	96,4	373	331	M 22	96	100	1,481	19,57
IPE A 450• 67,2	447	190	7,6	13,1	21	85,6	420,8	378,8	M 24	100	102	1,603	23,87
IPE 450 77,6	450	190	9,4	14,6	21	98,8	420,8	378,8	M 24	100	102	1,605	20,69
IPE O 450+ 92,4	456	192	11	17,6	21	118	420,8	378,8	M 24	102	104	1,622	17,56

• Commande minimale: pour S 235 JR, cf. conditions de livraison page 216; pour toute autre qualité 40 t ou suivant accord.
+ Commande minimale: 40 t par profilé et qualité ou suivant accord.

• Minimum order: for the S 235 JR grade cf. delivery conditions page 216; for any other grade 40 t or upon agreement.
+ Minimum order: 40 t per section and grade or upon agreement.

• Mindestbestellmenge: für S 235 JR gemäß Lieferbedingungen Seite 216; für jede andere Güte 40 t oder nach Vereinbarung.
+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.

IPE

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung		**Valeurs statiques / Section properties / Statische Kennwerte**												**Classification ENV 1993-1-1**						EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		axe fort y-y strong axis y-y starke Achse y-y					axe faible z-z weak axis z-z schwache Achse z-z							pure bending y-y			pure compression					
	G kg/m	I_y mm^4	$W_{el.y}$ mm^3	$W_{pl.y}$♦ mm^3	i_y mm	A_{vz} mm^2	I_z mm^4	$W_{el.z}$ mm^3	$W_{pl.z}$♦ mm^3	i_z mm	s_s mm	I_t mm^4	I_w mm^6	S 235	S 355	S 460	S 235	S 355	S 460			
		x 10^4	x 10^3	x 10^3	x 10	x 10^2	x 10^4	x 10^3	x 10^3	x 10		x 10^4	x 10^9									
IPE A 240	26,2	3290	277,7	311,6	9,94	16,31	240,1	40,02	62,40	2,68	39,37	8,35	31,26	1	1	-	2	4	-	✔	✔	✔
IPE 240	30,7	3892	324,3	366,6	9,97	19,14	283,6	47,27	73,92	2,69	43,37	12,88	37,39	1	1	-	1	2	-	✔	✔	✔
IPE O 240	34,3	4369	361,1	410,3	10,00	21,36	328,5	53,86	84,40	2,74	46,17	17,18	43,68	1	1	-	1	2	-	✔	✔	✔
IPE A 270	30,7	4917	368,3	412,5	11,21	18,75	358,0	53,03	82,34	3,02	40,47	10,30	59,51	1	1	-	3	4	-	✔	✔	✔
IPE 270	36,1	5790	428,9	484,0	11,23	22,14	419,9	62,20	96,95	3,02	44,57	15,94	70,58	1	1	-	2	3	-	✔	✔	✔
IPE O 270	42,3	6947	507,1	574,6	11,36	25,23	513,5	75,51	117,7	3,09	49,47	24,90	87,64	1	1	-	1	2	-	✔	✔	✔
IPE A 300	36,5	7173	483,1	541,8	12,42	22,25	519,0	69,20	107,3	3,34	42,07	13,43	107,2	1	2	-	3	4	-	✔	✔	✔
IPE 300	42,2	8356	557,1	628,4	12,46	25,68	603,8	80,50	125,2	3,35	46,07	20,12	125,9	1	1	-	2	4	-	✔	✔	✔
IPE O 300	49,3	9994	657,5	743,8	12,61	29,05	745,7	98,12	152,6	3,45	50,97	31,06	157,7	1	1	-	1	3	-	✔	✔	✔
IPE A 330	43,0	10230	625,7	701,9	13,67	26,99	685,2	85,64	133,3	3,54	47,59	19,57	171,5	1	1	-	3	4	-	✔	✔	✔
IPE 330	49,1	11770	713,1	804,3	13,71	30,81	788,1	98,52	153,7	3,55	51,59	28,15	199,1	1	1	-	2	4	-	✔	✔	✔
IPE O 330	57,0	13910	833,0	942,8	13,84	34,88	960,4	118,6	185,0	3,64	56,59	42,15	245,7	1	1	-	1	3	-	✔	✔	✔
IPE A 360	50,2	14520	811,8	906,8	15,06	29,76	944,3	111,1	171,9	3,84	50,69	26,51	282,0	1	1	-	4	4	-	✔	✔	✔
IPE 360	57,1	16270	903,6	1019	14,95	35,14	1043	122,8	191,1	3,79	54,49	37,32	313,6	1	1	-	2	4	-	✔	✔	✔
IPE O 360	66,0	19050	1047	1186	15,05	40,21	1251	145,5	226,9	3,86	59,69	55,76	380,3	1	1	-	1	3	-	✔	✔	✔
IPE A 400	57,4	20290	1022	1144	16,66	35,78	1171	130,1	202,1	4,00	55,60	34,79	432,2	1	1	-	4	4	-	✔	✔	✔
IPE 400	66,3	23130	1156	1307	16,55	42,69	1318	146,4	229,0	3,95	60,20	51,08	490,0	1	1	-	3	4	-	✔	✔	✔
IPE O 400	75,7	26750	1324	1502	16,66	47,98	1564	171,9	269,1	4,03	65,30	73,10	587,6	1	1	-	2	3	-	✔	✔	✔
IPE A 450	67,2	29760	1331	1494	18,65	42,26	1502	158,1	245,7	4,19	58,40	45,67	704,9	1	1	-	4	4	-	✔	✔	✔
IPE 450	77,6	33740	1500	1702	18,48	50,85	1676	176,4	276,4	4,12	63,20	66,87	791,0	1	1	-	3	4	-	✔	✔	✔
IPE O 450	92,4	40920	1795	2046	18,65	59,40	2085	217,2	341,0	4,21	70,80	109	997,6	1	1	-	2	4	-	✔	✔	✔

♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Poutrelles I européennes (suite)

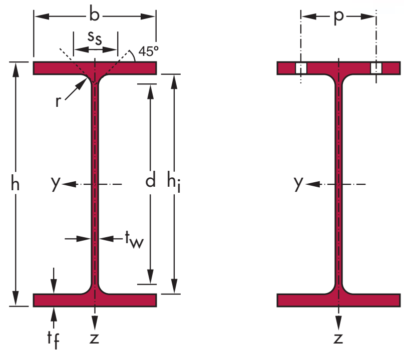
Dimensions: IPE 80 - 600 conformes à l'Euronorme 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Tolérances: EN 10034: 1993
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European I beams (continued)

Dimensions: IPE 80 - 600 in accordance with Euronorm 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Tolerances: EN 10034: 1993
Surface condition according to EN 10163-3:1991, class C, subclass 1

Europäische I-Profile (Fortsetzung)

Abmessungen: IPE 80 - 600 gemäß Euronorm 19-57; IPE A 80 - 600; IPE O 180 - 600; IPE 750
Toleranzen: EN 10034: 1993
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung		Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm^2	h_i mm	d mm	Ø	p_{min} mm	p_{max} mm	A_L m^2/m	A_G m^2/t
							x 10^2							
IPE A 500•	79,4	497	200	8,4	14,5	21	101	468	426	M 24	100	112	1,741	21,94
IPE 500	90,7	500	200	10,2	16	21	116	468	426	M 24	102	112	1,744	19,23
IPE O 500+	107	506	202	12	19	21	137	468	426	M 24	104	114	1,760	16,40
IPE A 550•	92,1	547	210	9	15,7	24	117	515,6	467,6	M 24	106	122	1,875	20,36
IPE 550	106	550	210	11,1	17,2	24	134	515,6	467,6	M 24	110	122	1,877	17,78
IPE O 550+	123	556	212	12,7	20,2	24	156	515,6	467,6	M 24	110	122	1,893	15,45
IPE A 600•	108	597	220	9,8	17,5	24	137	562	514	M 27	114	118	2,013	18,72
IPE 600	122	600	220	12	19	24	156	562	514	M 27	116	118	2,015	16,45
IPE O 600+	154	610	224	15	24	24	197	562	514	M 27	118	122	2,045	13,24
IPE 750 x 137*	137	753	263	11,5	17	17	175	719	685	M 27	102	162	2,506	18,28
IPE 750 x 147	147	753	265	13,2	17	17	188	719	685	M 27	104	164	2,510	17,06
IPE 750 x 173+	173	762	267	14,4	21,6	17	221	718,8	684,8	M 27	104	166	2,534	14,58
IPE 750 x 196+	196	770	268	15,6	25,4	17	251	719,2	685,2	M 27	106	166	2,552	12,96

• Commande minimale: pour S 235 JR, cf. conditions de livraison page 216 ; pour toute autre qualité 40 t ou suivant accord.
\+ Commande minimale: 40 t par profilé et qualité ou suivant accord.
* Tonnage minimum et conditions de livraison nécessitent un accord préalable.

• Minimum order: for the S 235 JR grade cf. delivery conditions page 216 ; for any other grade 40 t or upon agreement.
\+ Minimum order: 40 t per section and grade or upon agreement.
* Minimum tonnage and delivery conditions upon agreement.

• Mindestbestellmenge: für S 235 JR gemäß Lieferbedingungen Seite 216 ; für jede andere Güte 40 t oder nach Vereinbarung.
\+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.
* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

IPE

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation / Designation / Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte: axe fort y-y / strong axis y-y / starke Achse y-y					axe faible z-z / weak axis z-z / schwache Achse z-z							Classification ENV 1993-1-1: pure bending y-y			pure compression			EN 10025:1993	EN 10113-3:1993	EN 10225:2001
	G	I_y	$W_{el.y}$	$W_{pl.y}$♦	i_y	A_{vz}	I_z	$W_{el.z}$	$W_{pl.z}$♦	i_z	s_s	I_t	I_w	S 235	S 355	S 460	S 235	S 355	S 460			
	kg/m	mm^4	mm^3	mm^3	mm	mm^2	mm^4	mm^3	mm^3	mm	mm	mm^4	mm^6									
		$x\ 10^4$	$x\ 10^3$	$x\ 10^3$	x 10	$x\ 10^2$	$x\ 10^4$	$x\ 10^3$	$x\ 10^3$	x 10		$x\ 10^4$	$x\ 10^9$									
IPE A 500	79,4	42930	1728	1946	20,61	50,41	1939	193,9	301,6	4,38	62,00	62,78	1125	1	1	-	4	4	-	✔	✔	✔
IPE 500	90,7	48200	1928	2194	20,43	59,87	2142	214,2	335,9	4,31	66,80	89,29	1249	1	1	1	3	4	4	✔	HI	HI
IPE O 500	107	57780	2284	2613	20,56	70,21	2622	259,6	408,5	4,38	74,60	143,5	1548	1	1	1	2	4	4	✔	HI	HI
IPE A 550	92,1	59980	2193	2475	22,61	60,30	2432	231,6	361,5	4,55	68,52	86,53	1710	1	1	-	4	4	-	✔	✔	✔
IPE 550	106	67120	2441	2787	22,35	72,34	2668	254,1	400,5	4,45	73,62	123,2	1884	1	1	1	4	4	4	✔	HI	HI
IPE O 550	123	79160	2847	3263	22,52	82,69	3224	304,2	480,5	4,55	81,22	187,5	2302	1	1	1	2	4	4	✔	HI	HI
IPE A 600	108	82920	2778	3141	24,60	70,14	3116	283,3	442,1	4,77	72,92	118,8	2607	1	1	-	4	4	-	✔	✔	✔
IPE 600	122	92080	3069	3512	24,30	83,78	3387	307,9	485,6	4,66	78,12	165,4	2846	1	1	1	4	4	4	✔	HI	HI
IPE O 600	154	118300	3879	4471	24,52	104,4	4521	403,6	640,1	4,79	91,12	318,1	3860	1	1	1	2	4	4	✔	HI	HI
IPE 750 x 137	137	159900	4246	4865	30,26	92,90	5166	392,8	614,1	5,44	65,42	137,1	6980	1	2	-	4	4	-	✔	✔	✔
IPE 750 x 147	147	166100	4411	5110	29,76	105,4	5289	399,2	630,8	5,31	67,12	161,5	7141	1	1	-	4	4	-	✔	✔	✔
IPE 750 x 173	173	205800	5402	6218	30,49	116,4	6873	514,9	809,9	5,57	77,52	273,6	9391	1	1	1	4	4	4	✔	HI	HI
IPE 750 x 196	196	240300	6241	7174	30,95	127,3	8175	610,1	958,8	5,71	86,32	408,9	11290	1	1	1	4	4	4	✔	HI	HI

HI = HISTAR®

♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Poutrelles normales européennes

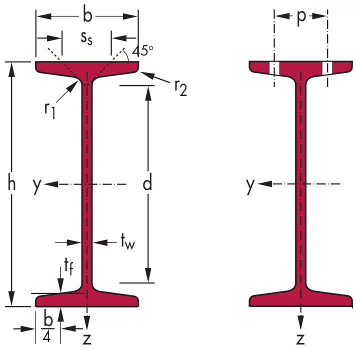
Inclinaison des ailes: 14%
Dimensions: DIN 1025-1: 1963, NF A 45-209 (1983)
Tolérances: EN 10024: 1995
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European standard beams

Flange slope: 14%
Dimensions: DIN 1025-1: 1963, NF A 45-209 (1983)
Tolerances: EN 10024: 1995
Surface condition according to EN 10163-3:1991, class C, subclass 1

Europäische Normalträger

Flanschneigung: 14%
Abmessungen: DIN 1025-1: 1963, NF A 45-209 (1983)
Toleranzen: EN 10024: 1995
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung	Dimensions Abmessungen							Dimensions de construction Dimensions for detailing Konstruktionsmaße				Surface Oberfläche	
G kg/m	h mm	b mm	t_w mm	t_f mm	r_1 mm	r_2 mm	A mm^2	d mm	Ø	p_{min} mm	p_{max} mm	A_L m^2/m	A_G m^2/t
							x 10^2						
IPN 80* 5,9	80	42	3,9	5,9	3,9	2,3	7,58	59	-	-	-	0,304	51,09
IPN 100* 8,3	100	50	4,5	6,8	4,5	2,7	10,6	75,7	-	-	-	0,370	44,47
IPN 120* 11,1	120	58	5,1	7,7	5,1	3,1	14,2	92,4	-	-	-	0,439	39,38
IPN 140* 14,3	140	66	5,7	8,6	5,7	3,4	18,3	109,1	-	-	-	0,502	34,94
IPN 160* 17,9	160	74	6,3	9,5	6,3	3,8	22,8	125,8	-	-	-	0,575	32,13
IPN 180* 21,9	180	82	6,9	10,4	6,9	4,1	27,9	142,4	-	-	-	0,640	29,22
IPN 200* 26,2	200	90	7,5	11,3	7,5	4,5	33,4	159,1	-	-	-	0,709	27,04
IPN 220* 31,1	220	98	8,1	12,2	8,1	4,9	39,5	175,8	M 10	50	56	0,775	24,99
IPN 240* 36,2	240	106	8,7	13,1	8,7	5,2	46,1	192,5	M 10	54	60	0,844	23,32
IPN 260* 41,9	260	113	9,4	14,1	9,4	5,6	53,3	208,9	M 12	62	62	0,906	21,65
IPN 280* 47,9	280	119	10,1	15,2	10,1	6,1	61,0	225,1	M 12	68	68	0,966	20,17
IPN 300* 54,2	300	125	10,8	16,2	10,8	6,5	69,0	241,6	M 12	70	74	1,03	19,02
IPN 320* 61,0	320	131	11,5	17,3	11,5	6,9	77,7	257,9	M 12	70	80	1,09	17,87
IPN 340* 68,0	340	137	12,2	18,3	12,2	7,3	86,7	274,3	M 12	78	86	1,15	16,90
IPN 360* 76,1	360	143	13	19,5	13	7,8	97,0	290,2	M 12	78	92	1,21	15,89
IPN 380* 84,0	380	149	13,7	20,5	13,7	8,2	107	306,7	M 16	84	86	1,27	15,12
IPN 400* 92,4	400	155	14,4	21,6	14,4	8,6	118	322,9	M 16	86	92	1,33	14,36
IPN 450* 115	450	170	16,2	24,3	16,2	9,7	147	363,6	M 16	92	106	1,48	12,83
IPN 500* 141	500	185	18	27	18	10,8	179	404,3	M 20	102	110	1,63	11,60
IPN 550* 166	550	200	19	30	19	11,9	212	445,6	M 22	112	118	1,80	10,80
IPN 600* 199	600	215	21,6	32,4	21,6	13	254	485,8	M 24	126	128	1,97	9,89

* Tonnage minimum et conditions de livraison nécessitent un accord préalable.

* Minimum tonnage and delivery conditions upon agreement.

* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

IPN

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation / Designation / Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte — axe fort y-y / strong axis y-y / starke Achse y-y					axe faible z-z / weak axis z-z / schwache Achse z-z							Classification ENV 1993-1-1 — pure bending y-y		pure compression		EN 10025:1993	EN 10113-3:1993	EN 10225:2001
	G	I_y	$W_{el.y}$	$W_{pl.y}$♦	i_y	A_{vz}	I_z	$W_{el.z}$	$W_{pl.z}$♦	i_z	s_s	I_t	I_w	S 235	S 355	S 235	S 355			
	kg/m	mm^4	mm^3	mm^3	mm	mm^2	mm^4	mm^3	mm^3	mm	mm	mm^4	mm^6							
		x 10^4	x 10^3	x 10^3	x 10	x 10^2	x 10^4	x 10^3	x 10^3	x 10		x 10^4	x 10^9							
IPN 80	5,9	77,8	19,5	22,8	3,20	3,41	6,29	3,00	5,00	0,91	21,6	0,87	0,09	4	4	4	4	✔		
IPN 100	8,3	171	34,2	39,8	4,01	4,85	12,2	4,88	8,10	1,07	25,0	1,60	0,27	1	1	1	1	✔		
IPN 120	11,1	328	54,7	63,6	4,81	6,63	21,5	7,41	12,4	1,23	28,4	2,71	0,69	1	1	1	1	✔		
IPN 140	14,3	573	81,9	95,4	5,61	8,65	35,2	10,7	17,9	1,40	31,8	4,32	1,54	1	1	1	1	✔		
IPN 160	17,9	935	117	136	6,40	10,83	54,7	14,8	24,9	1,55	35,2	6,57	3,14	1	1	1	1	✔		
IPN 180	21,9	1450	161	187	7,20	13,35	81,3	19,8	33,2	1,71	38,6	9,58	5,92	1	1	1	1	✔		
IPN 200	26,2	2140	214	250	8,00	16,03	117	26,0	43,5	1,87	42,0	13,5	10,5	1	1	1	1	✔		
IPN 220	31,1	3060	278	324	8,80	19,06	162	33,1	55,7	2,02	45,4	18,6	17,8	1	1	1	1	✔		
IPN 240	36,2	4250	354	412	9,59	22,33	221	41,7	70,0	2,20	48,9	25,0	28,7	1	1	1	1	✔		
IPN 260	41,9	5740	442	514	10,40	26,08	288	51,0	85,9	2,32	52,6	33,5	44,1	1	1	1	1	✔		
IPN 280	47,9	7590	542	632	11,10	30,18	364	61,2	103	2,45	56,4	44,2	64,6	1	1	1	1	✔		
IPN 300	54,2	9800	653	762	11,90	34,58	451	72,2	121	2,56	60,1	56,8	91,8	1	1	1	1	✔		
IPN 320	61,0	12510	782	914	12,70	39,26	555	84,7	143	2,67	63,9	72,5	129	1	1	1	1	✔		
IPN 340	68,0	15700	923	1080	13,50	44,27	674	98,4	166	2,80	67,6	90,4	176	1	1	1	1	✔		
IPN 360	76,1	19610	1090	1276	14,20	49,95	818	114	194	2,90	71,8	115	240	1	1	1	1	✔		
IPN 380	84,0	24010	1260	1482	15,00	55,55	975	131	221	3,02	75,4	141	319	1	1	1	1	✔		
IPN 400	92,4	29210	1460	1714	15,70	61,69	1160	149	253	3,13	79,3	170	420	1	1	1	1	✔		
IPN 450	115	45850	2040	2400	17,70	77,79	1730	203	345	3,43	88,9	267	791	1	1	1	1	✔		
IPN 500	141	68740	2750	3240	19,60	95,60	2480	268	456	3,72	98,5	402	1400	1	1	1	1	✔		
IPN 550	166	99180	3610	4240	21,60	111,3	3490	349	592	4,02	107,3	544	2390	1	1	1	1	✔		
IPN 600	199	138800	4627	5452	23,39	138,0	4674	435	752	4,29	117,6	787	3814	1	1	1	1	✔		

♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

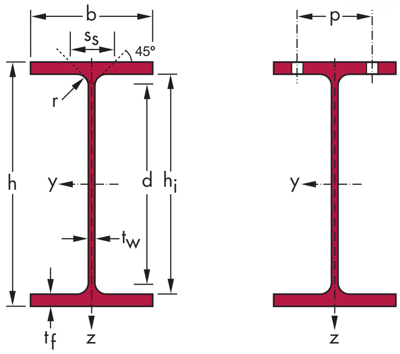
♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Poutrelles européennes à larges ailes

Dim.: HE A, HE B et HE M 100-1000 conformes à l'Euronorme 53-62 ; HE AA 100-1000 ; HL 920-1100
Tolérances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE avec $G_{HE}>G_{HE\ M}$; HL 920 ; HL 1000 avec $G_{HL}>G_{HL\ M}$
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European wide flange beams

Dim.: HE A, HE B and HE M 100 - 1000 in accordance with Euronorm 53-63 ; HE AA 100 - 1000 ; HL 920 - 1100
Tolerances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE with $G_{HE}>G_{HE\ M}$; HL 920 ; HL 1000 with $G_{HL}>G_{HL\ M}$
Surface condition according to EN 10163-3:1991, class C, subclass 1



Europäische Breitflanschträger

Abmessungen: HE A, HE B und HE M 100 - 1000 gemäß Euronorm 53-62 ; HE AA 100 - 1000 ; HL 920 - 1100
Toleranzen: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE mit $G_{HE}>G_{HE\ M}$; HL 920 ; HL 1000 mit $G_{HL}>G_{HL\ M}$
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1

Désignation Designation Bezeichnung		Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm²	h_i mm	d mm	Ø	p_{min} mm	p_{max} mm	A_L m²/m	A_G m²/t
							x 10²							
HE 100 AA•	12,2	91	100	4,2	5,5	12	15,6	80	56	M 10	54	58	0,553	45,17
HE 100 A	16,7	96	100	5	8	12	21,2	80	56	M 10	54	58	0,561	33,68
HE 100 B	20,4	100	100	6	10	12	26,0	80	56	M 10	56	58	0,567	27,76
HE 100 M	41,8	120	106	12	20	12	53,2	80	56	M 10	62	64	0,619	14,82
HE 120 AA•	14,6	109	120	4,2	5,5	12	18,6	98	74	M 12	58	68	0,669	45,94
HE 120 A	19,9	114	120	5	8	12	25,3	98	74	M 12	58	68	0,677	34,06
HE 120 B	26,7	120	120	6,5	11	12	34,0	98	74	M 12	60	68	0,686	25,71
HE 120 M	52,1	140	126	12,5	21	12	66,4	98	74	M 12	66	74	0,738	14,16
HE 140 AA•	18,1	128	140	4,3	6	12	23,0	116	92	M 16	64	76	0,787	43,53
HE 140 A	24,7	133	140	5,5	8,5	12	31,4	116	92	M 16	64	76	0,794	32,21
HE 140 B	33,7	140	140	7	12	12	43,0	116	92	M 16	66	76	0,805	23,88
HE 140 M	63,2	160	146	13	22	12	80,6	116	92	M 16	72	82	0,857	13,56
HE 160 AA•	23,8	148	160	4,5	7	15	30,4	134	104	M 20	76	84	0,901	37,81
HE 160 A	30,4	152	160	6	9	15	38,8	134	104	M 20	78	84	0,906	29,78
HE 160 B	42,6	160	160	8	13	15	54,3	134	104	M 20	80	84	0,918	21,56
HE 160 M	76,2	180	166	14	23	15	97,1	134	104	M 20	86	90	0,970	12,74
HE 180 AA•	28,7	167	180	5	7,5	15	36,5	152	122	M 24	84	92	1,018	35,51
HE 180 A	35,5	171	180	6	9,5	15	45,3	152	122	M 24	86	92	1,024	28,83
HE 180 B	51,2	180	180	8,5	14	15	65,3	152	122	M 24	88	92	1,037	20,25
HE 180 M	88,9	200	186	14,5	24	15	113,3	152	122	M 24	94	98	1,089	12,25
HE 200 AA•	34,6	186	200	5,5	8	18	44,1	170	134	M 27	96	100	1,130	32,62
HE 200 A	42,3	190	200	6,5	10	18	53,8	170	134	M 27	98	100	1,136	26,89
HE 200 B	61,3	200	200	9	15	18	78,1	170	134	M 27	100	100	1,151	18,78
HE 200 M	103	220	206	15	25	18	131,3	170	134	M 27	106	106	1,203	11,67
HE 220 AA•	40,4	205	220	6	8,5	18	51,5	188	152	M 27	98	118	1,247	30,87
HE 220 A	50,5	210	220	7	11	18	64,3	188	152	M 27	98	118	1,255	24,85
HE 220 B	71,5	220	220	9,5	16	18	91,0	188	152	M 27	100	118	1,270	17,77
HE 220 M	117	240	226	15,5	26	18	149,4	188	152	M 27	108	124	1,322	11,27

- Commande minimale: pour S 235 JR, cf. conditions de livraison page 216 ; pour toute autre qualité 40 t ou suivant accord.
- Minimum order: for the S 235 JR grade cf. delivery conditions page 216 ; for any other grade 40 t or upon agreement.
- Mindestbestellmenge: für S 235 JR gemäß Lieferbedingungen Seite 216 ; für jede andere Güte 40 t oder nach Vereinbarung.

HE

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation / Designation / Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte												Classification ENV 1993-1-1						EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		axe fort y-y / strong axis y-y / starke Achse y-y					axe faible z-z / weak axis z-z / schwache Achse z-z							pure bending y-y			pure compression					
	G	I_y	$W_{el.y}$	$W_{pl.y}$♦	i_y	A_{vz}	I_z	$W_{el.z}$	$W_{pl.z}$♦	i_z	s_s	I_t	I_w	S 235	S 355	S 460	S 235	S 355	S 460			
	kg/m	mm^4	mm^3	mm^3	mm	mm^2	mm^4	mm^3	mm^3	mm	mm	mm^4	mm^6									
		$x\ 10^4$	$x\ 10^3$	$x\ 10^3$	x 10	$x\ 10^2$	$x\ 10^4$	$x\ 10^3$	$x\ 10^3$	x 10		$x\ 10^4$	$x\ 10^9$									
HE 100 AA	12,2	236,5	51,98	58,36	3,89	6,15	92,06	18,41	28,44	2,43	29,26	2,51	1,68	1	3	-	1	3	-	✔	✔	✔
HE 100 A	16,7	349,2	72,76	83,01	4,06	7,56	133,8	26,76	41,14	2,51	35,06	5,24	2,58	1	1	-	1	1	-	✔	✔	✔
HE 100 B	20,4	449,5	89,91	104,2	4,16	9,04	167,3	33,45	51,42	2,53	40,06	9,25	3,38	1	1	-	1	1	-	✔	✔	✔
HE 100 M	41,8	1143	190,4	235,8	4,63	18,04	399,2	75,31	116,3	2,74	66,06	68,21	9,93	1	1	-	1	1	-	✔	✔	✔
HE 120 AA	14,6	413,4	75,85	84,12	4,72	6,90	158,8	26,47	40,62	2,93	29,26	2,78	4,24	2	3	-	2	3	-	✔	✔	✔
HE 120 A	19,9	606,2	106,3	119,5	4,89	8,46	230,9	38,48	58,85	3,02	35,06	5,99	6,47	1	1	-	1	1	-	✔	✔	✔
HE 120 B	26,7	864,4	144,1	165,2	5,04	10,96	317,5	52,92	80,97	3,06	42,56	13,84	9,41	1	1	-	1	1	-	✔	✔	✔
HE 120 M	52,1	2018	288,2	350,6	5,51	21,15	702,8	111,6	171,6	3,25	68,56	91,66	24,79	1	1	-	1	1	-	✔	✔	✔
HE 140 AA	18,1	719,5	112,4	123,8	5,59	7,92	274,8	39,26	59,93	3,45	30,36	3,54	10,21	3	3	-	3	3	-	✔	✔	✔
HE 140 A	24,7	1033	155,4	173,5	5,73	10,12	389,3	55,62	84,85	3,52	36,56	8,13	15,06	1	2	-	1	2	-	✔	✔	✔
HE 140 B	33,7	1509	215,6	245,4	5,93	13,08	549,7	78,52	119,8	3,58	45,06	20,06	22,48	1	1	-	1	1	-	✔	✔	✔
HE 140 M	63,2	3291	411,4	493,8	6,39	24,46	1144	156,8	240,5	3,77	71,06	120,0	54,33	1	1	-	1	1	-	✔	✔	✔
HE 160 AA	23,8	1283	173,4	190,4	6,50	10,38	478,7	59,84	91,36	3,97	36,07	6,33	23,75	3	3	-	3	3	-	✔	✔	✔
HE 160 A	30,4	1673	220,1	245,1	6,57	13,21	615,6	76,95	117,6	3,98	41,57	12,19	31,41	1	2	-	1	2	-	✔	✔	✔
HE 160 B	42,6	2492	311,5	354,0	6,78	17,59	889,2	111,2	170,0	4,05	51,57	31,24	47,94	1	1	-	1	1	-	✔	✔	✔
HE 160 M	76,2	5098	566,5	674,6	7,25	30,81	1759	211,9	325,5	4,26	77,57	162,4	108,1	1	1	-	1	1	-	✔	✔	✔
HE 180 AA	28,7	1967	235,6	258,2	7,34	12,16	730,0	81,11	123,6	4,47	37,57	8,33	46,36	3	3	-	3	3	-	✔	✔	✔
HE 180 A	35,5	2510	293,6	324,9	7,45	14,47	924,6	102,7	156,5	4,52	42,57	14,80	60,21	1	3	-	1	3	-	✔	✔	✔
HE 180 B	51,2	3831	425,7	481,4	7,66	20,24	1363	151,4	231,0	4,57	54,07	42,16	93,75	1	1	-	1	1	-	✔	✔	✔
HE 180 M	88,9	7483	748,3	883,4	8,13	34,65	2580	277,4	425,2	4,77	80,07	203,3	199,3	1	1	-	1	1	-	✔	✔	✔
HE 200 AA	34,6	2944	316,6	347,1	8,17	15,45	1068	106,8	163,2	4,92	42,59	12,69	84,49	3	4	-	3	4	-	✔	✔	✔
HE 200 A	42,3	3692	388,6	429,5	8,28	18,08	1336	133,6	203,8	4,98	47,59	20,98	108,0	1	3	-	1	3	-	✔	✔	✔
HE 200 B	61,3	5696	569,6	642,5	8,54	24,83	2003	200,3	305,8	5,07	60,09	59,28	171,1	1	1	-	1	1	-	✔	✔	✔
HE 200 M	103	10640	967,4	1135	9,00	41,03	3651	354,5	543,2	5,27	86,09	259,4	346,3	1	1	-	1	1	-	✔	✔	✔
HE 220 AA	40,4	4170	406,9	445,5	9,00	17,63	1510	137,3	209,3	5,42	44,09	15,93	145,6	3	4	-	3	4	-	✔	✔	✔
HE 220 A	50,5	5410	515,2	568,5	9,17	20,67	1955	177,7	270,6	5,51	50,09	28,46	193,3	1	3	-	1	3	-	✔	✔	✔
HE 220 B	71,5	8091	735,5	827,0	9,43	27,92	2843	258,5	393,9	5,59	62,59	76,57	295,4	1	1	-	1	1	-	✔	✔	✔
HE 220 M	117	14600	1217	1419	9,89	45,31	5012	443,5	678,6	5,79	88,59	315,3	572,7	1	1	-	1	1	-	✔	✔	✔

♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Poutrelles européennes à larges ailes (suite)

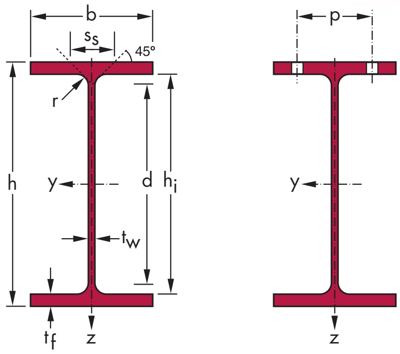
Dim.: HE A, HE B et HE M 100-1000 conformes à l'Euronorme 53-62 ; HE AA 100-1000 ; HL 920-1100
Tolérances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE avec $G_{HE}>G_{HE\,M}$; HL 920 ; HL 1000 avec $G_{HL}>G_{HL\,M}$
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European wide flange beams (continued)

Dim.: HE A, HE B and HE M 100 - 1000 in accordance with Euronorm 53-63 ; HE AA 100 - 1000 ; HL 920 - 1100
Tolerances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE with $G_{HE}>G_{HE\,M}$; HL 920 ; HL 1000 with $G_{HL}>G_{HL\,M}$
Surface condition according to EN 10163-3:1991, class C, subclass 1

Europäische Breitflanschträger (Fortsetzung)

Abmessungen: HE A, HE B und HE M 100 - 1000 gemäß Euronorm 53-62 ; HE AA 100 - 1000 ; HL 920 - 1100
Toleranzen: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE mit $G_{HE}>G_{HE\,M}$; HL 920 ; HL 1000 mit $G_{HL}>G_{HL\,M}$
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung	Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm²	h_i mm	d mm	Ø	p_{min} mm	p_{max} mm	A_L m²/m	A_G m²/t
						x 10²							
HE 240 AA• 47,4	224	240	6,5	9	21	60,4	206	164	M 27	104	138	1,359	28,67
HE 240 A 60,3	230	240	7,5	12	21	76,8	206	164	M 27	104	138	1,369	22,70
HE 240 B 83,2	240	240	10	17	21	106,0	206	164	M 27	108	138	1,384	16,63
HE 240 M 157	270	248	18	32	21	199,6	206	164	M 27	116	146	1,460	9,318
HE 260 AA• 54,1	244	260	6,5	9,5	24	69,0	225	177	M 27	110	158	1,474	27,22
HE 260 A 68,2	250	260	7,5	12,5	24	86,8	225	177	M 27	110	158	1,484	21,77
HE 260 B 93	260	260	10	17,5	24	118,4	225	177	M 27	114	158	1,499	16,12
HE 260 M 172	290	268	18	32,5	24	219,6	225	177	M 27	122	166	1,575	9,133
HE 280 AA• 61,2	264	280	7	10	24	78,0	244	196	M 27	110	178	1,593	26,01
HE 280 A 76,4	270	280	8	13	24	97,3	244	196	M 27	112	178	1,603	20,99
HE 280 B 103	280	280	10,5	18	24	131,4	244	196	M 27	114	178	1,618	15,69
HE 280 M 189	310	288	18,5	33	24	240,2	244	196	M 27	122	186	1,694	8,984
HE 300 AA• 69,8	283	300	7,5	10,5	27	88,9	262	208	M 27	116	198	1,705	24,42
HE 300 A 88,3	290	300	8,5	14	27	112,5	262	208	M 27	118	198	1,717	19,43
HE 300 B 117	300	300	11	19	27	149,1	262	208	M 27	120	198	1,732	14,80
HE 300 M 238	340	310	21	39	27	303,1	262	208	M 27	132	208	1,832	7,699
HE 320 AA• 74,2	301	300	8	11	27	94,6	279	225	M 27	118	198	1,740	23,43
HE 320 A 97,6	310	300	9	15,5	27	124,4	279	225	M 27	118	198	1,756	17,98
HE 320 B 127	320	300	11,5	20,5	27	161,3	279	225	M 27	122	198	1,771	13,98
HE 320 M 245	359	309	21	40	27	312,0	279	225	M 27	132	204	1,866	7,616
HE 340 AA• 78,9	320	300	8,5	11,5	27	100,5	297	243	M 27	118	198	1,777	22,52
HE 340 A 105	330	300	9,5	16,5	27	133,5	297	243	M 27	118	198	1,795	17,13
HE 340 B 134	340	300	12	21,5	27	170,9	297	243	M 27	122	198	1,810	13,49
HE 340 M 248	377	309	21	40	27	315,8	297	243	M 27	132	204	1,902	7,670
HE 360 AA• 83,7	339	300	9	12	27	106,6	315	261	M 27	118	198	1,814	21,67
HE 360 A 112	350	300	10	17,5	27	142,8	315	261	M 27	120	198	1,834	16,36
HE 360 B 142	360	300	12,5	22,5	27	180,6	315	261	M 27	122	198	1,849	13,04
HE 360 M 250	395	308	21	40	27	318,8	315	261	M 27	132	204	1,934	7,730

- • Commande minimale: pour S 235 JR, cf. conditions de livraison page 216 ; pour toute autre qualité 40 t ou suivant accord.
- • Minimum order: for the S 235 JR grade cf. delivery conditions page 216 ; for any other grade 40 t or upon agreement.
- • Mindestbestellmenge: für S 235 JR gemäß Lieferbedingungen Seite 216 ; für jede andere Güte 40 t oder nach Vereinbarung.

HE

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation / Designation / Bezeichnung	G	I_y	$W_{el.y}$	$W_{pl.y}$♦	i_y	A_{vz}	I_z	$W_{el.z}$	$W_{pl.z}$♦	i_z	s_s	I_t	I_w	Classification ENV 1993-1-1, pure bending y-y: S 235	S 355	S 460	pure compression: S 235	S 355	S 460	EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		Valeurs statiques / Section properties / Statische Kennwerte: axe fort y-y / strong axis y-y / starke Achse y-y					axe faible z-z / weak axis z-z / schwache Achse z-z															
	kg/m	mm^4	mm^3	mm^3	mm	mm^2	mm^4	mm^3	mm^3	mm	mm	mm^4	mm^6									
		x 10^4	x 10^3	x 10^3	x 10	x 10^2	x 10^4	x 10^3	x 10^3	x 10		x 10^4	x 10^9									
HE 240 AA	47,4	5835	521,0	570,6	9,83	21,54	2077	173,1	264,4	5,87	49,10	22,98	239,6	3	4	-	3	4	-	✔	✔	✔
HE 240 A	60,3	7763	675,1	744,6	10,05	25,18	2769	230,7	351,7	6,00	56,10	41,55	328,5	1	3	-	1	3	-	✔	✔	✔
HE 240 B	83,2	11260	938,3	1053	10,31	33,23	3923	326,9	498,4	6,08	68,60	102,7	486,9	1	1	-	1	1	-	✔	✔	✔
HE 240 M	157	24290	1799	2117	11,03	60,07	8153	657,5	1006	6,39	106,6	627,9	1152	1	1	-	1	1	-	✔	✔	✔
HE 260 AA	54,1	7981	654,1	714,5	10,76	24,75	2788	214,5	327,7	6,36	53,62	30,31	382,6	3	4	-	3	4	-	✔	✔	✔
HE 260 A	68,2	10450	836,4	919,8	10,97	28,76	3668	282,1	430,2	6,50	60,62	52,37	516,4	2	3	3	2	3	3	✔	HI	HI
HE 260 B	93	14920	1148	1283	11,22	37,59	5135	395,0	602,2	6,58	73,12	123,8	753,7	1	1	2	1	1	2	✔	HI	HI
HE 260 M	172	31310	2159	2524	11,94	66,89	10450	779,7	1192	6,90	111,1	719,0	1728	1	1	1	1	1	1	✔	HI	HI
HE 280 AA	61,2	10560	799,8	873,1	11,63	27,52	3664	261,7	399,4	6,85	55,12	36,22	590,1	3	4	-	3	4	-	✔	✔	✔
HE 280 A	76,4	13670	1013	1112	11,86	31,74	4763	340,2	518,1	7,00	62,12	62,10	785,4	2	3	4	2	3	4	✔	HI	HI
HE 280 B	103	19270	1376	1534	12,11	41,09	6595	471,0	717,6	7,09	74,62	143,7	1130	1	1	2	1	1	2	✔	HI	HI
HE 280 M	189	39550	2551	2966	12,83	72,03	13160	914,1	1397	7,40	112,6	807,3	2520	1	1	1	1	1	1	✔	HI	HI
HE 300 AA	69,8	13800	975,6	1065	12,46	32,37	4734	315,6	482,3	7,30	60,13	49,35	877,2	3	4	-	3	4	-	✔	✔	✔
HE 300 A	88,3	18260	1260	1383	12,74	37,28	6310	420,6	641,2	7,49	68,13	85,17	1200	2	3	3	2	3	3	✔	HI	HI
HE 300 B	117	25170	1678	1869	12,99	47,43	8563	570,9	870,1	7,58	80,63	185,0	1688	1	1	3	1	1	3	✔	HI	HI
HE 300 M	238	59200	3482	4078	13,98	90,53	19400	1252	1913	8,00	130,6	1408	4386	1	1	1	1	1	1	✔	HI	HI
HE 320 AA	74,2	16450	1093	1196	13,19	35,40	4959	330,6	505,7	7,24	61,63	55,87	1041	3	4	-	3	4	-	✔	✔	✔
HE 320 A	97,6	22930	1479	1628	13,58	41,13	6985	465,7	709,7	7,49	71,63	108,0	1512	1	3	3	1	3	3	✔	HI	HI
HE 320 B	127	30820	1926	2149	13,82	51,77	9239	615,9	939,1	7,57	84,13	225,1	2069	1	1	2	1	1	2	✔	HI	HI
HE 320 M	245	68130	3796	4435	14,78	94,85	19710	1276	1951	7,95	132,6	1501	5004	1	1	1	1	1	1	✔	HI	HI
HE 340 AA	78,9	19550	1222	1341	13,95	38,69	5185	345,6	529,3	7,18	63,13	63,07	1231	3	4	-	3	4	-	✔	✔	✔
HE 340 A	105	27690	1678	1850	14,40	44,95	7436	495,7	755,9	7,46	74,13	127,2	1824	1	3	3	1	3	3	✔	HI	HI
HE 340 B	134	36660	2156	2408	14,65	56,09	9690	646,0	985,7	7,53	86,63	257,2	2454	1	1	1	1	1	1	✔	HI	HI
HE 340 M	248	76370	4052	4718	15,55	98,63	19710	1276	1953	7,90	132,6	1506	5584	1	1	1	1	1	1	✔	HI	HI
HE 360 AA	83,7	23040	1359	1495	14,70	42,17	5410	360,7	553,0	7,12	64,63	70,99	1444	3	4	-	3	4	-	✔	✔	✔
HE 360 A	112	33090	1891	2088	15,22	48,96	7887	525,8	802,3	7,43	76,63	148,8	2177	1	2	3	1	2	3	✔	HI	HI
HE 360 B	142	43190	2400	2683	15,46	60,60	10140	676,1	1032	7,49	89,13	292,5	2883	1	1	1	1	1	1	✔	HI	HI
HE 360 M	250	84870	4297	4989	16,32	102,4	19520	1268	1942	7,83	132,6	1507	6137	1	1	1	1	1	1	✔	HI	HI

HI = HISTAR®

♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

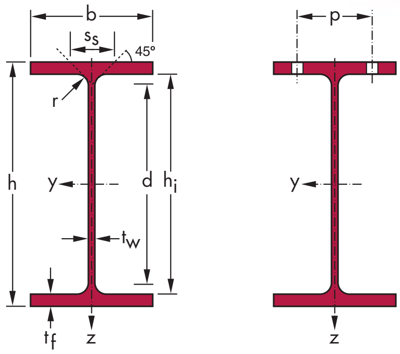
♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Poutrelles européennes à larges ailes (suite)

Dim.: HE A, HE B et HE M 100-1000 conformes à l'Euronorme 53-62 ; HE AA 100-1000 ; HL 920-1100
Tolérances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE avec $G_{HE}>G_{HE\ M}$; HL 920 ; HL 1000 avec $G_{HL}>G_{HL\ M}$
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European wide flange beams (continued)

Dim.: HE A, HE B and HE M 100 - 1000 in accordance with Euronorm 53-63 ; HE AA 100 - 1000 ; HL 920 - 1100
Tolerances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE with $G_{HE}>G_{HE\ M}$; HL 920 ; HL 1000 with $G_{HL}>G_{HL\ M}$
Surface condition according to EN 10163-3:1991, class C, subclass 1



Europäische Breitflanschträger (Fortsetzung)

Abmessungen: HE A, HE B und HE M 100 - 1000 gemäß Euronorm 53-62 ; HE AA 100 - 1000 ; HL 920 - 1100
Toleranzen: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE mit $G_{HE}>G_{HE\ M}$; HL 920 ; HL 1000 mit $G_{HL}>G_{HL\ M}$
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1

Désignation Designation Bezeichnung		Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm^2	h_i mm	d mm	Ø	p_{min} mm	p_{max} mm	A_L m^2/m	A_G m^2/t
							x 10^2							
HE 400 AA•	92,4	378	300	9,5	13	27	117,7	352	298	M 27	118	198	1,891	20,46
HE 400 A	125	390	300	11	19	27	159,0	352	298	M 27	120	198	1,912	15,32
HE 400 B	155	400	300	13,5	24	27	197,8	352	298	M 27	124	198	1,927	12,41
HE 400 M	256	432	307	21	40	27	325,8	352	298	M 27	132	202	2,004	7,835
HE 450 AA•	99,7	425	300	10	13,5	27	127,1	398	344	M 27	120	198	1,984	19,89
HE 450 A	140	440	300	11,5	21	27	178,0	398	344	M 27	122	198	2,011	14,39
HE 450 B	171	450	300	14	26	27	218,0	398	344	M 27	124	198	2,026	11,84
HE 450 M	263	478	307	21	40	27	335,4	398	344	M 27	132	202	2,096	7,959
HE 500 AA•	107	472	300	10,5	14	27	136,9	444	390	M 27	120	198	2,077	19,33
HE 500 A	155	490	300	12	23	27	197,5	444	390	M 27	122	198	2,110	13,60
HE 500 B	187	500	300	14,5	28	27	238,6	444	390	M 27	124	198	2,125	11,34
HE 500 M	270	524	306	21	40	27	344,3	444	390	M 27	132	202	2,184	8,079
HE 550 AA•	120	522	300	11,5	15	27	152,8	492	438	M 27	122	198	2,175	18,13
HE 550 A	166	540	300	12,5	24	27	211,8	492	438	M 27	122	198	2,209	13,29
HE 550 B	199	550	300	15	29	27	254,1	492	438	M 27	124	198	2,224	11,15
HE 550 M	278	572	306	21	40	27	354,4	492	438	M 27	132	202	2,280	8,195
HE 600 AA•	129	571	300	12	15,5	27	164,1	540	486	M 27	122	198	2,272	17,64
HE 600 A	178	590	300	13	25	27	226,5	540	486	M 27	122	198	2,308	12,98
HE 600 B	212	600	300	15,5	30	27	270,0	540	486	M 27	126	198	2,323	10,96
HE 600 M	285	620	305	21	40	27	363,7	540	486	M 27	132	200	2,372	8,308
HE 600 x 337•	337	632	310	25,5	46	27	429,2	540	486	M 27	138	202	2,407	7,144
HE 600 x 399•	399	648	315	30	54	27	508,5	540	486	M 27	142	208	2,450	6,137
HE 650 AA•	138	620	300	12,5	16	27	175,8	588	534	M 27	122	198	2,369	17,17
HE 650 A	190	640	300	13,5	26	27	241,6	588	534	M 27	124	198	2,407	12,69
HE 650 B	225	650	300	16	31	27	286,3	588	534	M 27	126	198	2,422	10,77
HE 650 M	293	668	305	21	40	27	373,7	588	534	M 27	132	200	2,468	8,411
HE 650 x 343•	343	680	309	25	46	27	437,5	588	534	M 27	138	202	2,500	7,278
HE 650 x 407•	407	696	314	29,5	54	27	518,8	588	534	M 27	142	206	2,543	6,243

- Commande minimale: pour S 235 JR, cf. conditions de livraison page 216 ; pour toute autre qualité 40 t ou suivant accord.
- Minimum order: for the S 235 JR grade cf. delivery conditions page 216 ; for any other grade 40 t or upon agreement.
- Mindestbestellmenge: für S 235 JR gemäß Lieferbedingungen Seite 216 ; für jede andere Güte 40 t oder nach Vereinbarung.

HE

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation / Designation / Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte — axe fort y-y / strong axis y-y / starke Achse y-y					axe faible z-z / weak axis z-z / schwache Achse z-z							Classification ENV 1993-1-1 — pure bending y-y			pure compression			EN 10025:1993	EN 10113-3:1993	EN 10225:2001
	G kg/m	I_y mm⁴	$W_{el.y}$ mm³	$W_{pl.y}$♦ mm³	i_y mm	A_{vz} mm²	I_z mm⁴	$W_{el.z}$ mm³	$W_{pl.z}$♦ mm³	i_z mm	s_s mm	I_t mm⁴	I_w mm⁶	S 235	S 355	S 460	S 235	S 355	S 460			
		$\times 10^4$	$\times 10^3$	$\times 10^3$	x 10	$\times 10^2$	$\times 10^4$	$\times 10^3$	$\times 10^3$	x 10		$\times 10^4$	$\times 10^9$									
HE 400 AA	92,4	31250	1654	1824	16,30	47,95	5861	390,8	599,7	7,06	67,13	84,69	1948	3	3	-	3	3	-	✔	✔	✔
HE 400 A	125	45070	2311	2562	16,84	57,33	8564	570,9	872,9	7,34	80,63	189,0	2942	1	1	3	1	2	3	✔	HI	HI
HE 400 B	155	57680	2884	3232	17,08	69,98	10820	721,3	1104	7,40	93,13	355,7	3817	1	1	1	1	1	1	✔	HI	HI
HE 400 M	256	104100	4820	5571	17,88	110,2	19340	1260	1934	7,70	132,6	1515	7410	1	1	1	1	1	1	✔	HI	HI
HE 450 AA	99,7	41890	1971	2183	18,16	54,70	6088	405,8	624,4	6,92	68,63	95,61	2572	3	3	-	3	4	-	✔	✔	✔
HE 450 A	140	63720	2896	3216	18,92	65,78	9465	631,0	965,5	7,29	85,13	243,8	4148	1	1	1	1	2	3	✔	HI	HI
HE 450 B	171	79890	3551	3982	19,14	79,66	11720	781,4	1198	7,33	97,63	440,5	5258	1	1	1	1	1	2	✔	HI	HI
HE 450 M	263	131500	5501	6331	19,80	119,8	19340	1260	1939	7,59	132,6	1529	9251	1	1	1	1	1	1	✔	HI	HI
HE 500 AA	107	54640	2315	2576	19,98	61,91	6314	420,9	649,3	6,79	70,13	107,7	3304	2	3	-	2	4	-	✔	✔	✔
HE 500 A	155	86970	3550	3949	20,98	74,72	10370	691,1	1059	7,24	89,63	309,3	5643	1	1	1	1	3	4	✔	HI	HI
HE 500 B	187	107200	4287	4815	21,19	89,82	12620	841,6	1292	7,27	102,1	538,4	7018	1	1	1	1	2	2	✔	HI	HI
HE 500 M	270	161900	6180	7094	21,69	129,5	19150	1252	1932	7,46	132,6	1539	11190	1	1	1	1	1	1	✔	HI	HI
HE 550 AA	120	72870	2792	3128	21,84	72,66	6767	451,1	698,6	6,65	73,13	133,7	4338	1	3	-	3	4	-	✔	✔	✔
HE 550 A	166	111900	4146	4622	22,99	83,72	10820	721,3	1107	7,15	92,13	351,5	7189	1	1	1	2	4	4	✔	HI	HI
HE 550 B	199	136700	4971	5591	23,20	100,1	13080	871,8	1341	7,17	104,6	600,3	8856	1	1	1	1	2	3	✔	HI	HI
HE 550 M	278	198000	6923	7933	23,64	139,6	19160	1252	1937	7,35	132,6	1554	13520	1	1	1	1	1	1	✔	HI	HI
HE 600 AA	129	91900	3218	3623	23,66	81,29	6993	466,2	724,5	6,53	74,63	149,8	5381	1	3	-	3	4	-	✔	✔	✔
HE 600 A	178	141200	4787	5350	24,97	93,21	11270	751,4	1156	7,05	94,63	397,8	8978	1	1	1	2	4	4	✔	HI	HI
HE 600 B	212	171000	5701	6425	25,17	110,8	13530	902,0	1391	7,08	107,1	667,2	10970	1	1	1	1	3	4	✔	HI	HI
HE 600 M	285	237400	7660	8772	25,55	149,7	18980	1244	1930	7,22	132,6	1564	15910	1	1	1	1	1	1	✔	HI	HI
HE 600 x 337	337	283200	8961	10380	25,69	180,5	22940	1480	2310	7,31	149,1	2451	19610	1	1	1	1	1	1	✔	HI	
HE 600 x 399	399	344600	10640	12460	26,03	213,6	28280	1796	2814	7,46	169,6	3966	24810	1	1	1	1	1	1	✔	HI	
HE 650 AA	138	113900	3676	4160	25,46	90,40	7221	481,4	750,7	6,41	76,13	167,5	6567	1	3	-	4	4	-	✔	✔	✔
HE 650 A	190	175200	5474	6136	26,93	103,2	11720	781,6	1205	6,97	97,13	448,3	11030	1	1	1	3	4	4	✔	HI	HI
HE 650 B	225	210600	6480	7320	27,12	122,0	13980	932,3	1441	6,99	109,6	739,2	13360	1	1	1	2	3	4	✔	HI	HI
HE 650 M	293	281700	8433	9657	27,45	159,7	18980	1245	1936	7,13	132,6	1579	18650	1	1	1	1	1	2	✔	HI	HI
HE 650 x 343	343	333700	9815	11350	27,62	189,6	22720	1470	2300	7,21	148,6	2442	22730	1	1	1	1	1	1	✔	HI	
HE 650 x 407	407	405400	11650	13620	27,95	224,8	28020	1785	2803	7,35	169,1	3958	28710	1	1	1	1	1	1	✔	HI	

HI = HISTAR®

♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

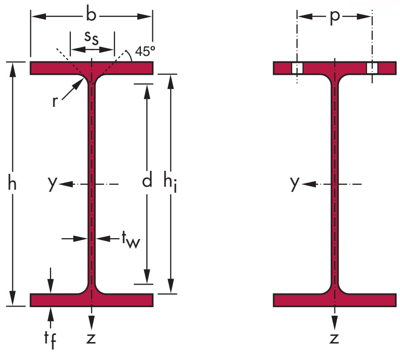
♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Poutrelles européennes à larges ailes (suite)

Dim.: HE A, HE B et HE M 100-1000 conformes à l'Euronorme 53-62 ; HE AA 100-1000 ; HL 920-1100
Tolérances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE avec G_{HE}>$G_{HE\ M}$; HL 920 ; HL 1000 avec G_{HL}>$G_{HL\ M}$
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European wide flange beams (continued)

Dim.: HE A, HE B and HE M 100 - 1000 in accordance with Euronorm 53-63 ; HE AA 100 - 1000 ; HL 920 - 1100
Tolerances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE with G_{HE}>$G_{HE\ M}$; HL 920 ; HL 1000 with G_{HL}>$G_{HL\ M}$
Surface condition according to EN 10163-3:1991, class C, subclass 1



Europäische Breitflanschträger (Fortsetzung)

Abmessungen: HE A, HE B und HE M 100 - 1000 gemäß Euronorm 53-62 ; HE AA 100 - 1000 ; HL 920 - 1100
Toleranzen: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE mit G_{HE}>$G_{HE\ M}$; HL 920 ; HL 1000 mit G_{HL}>$G_{HL\ M}$
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1

Désignation Designation Bezeichnung		Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm^2	h_i mm	d mm	Ø	p_{min} mm	p_{max} mm	A_L m^2/m	A_G m^2/t
							x 10^2							
HE 700 AA•	150	670	300	13	17	27	190,9	636	582	M 27	122	198	2,468	16,46
HE 700 A	204	690	300	14,5	27	27	260,5	636	582	M 27	124	198	2,505	12,25
HE 700 B	241	700	300	17	32	27	306,4	636	582	M 27	126	198	2,520	10,48
HE 700 M	301	716	304	21	40	27	383,0	636	582	M 27	132	200	2,560	8,513
HE 700 x 352•	352	728	308	25	46	27	448,6	636	582	M 27	138	200	2,592	7,359
HE 700 x 418•	418	744	313	29,5	54	27	531,9	636	582	M 27	142	206	2,635	6,310
HE 800 AA•	172	770	300	14	18	30	218,5	734	674	M 27	130	198	2,660	15,51
HE 800 A	224	790	300	15	28	30	285,8	734	674	M 27	130	198	2,698	12,03
HE 800 B	262	800	300	17,5	33	30	334,2	734	674	M 27	134	198	2,713	10,34
HE 800 M	317	814	303	21	40	30	404,3	734	674	M 27	138	198	2,746	8,655
HE 800 x 373•	373	826	308	25	46	30	474,6	734	674	M 27	144	200	2,782	7,469
HE 800 x 444•	444	842	313	30	54	30	566,0	734	674	M 27	148	206	2,824	6,357
HE 900 AA•	198	870	300	15	20	30	252,2	830	770	M 27	130	198	2,858	14,44
HE 900 A	252	890	300	16	30	30	320,5	830	770	M 27	132	198	2,896	11,51
HE 900 B	291	900	300	18,5	35	30	371,3	830	770	M 27	134	198	2,911	9,99
HE 900 M	333	910	302	21	40	30	423,6	830	770	M 27	138	198	2,934	8,824
HE 900 x 391•	391	922	307	25	46	30	497,7	830	770	M 27	144	200	2,970	7,604
HE 900 x 466•	466	938	312	30	54	30	593,7	830	770	M 27	148	204	3,012	6,464
HE 1000 AA•	222	970	300	16	21	30	282,2	928	868	M 27	132	198	3,056	13,80
HE 1000 x 249•	249	980	300	16,5	26	30	316,8	928	868	M 27	134	194	3,08	12,37
HE 1000 A	272	990	300	16,5	31	30	346,8	928	868	M 27	132	198	3,095	11,37
HE 1000 B	314	1000	300	19	36	30	400,0	928	868	M 27	134	198	3,110	9,905
HE 1000 M	349	1008	302	21	40	30	444,2	928	868	M 27	138	198	3,130	8,978
HE 1000 x 393•	393	1016	303	24,4	43,9	30	500,2	928	868	M 27	142	198	3,14	8,01
HE 1000 x 415•	415	1020	304	26	46	30	528,7	928	868	M 27	144	198	3,15	7,60
HE 1000 x 438•	437	1026	305	26,9	49	30	557,2	928	868	M 27	146	198	3,17	7,24
HE 1000 x 494•	494	1036	309	31	54	30	629,1	928	868	M 27	148	204	3,19	6,47
HE 1000 x 584•	584	1056	314	36	64	30	743,7	928	868	M 27	154	208	3,24	5,56

- Commande minimale: pour S 235 JR, cf. conditions de livraison page 216 ; pour toute autre qualité 40 t ou suivant accord.
- Minimum order: for the S 235 JR grade cf. delivery conditions page 216 ; for any other grade 40 t or upon agreement.
- Mindestbestellmenge: für S 235 JR gemäß Lieferbedingungen Seite 216 ; für jede andere Güte 40 t oder nach Vereinbarung.

HE

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation / Designation / Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte: axe fort y-y / strong axis y-y / starke Achse y-y					axe faible z-z / weak axis z-z / schwache Achse z-z							Classification ENV 1993-1-1: pure bending y-y			pure compression					
	G kg/m	I_y mm^4	$W_{el.y}$ mm^3	$W_{pl.y}$♦ mm^3	i_y mm	A_{vz} mm^2	I_z mm^4	$W_{el.z}$ mm^3	$W_{pl.z}$♦ mm^3	i_z mm	s_s mm	I_t mm^4	I_w mm^6	S 235	S 355	S 460	S 235	S 355	S 460	EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		x 10^4	x 10^3	x 10^3	x 10	x 10^2	x 10^4	x 10^3	x 10^3	x 10		x 10^4	x 10^9									
HE 700 AA	150	142700	4260	4840	27,34	100,3	7673	511,5	799,7	6,34	78,63	195,2	8155	1	2	-	4	4	-	✔	✔	✔
HE 700 A	204	215300	6241	7032	28,75	117,0	12180	811,9	1257	6,84	100,1	513,9	13350	1	1	1	3	4	4	✔	HI	HI
HE 700 B	241	256900	7340	8327	28,96	137,1	14440	962,7	1495	6,87	112,6	830,9	16060	1	1	1	2	4	4	✔	HI	HI
HE 700 M	301	329300	9198	10540	29,32	169,8	18800	1237	1929	7,01	132,6	1589	21400	1	1	1	1	2	3	✔	HI	HI
HE 700 x 352	352	389700	10710	12390	29,47	201,6	22510	1461	2293	7,08	148,6	2461	26050	1	1	1	1	1	1	✔	HI	
HE 700 x 418	418	472500	12700	14840	29,80	239,0	27760	1774	2797	7,22	169,1	3989	32850	1	1	1	1	1	1	✔	HI	
HE 800 AA	172	208900	5426	6225	30,92	123,8	8134	542,2	856,6	6,10	85,15	256,8	11450	1	2	-	4	4	-	✔	✔	✔
HE 800 A	224	303400	7682	8699	32,58	138,8	12640	842,6	1312	6,65	106,1	596,9	18290	1	1	1	4	4	4	✔	HI	HI
HE 800 B	262	359100	8977	10230	32,78	161,8	14900	993,6	1553	6,68	118,6	946,0	21840	1	1	1	3	4	4	✔	HI	HI
HE 800 M	317	442600	10870	12490	33,09	194,3	18630	1230	1930	6,79	136,1	1646	27780	1	1	1	1	3	4	✔	HI	HI
HE 800 x 373	373	523900	12690	14700	33,23	230,3	22530	1463	2311	6,89	152,1	2554	34070	1	1	1	1	2	2	✔	HI	
HE 800 x 444	444	634500	15070	17640	33,48	276,5	27800	1776	2827	7,01	173,1	4180	42840	1	1	1	1	1	1	✔	HI	
HE 900 AA	198	301100	6923	7999	34,55	147,2	9041	602,8	957,7	5,99	90,15	334,9	16260	1	1	-	4	4	-	✔	✔	✔
HE 900 A	252	422100	9485	10810	36,29	163,3	13550	903,2	1414	6,50	111,1	736,8	24960	1	1	1	4	4	4	✔	HI	HI
HE 900 B	291	494100	10980	12580	36,48	188,8	15820	1054	1658	6,53	123,6	1137	29460	1	1	1	3	4	4	✔	HI	HI
HE 900 M	333	570400	12540	14440	36,70	214,4	18450	1222	1929	6,60	136,1	1671	34750	1	1	1	2	4	4	✔	HI	HI
HE 900 x 391	391	674300	14630	16990	36,81	254,3	22320	1454	2312	6,70	152,1	2597	42560	1	1	1	1	3	4	✔	HI	
HE 900 x 466	466	814900	17380	20380	37,05	305,3	27560	1767	2832	6,81	173,1	4256	53400	1	1	1	1	1	2	✔	HI	
HE 1000 AA	222	406500	8380	9777	37,95	172,2	9501	633,4	1016	5,80	93,15	403,4	21280	1	1	-	4	4	-	✔		
HE 1000 x 249	249	481100	9818	11350	38,97	180,7	11750	784,0	1245	6,09	103,6	584,4	26620	1	1	2	4	4	4	✔	HI	HI
HE 1000 A	272	553800	11190	12820	39,96	184,6	14000	933,6	1470	6,35	113,6	822,4	32070	1	1	2	4	4	4	✔	HI	HI
HE 1000 B	314	644700	12890	14860	40,15	212,5	16280	1085	1716	6,38	126,1	1254	37640	1	1	1	4	4	4	✔	HI	HI
HE 1000 M	349	722300	14330	16570	40,32	235,0	18460	1222	1940	6,45	136,1	1701	43020	1	1	1	3	4	4	✔	HI	HI
HE 1000 x 393	393	807700	15900	18540	40,18	271,3	20500	1353	2168	6,40	147,3	2332	48080	1	1	1	2	4	4	✔	HI	
HE 1000 x 415	415	853100	16728	19571	40,17	288,6	21710	1428	2298	6,41	153,1	2713	51080	1	1	1	2	3	4	✔	HI	
HE 1000 x 438	437	909800	17740	20770	40,41	300,9	23360	1532	2464	6,47	160,1	3200	55290	1	1	1	1	3	4	✔	HI	
HE 1000 x 494	494	1028000	19845	23413	40,42	344,5	26820	1736	2818	6,53	174,1	4433	64010	1	1	1	1	2	3	✔	HI	
HE 1000 x 584	584	1246100	23600	28039	40,93	403,2	33430	2130	3475	6,70	199,1	7230	81240	1	1	1	1	1	2	✔	HI	

HI = HISTAR®

♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

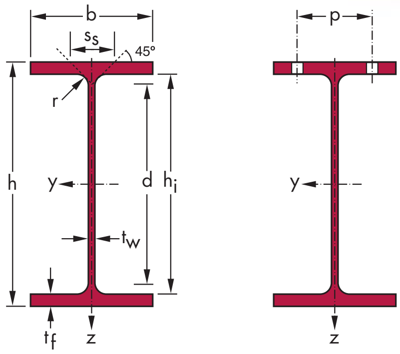
♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Poutrelles européennes à larges ailes (suite)

Dim.: HE A, HE B et HE M 100-1000 conformes à l'Euronorme 53-62 ; HE AA 100-1000 ; HL 920-1100
Tolérances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE avec $G_{HE}>G_{HE\,M}$; HL 920 ; HL 1000 avec $G_{HL}>G_{HL\,M}$
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European wide flange beams (continued)

Dim.: HE A, HE B and HE M 100 - 1000 in accordance with Euronorm 53-63 ; HE AA 100 - 1000 ; HL 920 - 1100
Tolerances: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE with $G_{HE}>G_{HE\,M}$; HL 920 ; HL 1000 with $G_{HL}>G_{HL\,M}$
Surface condition according to EN 10163-3:1991, class C, subclass 1



Europäische Breitflanschträger (Fortsetzung)

Abmessungen: HE A, HE B und HE M 100 - 1000 gemäß Euronorm 53-62 ; HE AA 100 - 1000 ; HL 920 - 1100
Toleranzen: EN 10034: 1993 HE 100 - 900 ; HE 1000 AA-M ; HL AA-R
A6 - 02 HE mit $G_{HE}>G_{HE\,M}$; HL 920 ; HL 1000 mit $G_{HL}>G_{HL\,M}$
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1

Désignation Designation Bezeichnung		Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm^2	h_i mm	d mm	Ø	p_{min} mm	p_{max} mm	A_L m^2/m	A_G m^2/t
							x 10^2							
HL 920 x 342•	342	912	418	19,3	32	24	436,1	848	800	M 27	126	312	3,42	9,98
HL 920 x 365•	365	916	419	20,3	34,3	24	464,4	847,4	799,4	M 27	128	314	3,43	9,40
HL 920 x 387•	387	921	420	21,3	36,6	24	493,0	847,8	799,8	M 27	128	314	3,44	8,88
HL 920 x 417•	417	928	422	22,5	39,9	24	532,5	848,2	800,2	M 27	130	316	3,46	8,27
HL 920 x 446•	446	933	423	24	42,7	24	569,6	847,6	799,6	M 27	130	318	3,47	7,76
HL 920 x 488•	488	942	422	25,9	47	24	621,3	848	800	M 27	132	316	3,48	7,13
HL 920 x 534•	534	950	425	28,4	51,1	24	680,1	847,8	799,8	M 27	136	320	3,50	6,56
HL 920 x 585•	585	960	427	31	55,9	24	745,3	848,2	800,2	M 27	138	322	3,52	6,02
HL 920 x 653•	653	972	431	34,5	62	24	831,9	848	800	M 27	144	320	3,56	5,45
HL 920 x 784•	784	996	437	40,9	73,9	24	997,7	848,2	800,2	M 27	152	326	3,62	4,62
HL 920 x 967•	967	1028	446	50	89,9	24	1231,0	848,2	800,2	M 27	160	334	3,70	3,83
HL 1000 AA•	296	982	400	16,5	27	30	376,8	928	868	M 27	134	294	3,479	11,76
HL 1000 A•	321	990	400	16,5	31	30	408,8	928	868	M 27	134	294	3,495	10,89
HL 1000 B•	371	1000	400	19	36	30	472,0	928	868	M 27	136	294	3,510	9,474
HL 1000 M•	412	1008	402	21	40	30	524,2	928	868	M 27	142	290	3,530	8,580
HL 1000 x 443•	443	1012	402	23,6	41,9	30	563,7	928	868	M27	142	296	3,53	7,99
HL 1000 x 483•	483	1020	404	25,4	46	30	615,1	928	868	M 27	144	298	3,55	7,36
HL 1000 x 539•	539	1030	407	28,4	51,1	30	687,2	928	868	M 27	146	302	3,58	6,64
HL 1000 x 554•	554	1032	408	29,5	52	30	705,8	928	868	M 27	150	296	3,59	6,47
HL 1000 x 591•	591	1040	409	31	55,9	30	752,7	928	868	M 27	148	304	3,60	6,10
HL 1000 x 642•	642	1048	412	34	60	30	817,6	928	868	M 27	154	300	3,62	5,65
HL 1000 x 748•	748	1068	417	39	70	30	953,4	928	868	M 27	160	304	3,67	4,91
HL 1000 x 883•	883	1092	424	45,5	82	30	1125,3	928	868	M 27	166	312	3,74	4,23
HL 1100 A•	343	1090	400	18	31	20	436,5	1028	988	M 27	116	294	3,710	10,83
HL 1100 B•	390	1100	400	20	36	20	497,0	1028	988	M 27	118	294	3,726	9,549
HL 1100 M•	433	1108	402	22	40	20	551,2	1028	988	M 27	122	290	3,746	8,657
HL 1100 R•	499	1118	405	26	45	20	635,2	1028	988	M 27	126	294	3,770	7,560

- Commande minimale: pour S 235 JR, cf. conditions de livraison page 216 ; pour toute autre qualité 40 t ou suivant accord.
- Minimum order: for the S 235 JR grade cf. delivery conditions page 216 ; for any other grade 40 t or upon agreement.
- Mindestbestellmenge: für S 235 JR gemäß Lieferbedingungen Seite 216 ; für jede andere Güte 40 t oder nach Vereinbarung.

HL

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte												Classification ENV 1993-1-1								
		axe fort y-y strong axis y-y starke Achse y-y					axe faible z-z weak axis z-z schwache Achse z-z							pure bending y-y			pure compression					
	G kg/m	I_y mm⁴	$W_{el.y}$ mm³	$W_{pl.y}$♦ mm³	i_y mm	A_{vz} mm²	I_z mm⁴	$W_{el.z}$ mm³	$W_{pl.z}$♦ mm³	i_z mm	s_s mm	I_t mm⁴	I_w mm⁶	S 235	S 355	S 460	S 235	S 355	S 460	EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		x 10⁴	x 10³	x 10³	x 10	x 10²	x 10⁴	x 10³	x 10³	x 10		x 10⁴	x 10⁹									
HL 920 x 342	342	624900	13700	15450	37,85	190,1	39010	1867	2882	9,46	111,4	1193	75410	1	1	1	3	4	4	✔	HI	HI
HL 920 x 365	365	670500	14640	16520	38,00	200,4	42120	2011	3106	9,52	117,0	1446	81730	1	1	1	3	4	4	✔	HI	HI
HL 920 x 387	387	718300	15600	17630	38,17	210,9	45280	2156	3332	9,58	122,6	1734	88370	1	1	1	2	4	4	✔	HI	HI
HL 920 x 417	417	787600	16970	19210	38,46	223,9	50070	2373	3668	9,70	130,4	2200	98540	1	1	1	2	4	4	✔	HI	HI
HL 920 x 446	446	846800	18150	20600	38,56	239,1	53980	2552	3951	9,73	137,5	2685	106740	1	1	1	2	3	4	✔	HI	
HL 920 x 488	488	935390	19860	22615	38,80	259,3	59010	2797	4336	9,75	148,0	3514	117890	1	1	1	1	2	4	✔	HI	
HL 920 x 534	534	1031000	21710	24830	38,94	284,8	65560	3085	4796	9,82	158,7	4542	132070	1	1	1	1	2	3	✔	HI	
HL 920 x 585	585	1143090	23814	27363	39,16	312,0	72770	3408	5310	9,88	170,9	5932	148220	1	1	1	1	1	2	✔	HI	
HL 920 x 653	653	1292000	26590	30730	39,41	348,7	83050	3854	6022	9,99	186,6	8124	171280	1	1	1	1	1	1	✔	HI	
HL 920 x 784	784	1593000	31980	37340	39,95	417,6	103300	4728	7424	10,18	216,8	13730	218490	1	1	-	1	1	-	○		
HL 920 x 967	967	2033000	39540	46810	40,64	517,1	133900	6003	9486	10,43	257,9	24930	292450	1	1	-	1	1	-	○		
HL 1000 AA	296	618700	12600	14220	40,52	181,5	28850	1443	2235	8,75	105,6	756,9	65670	1	1	2	4	4	4	✔	HI	HI
HL 1000 A	321	696400	14070	15800	41,27	184,6	33120	1656	2555	9,00	113,6	1021	76030	1	1	2	4	4	4	✔	HI	HI
HL 1000 B	371	812100	16240	18330	41,48	212,5	38480	1924	2976	9,03	126,1	1565	89210	1	1	1	4	4	4	✔	HI	HI
HL 1000 M	412	909800	18050	20440	41,66	235,0	43410	2160	3348	9,10	136,1	2128	101460	1	1	1	3	4	4	✔	HI	HI
HL 1000 x 443	443	966510	19101	21777	41,41	261,8	45500	2264	3529	8,98	142,5	2545	106740	1	1	1	2	4	4	✔	HI	
HL 1000 x 483	483	1067480	20931	23923	41,66	282,7	50710	2510	3919	9,08	152,5	3311	119900	1	1	1	2	4	4	✔	HI	
HL 1000 x 539	539	1202540	23350	26824	41,83	316,4	57630	2832	4436	9,16	165,7	4546	137550	1	1	1	1	2	4	✔	HI	
HL 1000 x 554	554	1232000	23880	27500	41,79	328,0	59100	2897	4547	9,15	168,6	4860	141330	1	1	1	1	2	3	✔	HI	
HL 1000 x 591	591	1331040	25597	29530	42,05	346,3	64010	3130	4916	9,22	177,9	5927	154330	1	1	1	1	2	3	✔	HI	
HL 1000 x 642	642	1451000	27680	32100	42,12	379,6	70280	3412	5379	9,27	189,1	7440	170670	1	1	1	1	1	2	✔	HI	
HL 1000 x 748	748	1732000	32430	37880	42,62	438,9	85111	4082	6459	9,45	214,1	11670	210650	1	1	1	1	1	1	✔	HI	
HL 1000 x 883	883	2096000	38390	45260	43,16	516,5	105000	4952	7874	9,66	244,6	18750	265670	1	1	-	1	1	-	○		
HL 1100 A	343	867400	15920	18060	44,58	206,5	33120	1656	2568	8,71	103,4	1037	92710	1	1	2	4	4	4	✔	HI	HI
HL 1100 B	390	1005000	18280	20780	44,98	230,6	38480	1924	2988	8,80	115,4	1564	108680	1	1	1	4	4	4	✔	HI	HI
HL 1100 M	433	1126000	20320	23160	45,19	254,4	43410	2160	3362	8,87	125,4	2130	123500	1	1	1	4	4	4	✔	HI	HI
HL 1100 R	499	1294000	23150	26600	45,14	300,4	49980	2468	3870	8,87	139,4	3135	143410	1	1	1	2	4	4	✔	HI	

HI = HISTAR®

○ Disponible seulement en JR, JO.
♦ W_{pl}: Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 suivant la capacité de rotation requise. Voir page 215.

○ Only available in JR, JO.
♦ W_{pl}: For plastic design, the shape must belong to class 1 or 2 according to the required rotation capacity. See page 215.

○ Nur in JR, JO verfügbar.
♦ W_{pl}: Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, entsprechend der erforderlichen Rotationskapazität, angehören. Siehe Seite 215.

Fers U à ailes parallèles

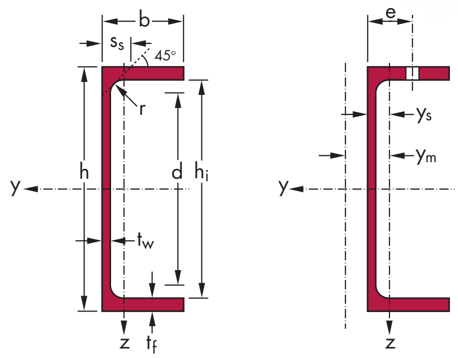
Dimensions: DIN 1026-2: 2002-10
Tolérances: EN 10279: 2000
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Channel with parallel flanges

Dimensions: DIN 1026-2: 2002-10
Tolerances: EN 10279: 2000
Surface condition according to EN 10163-3: 1991, class C, subclass 1

U-Profile mit parallelen Flanschen

Abmessungen: DIN 1026-2: 2002-10
Toleranzen: EN 10279: 2000
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung	Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm^2	h_i mm	d mm	Ø	e_{min} mm	e_{max} mm	A_L m^2/m	A_G m^2/t
						x 10^2							
UPE 80* 7,90	80	50	4	7	10	10,1	66	46	-	-	-	0,34	43,45
UPE 100* 9,82	100	55	4,5	7,5	10	12,5	85	65	M 12	35	36	0,40	41,00
UPE 120* 12,1	120	60	5	8	12	15,4	104	80	M 12	35	41	0,46	37,98
UPE 140* 14,5	140	65	5	9	12	18,4	122	98	M 16	35	38	0,52	35,95
UPE 160* 17,0	160	70	5,5	9,5	12	21,7	141	117	M 16	36	43	0,58	34,01
UPE 180* 19,7	180	75	5,5	10,5	12	25,1	159	135	M 16	36	48	0,64	32,40
UPE 200* 22,8	200	80	6	11	13	29,0	178	152	M 20	46	47	0,70	30,60
UPE 220* 26,6	220	85	6,5	12	13	33,9	196	170	M 22	47	49	0,76	28,43
UPE 240* 30,2	240	90	7	12,5	15	38,5	215	185	M 24	47	51	0,81	26,89
UPE 270* 35,2	270	95	7,5	13,5	15	44,8	243	213	M 27	48	50	0,89	25,34
UPE 300* 44,4	300	100	9,5	15	15	56,6	270	240	M 27	50	55	0,97	21,78
UPE 330* 53,2	330	105	11	16	18	67,8	298	262	M 27	54	60	1,04	19,60
UPE 360* 61,2	360	110	12	17	18	77,9	326	290	M 27	55	65	1,12	18,32
UPE 400* 72,2	400	115	13,5	18	18	91,9	364	328	M 27	57	70	1,22	16,87

* Tonnage minimum et conditions de livraison nécessitent un accord préalable.

* Minimum tonnage and delivery conditions upon agreement.

* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

UPE

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung	Valeurs statiques / Section properties / Statische Kennwerte															Classification ENV 1993-1-1						
	axe fort y-y strong axis y-y starke Achse y-y					axe faible z-z weak axis z-z schwache Achse z-z										pure bending y-y		pure compression		EN 10025:1993	EN 10113-3:1993	EN 10225:2001
	G kg/m	I_y mm^4	$W_{el.y}$ mm^3	$W_{pl.y}$ ■ mm^3	i_y mm	A_{vz} mm^2	I_z mm^4	$W_{el.z}$ mm^3	$W_{pl.z}$ mm^3	i_z mm	s_s mm	I_t mm^4	I_w mm^6	y_s mm	y_m mm	S 235	S 355	S 235	S 355			
		x 10^4	x 10^3	x 10^3	x 10	x 10^2	x 10^4	x 10^3	x 10^3	x 10		x 10^4	x 10^9	x 10	x 10							
UPE 80	7,90	107,2	26,80	31,23	3,26	4,05	25,41	7,98	14,28	1,59	16,9	1,47	0,22	1,82	3,71	1	1	1	1	✔		
UPE 100	9,82	206,9	41,37	48,01	4,07	5,34	38,21	10,63	19,34	1,75	17,9	2,01	0,53	1,91	3,93	1	1	1	1	✔		
UPE 120	12,1	363,5	60,58	70,33	4,86	7,18	55,40	13,79	25,28	1,90	20,0	2,90	1,12	1,98	4,12	1	1	1	1	✔	✔	✔
UPE 140	14,5	599,5	85,64	98,84	5,71	8,25	78,70	18,19	33,22	2,07	21,0	4,05	2,20	2,17	4,54	1	1	1	1	✔	✔	✔
UPE 160	17,0	911,1	113,9	131,6	6,48	10,04	106,8	22,58	41,49	2,22	22,0	5,20	3,96	2,27	4,76	1	1	1	1	✔	✔	✔
UPE 180	19,7	1353	150,4	173,0	7,34	11,20	143,7	28,56	52,30	2,39	23,0	6,99	6,81	2,47	5,19	1	1	1	1	✔	✔	✔
UPE 200	22,8	1909	190,9	220,1	8,11	13,50	187,3	34,43	63,28	2,54	24,6	8,89	11,00	2,56	5,41	1	1	1	1	✔	✔	✔
UPE 220	26,6	2682	243,9	281,5	8,90	15,81	246,4	42,51	78,25	2,70	26,1	12,05	17,61	2,70	5,70	1	1	1	1	✔	✔	✔
UPE 240	30,2	3599	299,9	346,9	9,67	18,77	310,9	50,08	92,18	2,84	28,3	15,14	26,42	2,79	5,91	1	1	1	1	✔	✔	✔
UPE 270	35,2	5255	389,2	451,1	10,83	22,23	401,0	60,69	111,6	2,99	29,8	19,91	43,55	2,89	6,14	1	1	1	2	✔	✔	✔
UPE 300	44,4	7823	521,5	613,4	11,76	30,29	537,7	75,58	136,6	3,08	33,3	31,52	72,66	2,89	6,03	1	1	1	1	✔	✔	✔
UPE 330	53,2	11010	667,1	791,9	12,74	38,81	681,5	89,66	156,2	3,17	37,5	45,18	111,8	2,90	6,00	1	1	1	1	✔	✔	✔
UPE 360	61,2	14830	823,6	982,3	13,79	45,61	843,7	105,1	177,8	3,29	39,5	58,49	166,4	2,97	6,12	1	1	1	1	✔	✔	✔
UPE 400	72,2	20980	1049	1263	15,11	56,20	1045	122,6	191,4	3,37	42,0	79,14	259,0	2,98	6,06	1	1	1	1	✔	✔	✔

- ■ $W_{pl.y}$ est calculé selon l'hypothèse d'un diagramme de contraintes bi-rectangulaire et n'est applicable que si deux ou plusieurs fers U sont associés de façon à constituer une section doublement symétrique pour laquelle un moment de flexion agissant dans le plan du centre de gravité n'engendre pas de torsion.
- ■ $W_{pl.y}$ is determined assuming a bi-rectangular stress block distribution. Thus, the given value applies only if two or more channels are combined in such a way to form a doubly symmetric cross-section so that the bending moment acting in the plane of the centre of gravity will not lead to torsion.
- ■ Für die Berechnung von $W_{pl.y}$ wurde eine doppelrechteckige Spannungsverteilung angenommen. Der angegebene Wert ist daher nur anwendbar, wenn zwei oder mehr U-Profile so miteinander kombiniert sind, dass sie einen doppelsymmetrischen Querschnitt bilden, womit ein Biegemoment, das in der Schwerpunktebene angreift, keine Torsion hervorruft.

Fers U à ailes parallèles

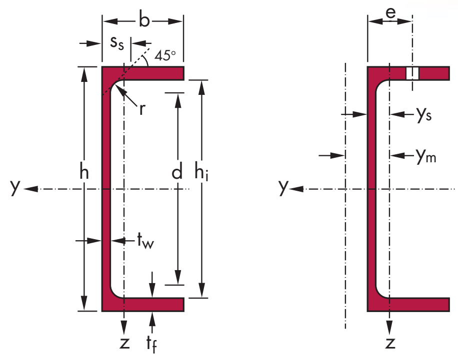
Dimensions: NF A 45-255 (1983)
Tolérances: EN 10279: 2000
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Channels with parallel flanges

Dimensions: NF A 45-255 (1983)
Tolerances: EN 10279: 2000
Surface condition according to EN 10163-3: 1991, class C, subclass 1

U-Profiles mit parallelen Flanschen

Abmessungen: NF A 45-255 (1983)
Toleranzen: EN 10279: 2000
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung		Dimensions Abmessungen						Dimensions de construction Dimensions for detailing Konstruktionsmaße					Surface Oberfläche	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A mm^2	h_i mm	d mm	Ø	e_{min} mm	e_{max} mm	A_L m^2/m	A_G m^2/t
							x 10^2							
UAP 80*	8,38	80	45	5	8	8	10,7	64	48	-	-	-	0,32	38,56
UAP 100*	10,5	100	50	5,5	8,5	8,5	13,4	83	66	M 10	25	30	0,38	36,35
UAP 130*	13,7	130	55	6	9,5	9,5	17,5	111	92	M 10	27	35	0,46	33,48
UAP 150*	17,9	150	65	7	10,25	10,25	22,9	129,5	109	M 16	33	36	0,54	29,96
UAP 175*	21,2	175	70	7,5	10,75	10,75	27,0	153,5	132	M 16	34	41	0,61	28,52
UAP 200*	25,1	200	75	8	11,5	11,5	32,0	177	154	M 16	35	46	0,67	26,86
UAP 220*	28,5	220	80	8	12,5	12,5	36,3	195	170	M 16	36	51	0,73	25,75
UAP 250	34,4	250	85	9	13,5	13,5	43,8	223	196	M 22	43	47	0,81	23,57
UAP 300	46,0	300	100	9,5	16	16	58,6	268	236	M 27	51	53	0,97	21,04

* Tonnage minimum et conditions de livraison nécessitent un accord préalable.
* Minimum tonnage and delivery conditions upon agreement.
* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

UAP

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation / Designation / Bezeichnung	G	I_y	$W_{el.y}$	$W_{pl.y}$■	i_y	A_{vz}	I_z	$W_{el.z}$	$W_{pl.z'}$	i_z	s_s	I_t	I_w	y_s	y_m	Classification ENV 1993-1-1: pure bending y-y S 235	pure bending y-y S 355	pure compression S 235	pure compression S 355	EN 10025:1993	EN 10113-3:1993	EN 10225:2001
Valeurs statiques / Section properties / Statische Kennwerte		axe fort y-y / strong axis y-y / starke Achse y-y					axe faible z-z / weak axis z-z / schwache Achse z-z															
	kg/m	mm⁴	mm³	mm³	mm	mm²	mm⁴	mm³	mm³	mm	mm	mm⁴	mm⁶	mm	mm							
		x 10^4	x 10^3	x 10^3	x 10	x 10^2	x 10^4	x 10^3	x 10^3	x 10		x 10^4	x 10^9	x 10	x 10							
UAP 80	8,38	107,1	26,78	31,87	3,17	4,51	21,33	7,38	13,64	1,41	17,7	1,90	0,18	1,61	3,17	1	1	1	1	✔		
UAP 100	10,5	209,5	41,90	49,59	3,96	6,07	32,83	9,95	18,47	1,57	19,0	2,65	0,45	1,70	3,38	1	1	1	1	✔		
UAP 130	13,7	459,6	70,70	83,51	5,12	8,52	51,34	13,78	25,55	1,71	21,1	4,15	1,22	1,77	3,56	1	1	1	1	✔		
UAP 150	17,9	796,1	106,1	125,3	5,90	11,28	93,25	20,97	38,78	2,02	23,3	6,51	2,99	2,05	4,15	1	1	1	1	✔		
UAP 175	21,2	1270	145,1	171,5	6,85	13,97	126,4	25,92	47,47	2,16	24,5	8,43	5,62	2,12	4,32	1	1	1	1	✔		
UAP 200	25,1	1946	194,6	230,1	7,80	16,97	169,7	32,13	58,29	2,30	26,2	11,24	9,98	2,22	4,53	1	1	1	1	✔		
UAP 220	28,5	2710	246,4	289,9	8,64	18,83	222,3	39,68	72,56	2,48	27,8	14,40	15,82	2,40	4,94	1	1	1	1	✔		
UAP 250	34,4	4136	330,9	391,8	9,72	23,89	295,4	48,87	87,65	2,60	30,4	20,38	27,43	2,45	5,04	1	1	1	1	✔		
UAP 300	46,0	8170	544,7	639,3	11,81	30,64	562,1	79,88	145,8	3,10	34,9	36,30	75,04	2,96	6,17	1	1	1	1	✔		

- ■ $W_{pl.y}$ est calculé selon l'hypothèse d'un diagramme de contraintes bi-rectangulaire et n'est applicable que si deux ou plusieurs fers U sont associés de façon à constituer une section doublement symétrique pour laquelle un moment de flexion agissant dans le plan du centre de gravité n'engendre pas de torsion.
- ■ $W_{pl.y}$ is determined assuming a bi-rectangular stress block distribution. Thus, the given value applies only if two or more channels are combined in such a way to form a doubly symmetric cross-section so that the bending moment acting in the plane of the centre of gravity will not lead to torsion.
- ■ Für die Berechnung von $W_{pl.y}$ wurde eine doppelrechteckige Spannungsverteilung angenommen. Der angegebene Wert ist daher nur anwendbar, wenn zwei oder mehr U-Profile so miteinander kombiniert sind, dass sie einen doppelsymmetrischen Querschnitt bilden, womit ein Biegemoment, das in der Schwerpunktebene angreift, keine Torsion hervorruft.

Fers U normaux européens

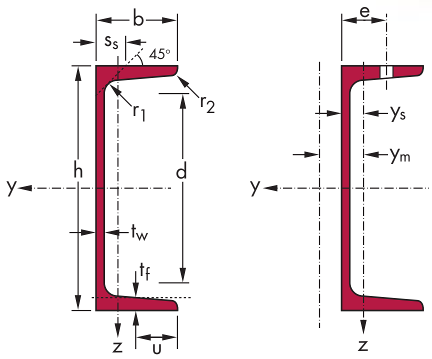
Dimensions: DIN 1026-1: 2000, NF A 45-202 (1983)
Tolérances: EN 10279: 2000
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European standard channels

Dimensions: DIN 1026-1: 2000, NF A 45-202 (1983)
Tolerances: EN 10279: 2000
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Europäische U-Stahl-Normalprofile

Abmessungen: DIN 1026-1: 2000, NF A 45-202 (1983)
Toleranzen: EN 10279: 2000
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung		Dimensions Abmessungen							Dimensions de construction Dimensions for detailing Konstruktionsmaße				Surface Oberfläche	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r_1 mm	r_2 mm	A mm^2	d mm	⌀	e_{min} mm	e_{max} mm	A_L m^2/m	A_G m^2/t
								x 10^2						
UPN 80*	8,65	80	45	6	8	8	4	11,02	47	-	-	-	0,321	37,10
UPN 100*	10,6	100	50	6	8,5	8,5	4,5	13,50	64	-	-	-	0,372	35,10
UPN 120	13,4	120	55	7	9	9	4,5	17,00	82	-	-	-	0,434	32,52
UPN 140	16,0	140	60	7	10	10	5	20,40	98	M 12	33	37	0,489	30,54
UPN 160	18,8	160	65	7,5	10,5	10,5	5,5	24,00	115	M 12	34	42	0,546	28,98
UPN 180	22,0	180	70	8	11	11	5,5	28,00	133	M 16	38	41	0,611	27,80
UPN 200	25,3	200	75	8,5	11,5	11,5	6	32,20	151	M 16	39	46	0,661	26,15
UPN 220	29,4	220	80	9	12,5	12,5	6,5	37,40	167	M 16	40	51	0,718	24,46
UPN 240	33,2	240	85	9,5	13	13	6,5	42,30	184	M 20	46	50	0,775	23,34
UPN 260	37,9	260	90	10	14	14	7	48,30	200	M 22	50	52	0,834	22,00
UPN 280	41,8	280	95	10	15	15	7,5	53,30	216	M 22	52	57	0,890	21,27
UPN 300	46,2	300	100	10	16	16	8	58,80	232	M 24	55	59	0,950	20,58
UPN 320*	59,5	320	100	14	17,5	17,5	8,75	75,80	246	M 22	58	62	0,982	16,50
UPN 350	60,6	350	100	14	16	16	8	77,30	282	M 22	56	62	1,047	17,25
UPN 380*	63,1	380	102	13,5	16	16	8	80,40	313	M 24	59	60	1,110	17,59
UPN 400*	71,8	400	110	14	18	18	9	91,50	324	M 27	61	62	1,182	16,46

	h ≤ 300	h > 300
u	$\frac{b}{2}$	$\frac{b - t_w}{2}$
Inclinaison des ailes Flange slope Flanschneigung	8%	5%

* Tonnage minimum et conditions de livraison nécessitent un accord préalable.
* Minimum tonnage and delivery conditions upon agreement.
* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

UPN

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte														Classification ENV 1993-1-1				EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		axe fort y-y strong axis y-y starke Achse y-y					axe faible z-z weak axis z-z schwache Achse z-z									pure bending y-y		pure compression				
	G kg/m	I_y mm⁴	$W_{el.y}$ mm³	$W_{pl.y}$■ mm³	i_y mm	A_{vz} mm²	I_z mm⁴	$W_{el.z}$ mm³	$W_{pl.z'}$ mm³	i_z mm	s_s mm	I_t mm⁴	I_w mm⁶	y_s mm	y_m mm	S 235	S 355	S 235	S 355			
		$x\ 10^4$	$x\ 10^3$	$x\ 10^3$	x 10	$x\ 10^2$	$x\ 10^4$	$x\ 10^3$	$x\ 10^3$	x 10		$x\ 10^4$	$x\ 10^9$	x 10	x 10							
UPN 80	8,65	106	26,6	32,3	3,10	4,90	19,4	6,38	11,9	1,33	19,4	2,20	0,18	1,42	2,65	1	1	1	1	✔		
UPN 100	10,6	206	41,2	49,0	3,91	6,46	29,3	8,49	16,2	1,47	20,3	2,81	0,41	1,55	2,93	1	1	1	1	✔	✔	✔
UPN 120	13,4	364	60,7	72,6	4,62	8,80	43,2	11,1	21,2	1,59	22,2	4,15	0,90	1,60	3,03	1	1	1	1	✔	✔	✔
UPN 140	16,0	605	86,4	103	5,45	10,41	62,7	14,8	28,3	1,75	23,9	5,68	1,80	1,75	3,37	1	1	1	1	✔	✔	✔
UPN 160	18,8	925	116	138	6,21	12,60	85,3	18,3	35,2	1,89	25,3	7,39	3,26	1,84	3,56	1	1	1	1	✔	✔	✔
UPN 180	22,0	1350	150	179	6,95	15,09	114	22,4	42,9	2,02	26,7	9,55	5,57	1,92	3,75	1	1	1	1	✔	✔	✔
UPN 200	25,3	1910	191	228	7,70	17,71	148	27,0	51,8	2,14	28,1	11,9	9,07	2,01	3,94	1	1	1	1	✔	✔	✔
UPN 220	29,4	2690	245	292	8,48	20,62	197	33,6	64,1	2,30	30,3	16,0	14,6	2,14	4,20	1	1	1	1	✔	✔	✔
UPN 240	33,2	3600	300	358	9,22	23,71	248	39,6	75,7	2,42	31,7	19,7	22,1	2,23	4,39	1	1	1	1	✔	✔	✔
UPN 260	37,9	4820	371	442	9,99	27,12	317	47,7	91,6	2,56	33,9	25,5	33,3	2,36	4,66	1	1	1	1	✔	✔	✔
UPN 280	41,8	6280	448	532	10,9	29,28	399	57,2	109	2,74	35,6	31,0	48,5	2,53	5,02	1	1	1	1	✔	✔	✔
UPN 300	46,2	8030	535	632	11,7	31,77	495	67,8	130	2,90	37,3	37,4	69,1	2,70	5,41	1	1	1	1	✔	✔	✔
UPN 320	59,5	10870	679	826	12,1	47,11	597	80,6	152	2,81	43,0	66,7	96,1	2,60	4,82	1	1	1	1	✔		
UPN 350	60,6	12840	734	918	12,9	50,84	570	75,0	143	2,72	40,7	61,2	114	2,40	4,45	1	1	1	1	✔	✔	✔
UPN 380	63,1	15760	829	1014	14,0	53,23	615	78,7	148	2,77	40,3	59,1	146	2,38	4,58	1	1	1	1	✔		
UPN 400	71,8	20350	1020	1240	14,9	58,55	846	102	190	3,04	44,0	81,6	221	2,65	5,11	1	1	1	1	✔		

- ■ $W_{pl.y}$ est calculé selon l'hypothèse d'un diagramme de contraintes bi-rectangulaire et n'est applicable que si deux ou plusieurs fers U sont associés de façon à constituer une section doublement symétrique pour laquelle un moment de flexion agissant dans le plan du centre de gravité n'engendre pas de torsion.
- ■ $W_{pl.y}$ is determined assuming a bi-rectangular stress block distribution. Thus, the given value applies only if two or more channels are combined in such a way to form a doubly symmetric cross-section so that the bending moment acting in the plane of the centre of gravity will not lead to torsion.
- ■ Für die Berechnung von $W_{pl.y}$ wurde eine doppelrechteckige Spannungsverteilung angenommen. Der angegebene Wert ist daher nur anwendbar, wenn zwei oder mehr U-Profile so miteinander kombiniert sind, dass sie einen doppelsymmetrischen Querschnitt bilden, womit ein Biegemoment, das in der Schwerpunktebene angreift, keine Torsion hervorruft.

Fers U à ailes inclinées

Tolérances EN 10279: 2000

Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

European channels with taper flanges

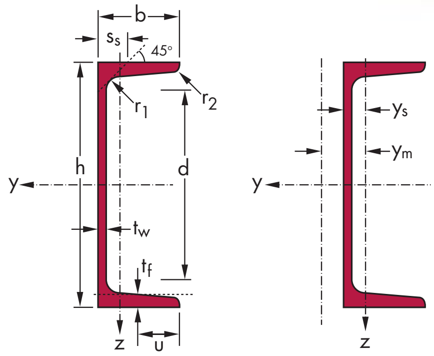
Tolerances: EN 10279: 2000

Surface condition according to EN 10163-3: 1991, class C, subclass 1

U-Profile mit geneigten inneren Flanschflächen

Toleranzen: EN 10279: 2000

Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung		Dimensions Abmessungen								Surface Oberfläche	
	G kg/m	h mm	b mm	t_w mm	t_f mm	r_1 mm	r_2 mm	d mm	A mm^2	A_L m^2/m	A_G m^2/t
									x 10^2		
U 40 x 20*	2,87	40	20	5	5,5	5	2,5	19	3,66	0,150	51,20
U 50 x 25*	3,86	50	25	5	6	6	3	26	4,92	0,180	48,22
U 60 x 30*	5,07	60	30	6	6	6	3	36	6,46	0,220	44,06
U 65 x 42*	7,09	65	42	5,5	7,5	7,5	4	34	9,03	0,280	39,58

* Tonnage minimum et conditions de livraison nécessitent un accord préalable.

* Minimum tonnage and delivery conditions upon agreement.

* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

U

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation / Designation / Bezeichnung	G	I_y	$W_{el.y}$	$W_{pl.y}$■	i_y	A_{vz}	I_z	$W_{el.z}$	$W_{pl.z'}$	i_z	s_s	I_t	I_w	y_s	y_m	Classification ENV 1993-1-1: pure bending y-y S 235	pure bending y-y S 355	pure compression S 235	pure compression S 355	EN 10025:1993	EN 10113-3:1993	EN 10225:2001
	Valeurs statiques / Section properties / Statische Kennwerte:	axe fort y-y / strong axis y-y / starke Achse y-y					axe faible z-z / weak axis z-z / schwache Achse z-z															
	kg/m	mm^4	mm^3	mm^3	mm	mm^2	mm^4	mm^3	mm^3	mm	mm	mm^4	mm^6	mm	mm							
		x 10^4	x 10^3	x 10^3	x 10	x 10^2	x 10^4	x 10^3	x 10^3	x 10		x 10^4	x 10^9	x 10	x 10							
U 40 x 20	2,87	7,62	3,81	4,91	1,44	1,96	1,15	0,86	1,65	0,56	13,4	0,39	0,003	0,67	1,03	1	1	1	1	✔		
U 50 x 25	3,86	16,9	6,76	8,52	1,85	2,52	2,50	1,48	2,84	0,71	14,6	0,59	0,009	0,81	1,36	1	1	1	1	✔		
U 60 x 30	5,07	31,7	10,56	13,3	2,21	3,54	4,53	2,16	4,19	0,84	15,8	0,89	0,024	0,90	1,52	1	1	1	1	✔		
U 65 x 42	7,09	57,7	17,77	21,7	2,53	3,68	14,1	5,06	9,38	1,25	18,0	1,61	0,082	1,39	2,58	1	1	1	1	✔		

■ $W_{pl.y}$ est calculé selon l'hypothèse d'un diagramme de contraintes bi-rectangulaire et n'est applicable que si deux ou plusieurs fers U sont associés de façon à constituer une section doublement symétrique pour laquelle un moment de flexion agissant dans le plan du centre de gravité n'engendre pas de torsion.

■ $W_{pl.y}$ is determined assuming a bi-rectangular stress block distribution. Thus, the given value applies only if two or more channels are combined in such a way to form a doubly symmetric cross-section so that the bending moment acting in the plane of the centre of gravity will not lead to torsion.

■ Für die Berechnung von $W_{pl.y}$ wurde eine doppelrechteckige Spannungsverteilung angenommen. Der angegebene Wert ist daher nur anwendbar, wenn zwei oder mehr U-Profile so miteinander kombiniert sind, dass sie einen doppelsymmetrischen Querschnitt bilden, womit ein Biegemoment, das in der Schwerpunktebene angreift, keine Torsion hervorruft.

Cornières à ailes égales▾

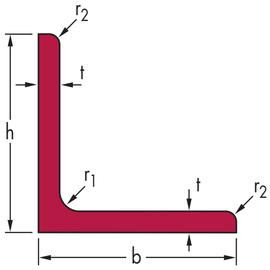
Dimensions: EN 10056-1: 1998
Tolérances: EN 10056-2: 1994
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

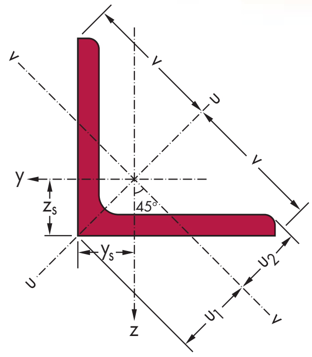
Equal leg angles▾

Dimensions: EN 10056-1: 1998
Tolerances: EN 10056-2: 1994
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Gleichschenkliger Winkelstahl▾

Abmessungen: EN 10056-1: 1998
Toleranzen: EN 10056-2: 1994
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1





Désignation Designation Bezeichnung	Dimensions Abmessungen					Position des axes Position of axes Lage der Achsen				Surface Oberfläche	
G kg/m	h = b mm	t mm	r_1 mm	r_2 mm	A mm^2	$z_s = y_s$ mm	v mm	u_1 mm	u_2 mm	A_L m^2/m	A_G m^2/t
					x 10^2	x 10	x 10	x 10	x 10		
L 20 x 20 x 3- 0,882	20	3	3,5	2	1,12	0,60	1,41	0,84	0,70	0,080	87,40
L 25 x 25 x 3×/- 1,12	25	3	3,5	2	1,42	0,72	1,77	1,02	0,88	0,100	86,88
L 25 x 25 x 4×/- 1,45	25	4	3,5	2	1,85	0,76	1,77	1,08	0,89	0,100	66,67
L 30 x 30 x 3×/- 1,36	30	3	5	2,5	1,74	0,84	2,12	1,18	1,05	0,120	84,87
L 30 x 30 x 4×/- 1,78	30	4	5	2,5	2,27	0,88	2,12	1,24	1,06	0,120	65,02
L 35 x 35 x 4×/- 2,09	35	4	5	2,5	2,67	1,00	2,47	1,42	1,24	0,140	64,82
L 40 x 40 x 4×/- 2,42	40	4	6	3	3,08	1,12	2,83	1,58	1,40	0,150	64,07
L 40 x 40 x 5×/- 2,97	40	5	6	3	3,79	1,16	2,83	1,64	1,41	0,150	52,07
L 45 x 45 x 4,5×/- 3,06	45	4,5	7	3,5	3,90	1,26	3,18	1,78	1,58	0,170	56,83
L 50 x 50 x 4×/- 3,06	50	4	7	3,5	3,89	1,36	3,54	1,92	1,75	0,190	63,49
L 50 x 50 x 5×/- 3,77	50	5	7	3,5	4,80	1,40	3,54	1,99	1,76	0,190	51,46
L 50 x 50 x 6×/- 4,47	50	6	7	3,5	5,69	1,45	3,54	2,04	1,77	0,190	43,41
L 60 x 60 x 5×/- 4,57	60	5	8	4	5,82	1,64	4,24	2,32	2,11	0,230	51,04
L 60 x 60 x 6×/- 5,42	60	6	8	4	6,91	1,69	4,24	2,39	2,11	0,230	42,99
L 60 x 60 x 8×/- 7,09	60	8	8	4	9,03	1,77	4,24	2,50	2,14	0,230	32,89
L 65 x 65 x 7- 6,83	65	7	9	4,5	8,70	1,85	4,60	2,61	2,29	0,250	36,95
L 70 x 70 x 6- 6,38	70	6	9	4,5	8,13	1,93	4,95	2,73	2,46	0,270	42,68
L 70 x 70 x 7- 7,38	70	7	9	4,5	9,40	1,97	4,95	2,79	2,47	0,270	36,91
L 75 x 75 x 6- 6,85	75	6	10	5	8,73	2,04	5,30	2,89	2,63	0,290	42,44
L 75 x 75 x 8- 8,99	75	8	10	5	11,4	2,13	5,30	3,01	2,65	0,290	32,37

▾ Autres dimensions sur demande. Le rayon r_2 peut être inférieur en fonction du procédé de laminage.
× Avec arêtes vives sur commande.
\- Profilé conforme à EN 10056-1: 1998.

▾ Other dimensions on request. The r_2 radius may be smaller depending on the rolling process.
× Available with sharp edges.
\- Section in accordance with EN 10056-1: 1998.

▾ Andere Abmessungen auf Anfrage. Der Radius r_2 kann je nach Walzprozess kleiner sein.
× Auch mit scharfen Kanten erhältlich.
\- Profil gemäß EN 10056-1: 1998.

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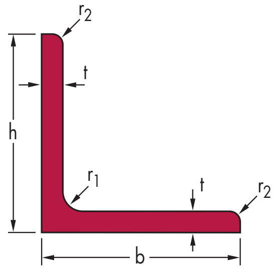
Notations pages 211-215 / Bezeichnungen Seiten 211-215

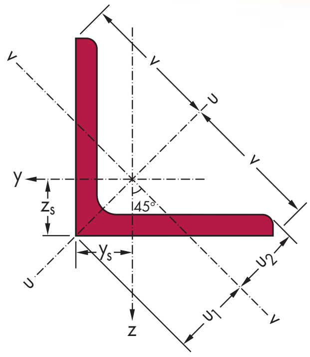
Désignation Designation Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte								Classification ENV 1993-1-1				
		axe y-y / axe z-z axis y-y / axis z-z Achse y-y / Achse z-z			axe u-u axis u-u Achse u-u		axe v-v axis v-v Achse v-v			pure compression		EN 10025:1993	EN 10113-3:1993	EN 10225:2001
	G kg/m	$I_y = I_z$ mm^4	$W_{el.y} = W_{el.z}$ mm^3	$i_y = i_y$ mm	I_u mm^4	i_u mm	I_v mm^4	i_v mm	I_{yz} mm^4	S 235	S 355			
		x 10^4	x 10^3	x 10	x 10^4	x 10	x 10^4	x 10	x 10^4					
L 20 x 20 x 3	0,882	0,39	0,28	0,59	0,61	0,74	0,16	0,38	-0,23	1	1	✔		
L 25 x 25 x 3	1,12	0,80	0,45	0,75	1,26	0,94	0,33	0,48	-0,47	1	2	✔		
L 25 x 25 x 4	1,45	1,01	0,58	0,74	1,60	0,93	0,43	0,48	-0,59	1	1	✔		
L 30 x 30 x 3	1,36	1,40	0,65	0,90	2,23	1,13	0,58	0,58	-0,83	1	4	✔		
L 30 x 30 x 4	1,78	1,80	0,85	0,89	2,86	1,12	0,75	0,57	-1,05	1	1	✔		
L 35 x 35 x 4	2,09	2,95	1,18	1,05	4,69	1,33	1,22	0,68	-1,73	1	2	✔		
L 40 x 40 x 4	2,42	4,47	1,55	1,21	7,10	1,52	1,84	0,77	-2,63	1	4	✔		
L 40 x 40 x 5	2,97	5,43	1,91	1,20	8,61	1,51	2,25	0,77	-3,18	1	1	✔		
L 45 x 45 x 4,5	3,06	7,15	2,20	1,35	11,35	1,71	2,94	0,87	-4,20	1	4	✔		
L 50 x 50 x 4	3,06	8,97	2,46	1,52	14,25	1,91	3,69	0,97	-5,28	4	4	✔		
L 50 x 50 x 5	3,77	10,96	3,05	1,51	17,42	1,90	4,51	0,97	-6,45	1	4	✔		
L 50 x 50 x 6	4,47	12,84	3,61	1,50	20,37	1,89	5,31	0,97	-7,53	1	2	✔		
L 60 x 60 x 5	4,57	19,37	4,45	1,82	30,78	2,30	7,97	1,17	-11,41	4	4	✔		
L 60 x 60 x 6	5,42	22,79	5,29	1,82	36,21	2,29	9,38	1,17	-13,41	1	4	✔		
L 60 x 60 x 8	7,09	29,15	6,89	1,80	46,20	2,26	12,11	1,16	-17,04	1	1	✔		
L 65 x 65 x 7	6,83	33,43	7,18	1,96	53,09	2,47	13,78	1,26	-19,65	1	3	✔		
L 70 x 70 x 6	6,38	36,88	7,27	2,13	58,61	2,69	15,16	1,37	-21,73	4	4	✔		
L 70 x 70 x 7	7,38	42,30	8,41	2,12	67,19	2,67	17,40	1,36	-24,90	1	4	✔		
L 75 x 75 x 6	6,85	45,57	8,35	2,28	72,40	2,88	18,74	1,46	-26,83	4	4	✔		
L 75 x 75 x 8	8,99	58,87	10,96	2,27	93,49	2,86	24,25	1,45	-34,62	1	4	✔		

Cornières à ailes égales▾ (suite)
Dimensions: EN 10056-1: 1998
Tolérances: EN 10056-2: 1994
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Equal leg angles▾ (continued)
Dimensions: EN 10056-1: 1998
Tolerances: EN 10056-2: 1994
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Gleichschenkliger Winkelstahl▾ (Fortsetzung)
Abmessungen: EN 10056-1: 1998
Toleranzen: EN 10056-2: 1994
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1





Désignation Designation Bezeichnung	G kg/m	Dimensions Abmessungen h = b mm	t mm	r_1 mm	r_2 mm	A mm²	Position des axes Position of axes Lage der Achsen $z_s = y_s$ mm	v mm	u_1 mm	u_2 mm	Surface Oberfläche A_L m²/m	A_G m²/t
						x 10²	x 10	x 10	x 10	x 10		
L 80 x 80 x 8-	9,63	80	8	10	5	12,3	2,26	5,66	3,19	2,83	0,310	32,34
L 80 x 80 x 10-	11,9	80	10	10	5	15,1	2,34	5,66	3,30	2,85	0,310	26,26
L 90 x 90 x 7-	9,61	90	7	11	5,5	12,2	2,45	6,36	3,47	3,16	0,350	36,48
L 90 x 90 x 8-	10,9	90	8	11	5,5	13,9	2,50	6,36	3,53	3,17	0,350	32,15
L 90 x 90 x 9-	12,2	90	9	11	5,5	15,5	2,54	6,36	3,59	3,18	0,350	28,77
L 90 x 90 x 10-	13,4	90	10	11	5,5	17,1	2,58	6,36	3,65	3,19	0,350	26,07
L 100 x 100 x 8*/+/-	12,2	100	8	12	6	15,5	2,74	7,07	3,87	3,52	0,390	32,00
L 100 x 100 x 10*/+/-	15,0	100	10	12	6	19,2	2,82	7,07	3,99	3,54	0,390	25,92
L 100 x 100 x 12*/+/-	17,8	100	12	12	6	22,7	2,90	7,07	4,11	3,57	0,390	21,86
L 110 x 110 x 10*/+	16,6	110	10	13	6,5	21,2	3,06	7,78	4,33	3,88	0,429	25,79
L 110 x 110 x 12*	19,7	110	12	13	6,5	25,1	3,15	7,78	4,45	3,91	0,429	21,73
L 120 x 120 x 10-	18,2	120	10	13	6,5	23,2	3,31	8,49	4,69	4,24	0,469	25,76
L 120 x 120 x 11	19,9	120	11	13	6,5	25,4	3,36	8,49	4,75	4,25	0,469	23,54
L 120 x 120 x 12-	21,6	120	12	13	6,5	27,5	3,40	8,49	4,80	4,26	0,469	21,69
L 120 x 120 x 13	23,3	120	13	13	6,5	29,7	3,44	8,49	4,86	4,28	0,469	20,12
L 120 x 120 x 15	26,6	120	15	13	6,5	33,9	3,51	8,49	4,97	4,31	0,469	17,60
L 130 x 130 x 12-/*	23,6	130	12	14	7	30,0	3,64	9,19	5,15	4,60	0,508	21,59
L 140 x 140 x 10*	21,4	140	10	15	7,5	27,2	3,79	9,90	5,37	4,93	0,547	25,59
L 140 x 140 x 13*	27,4	140	13	15	7,5	35,0	3,92	9,90	5,55	4,96	0,547	19,94

▾ Autres dimensions sur demande. Le rayon r_2 peut être inférieur en fonction du procédé de laminage.
\- Profilé conforme à EN 10056-1: 1998.
* Tonnage minimum et conditions de livraison nécessitent un accord préalable.
\+ Commande minimale: 40 t par profilé et qualité ou suivant accord.

▾ Other dimensions on request. The r_2 radius may be smaller depending on the rolling process.
\- Section in accordance with EN 10056-1: 1998.
* Minimum tonnage and delivery conditions upon agreement.
\+ Minimum order: 40 t per section and grade or upon agreement.

▾ Andere Abmessungen auf Anfrage. Der Radius r_2 kann je nach Walzprozess kleiner
\- Profil gemäß EN 10056-1: 1998.
* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.
\+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.

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Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte								Classification ENV 1993-1-1				
		axe y-y / axe z-z axis y-y / axis z-z Achse y-y / Achse z-z			axe u-u axis u-u Achse u-u		axe v-v axis v-v Achse v-v			pure compression				
	G kg/m	$I_y = I_z$ mm⁴	$W_{el.y} = W_{el.z}$ mm³	$i_y = i_y$ mm	I_u mm⁴	i_u mm	I_v mm⁴	i_v mm	I_{yz} mm⁴	S 235	S 355	EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		$x\ 10^4$	$x\ 10^3$	x 10	$x\ 10^4$	x 10	$x\ 10^4$	x 10	$x\ 10^4$					
L 80 x 80 x 8	9,63	72,25	12,58	2,43	114,8	3,06	29,72	1,56	-42,53	1	4	✔		
L 80 x 80 x 10	11,9	87,50	15,45	2,41	138,8	3,03	36,23	1,55	-51,27	1	1	✔		
L 90 x 90 x 7	9,61	92,55	14,13	2,75	147,1	3,47	38,02	1,76	-54,53	4	4	✔		
L 90 x 90 x 8	10,9	104,4	16,05	2,74	165,9	3,46	42,87	1,76	-61,51	3	4	✔		
L 90 x 90 x 9	12,2	115,8	17,93	2,73	184,0	3,44	47,63	1,75	-68,20	1	4	✔		
L 90 x 90 x 10	13,4	126,9	19,77	2,72	201,5	3,43	52,32	1,75	-74,60	1	3	✔		
L 100 x 100 x 8	12,2	144,8	19,94	3,06	230,2	3,85	59,47	1,96	-85,37	4	4	✔		
L 100 x 100 x 10	15,0	176,7	24,62	3,04	280,7	3,83	72,65	1,95	-104,0	1	4	✔		
L 100 x 100 x 12	17,8	206,7	29,12	3,02	328,0	3,80	85,42	1,94	-121,3	1	2	✔		
L 110 x 110 x 10	16,6	238,0	29,99	3,35	378,2	4,23	97,72	2,15	-140,3	2	4	✔		
L 110 x 110 x 12	19,7	279,1	35,54	3,33	443,3	4,20	115,0	2,14	-164,1	1	3	✔		
L 120 x 120 x 10	18,2	312,9	36,03	3,67	497,6	4,63	128,3	2,35	-184,6	4	4	✔		
L 120 x 120 x 11	19,9	340,6	39,41	3,66	541,5	4,62	139,8	2,35	-200,9	2	4	✔		
L 120 x 120 x 12	21,6	367,7	42,73	3,65	584,3	4,61	151,0	2,34	-216,6	1	4	✔		
L 120 x 120 x 13	23,3	394,0	46,01	3,64	625,9	4,59	162,2	2,34	-231,8	1	3	✔		
L 120 x 120 x 15	26,6	444,9	52,43	3,62	705,6	4,56	184,2	2,33	-260,7	1	1	✔		
L 130 x 130 x 12	23,6	472,2	50,44	3,97	750,6	5,00	193,7	2,54	-278,5	2	4	✔		
L 140 x 140 x 10	21,4	504,4	49,43	4,30	802,0	5,43	206,8	2,76	-297,6	4	4	✔		
L 140 x 140 x 13	27,4	638,5	63,37	4,27	1015	5,39	262,0	2,74	-376,6	2	4	✔		

Cornières à ailes égales▼ (suite)

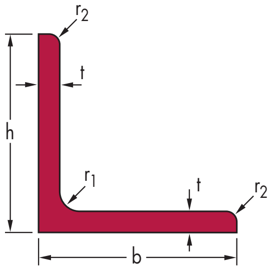
Dimensions: EN 10056-1: 1998
Tolérances: EN 10056-2: 1994
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

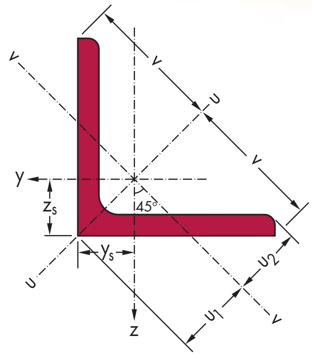
Equal leg angles▼ (continued)

Dimensions: EN 10056-1: 1998
Tolerances: EN 10056-2: 1994
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Gleichschenkliger Winkelstahl▼ (Fortsetzung)

Abmessungen: EN 10056-1: 1998
Toleranzen: EN 10056-2: 1994
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1





Désignation Designation Bezeichnung		Dimensions Abmessungen					Position des axes Position of axes Lage der Achsen				Surface Oberfläche	
	G kg/m	h = b mm	t mm	r_1 mm	r_2 mm	A mm^2	$z_s = y_s$ mm	v mm	u_1 mm	u_2 mm	A_L m^2/m	A_G m^2/t
						x 10^2	x 10	x 10	x 10	x 10		
L 150 x 150 x 10[-/+]	23,0	150	10	16	8	29,3	4,03	10,61	5,71	5,28	0,586	25,51
L 150 x 150 x 12[-/+]	27,3	150	12	16	8	34,8	4,12	10,61	5,83	5,29	0,586	21,44
L 150 x 150 x 14[+]	31,6	150	14	16	8	40,3	4,21	10,61	5,95	5,32	0,586	18,53
L 150 x 150 x 15[-/+]	33,8	150	15	16	8	43,0	4,25	10,61	6,01	5,33	0,586	17,36
L 150 x 150 x 18[+]	40,1	150	18	16	8	51,0	4,37	10,61	6,17	5,37	0,586	14,63
L 160 x 160 x 14[+]	33,9	160	14	17	8,5	43,2	4,45	11,31	6,29	5,66	0,625	18,46
L 160 x 160 x 15[-/+]	36,2	160	15	17	8,5	46,1	4,49	11,31	6,35	5,67	0,625	17,30
L 160 x 160 x 16[+]	38,4	160	16	17	8,5	49,0	4,53	11,31	6,41	5,69	0,625	16,28
L 160 x 160 x 17[+]	40,7	160	17	17	8,5	51,8	4,57	11,31	6,46	5,70	0,625	15,37
L 180 x 180 x 13[+]	35,7	180	13	18	9	45,5	4,90	12,73	6,93	6,35	0,705	19,74
L 180 x 180 x 14[+]	38,3	180	14	18	9	48,8	4,94	12,73	6,99	6,36	0,705	18,40
L 180 x 180 x 15[+]	40,9	180	15	18	9	52,1	4,98	12,73	7,05	6,37	0,705	17,23
L 180 x 180 x 16[-/+]	43,5	180	16	18	9	55,4	5,02	12,73	7,10	6,38	0,705	16,20
L 180 x 180 x 17[+]	46,0	180	17	18	9	58,7	5,06	12,73	7,16	6,40	0,705	15,30
L 180 x 180 x 18[-/+]	48,6	180	18	18	9	61,9	5,10	12,73	7,22	6,41	0,705	14,50
L 180 x 180 x 19[+]	51,1	180	19	18	9	65,1	5,14	12,73	7,27	6,42	0,705	13,78
L 180 x 180 x 20[+]	53,7	180	20	18	9	68,4	5,18	12,73	7,33	6,44	0,705	13,13

▼ Autres dimensions sur demande. Le rayon r_2 peut être inférieur en fonction du procédé de laminage.
\- Profilé conforme à EN 10056-1: 1998.
\+ Commande minimale: 40 t par profilé et qualité ou suivant accord.

▼ Other dimensions on request. The r_2 radius may be smaller depending on the rolling process.
\- Section in accordance with EN 10056-1: 1998.
\+ Minimum order: 40 t per section and grade or upon agreement.

▼ Andere Abmessungen auf Anfrage. Der Radius r_2 kann je nach Walzprozess kleiner sein.
\- Profil gemäß EN 10056-1: 1998.
\+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.

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Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte								Classification ENV 1993-1-1				
		axe y-y / axe z-z axis y-y / axis z-z Achse y-y / Achse z-z			axe u-u axis u-u Achse u-u		axe v-v axis v-v Achse v-v			pure compression				
	G kg/m	$I_y = I_z$ mm^4	$W_{el.y} = W_{el.z}$ mm^3	$i_y = i_y$ mm	I_u mm^4	i_u mm	I_v mm^4	i_v mm	I_{yz} mm^4	S 235	S 355	EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		x 10^4	x 10^3	x 10	x 10^4	x 10	x 10^4	x 10	x 10^4					
L 150 x 150 x 10	23,0	624,0	56,91	4,62	992,0	5,82	256,0	2,96	-368,0	4	4	✔		
L 150 x 150 x 12	27,3	736,9	67,75	4,60	1172	5,80	302,0	2,94	-434,9	4	4	✔		
L 150 x 150 x 14	31,6	845,4	78,33	4,58	1344	5,77	346,9	2,93	-498,5	2	4	✔		
L 150 x 150 x 15	33,8	898,1	83,52	4,57	1427	5,76	368,9	2,93	-529,1	1	4	✔		
L 150 x 150 x 18	40,1	1050	98,74	4,54	1666	5,71	433,8	2,92	-616,2	1	2	✔		
L 160 x 160 x 14	33,9	1034	89,50	4,89	1644	6,17	423,8	3,13	-610,0	3	4	✔		
L 160 x 160 x 15	36,2	1099	95,50	4,88	1747	6,16	450,8	3,13	-648,0	2	4	✔		
L 160 x 160 x 16	38,4	1163	101,4	4,87	1848	6,14	477,6	3,12	-685,1	1	4	✔		
L 160 x 160 x 17	40,7	1225	107,2	4,86	1947	6,13	504,1	3,12	-721,3	1	4	✔		
L 180 x 180 x 13	35,7	1396	106,5	5,54	2221	6,99	571,6	3,55	-824,5	4	4	✔		
L 180 x 180 x 14	38,3	1493	114,3	5,53	2375	6,98	611,3	3,54	-882,0	4	4	✔		
L 180 x 180 x 15	40,9	1589	122,0	5,52	2527	6,96	650,5	3,53	-938,0	4	4	✔		
L 180 x 180 x 16	43,5	1682	129,7	5,51	2675	6,95	689,4	3,53	-993,0	3	4	✔		
L 180 x 180 x 17	46,0	1775	137,2	5,50	2822	6,94	727,8	3,52	-1047	2	4	✔		
L 180 x 180 x 18	48,6	1866	144,7	5,49	2965	6,92	766,0	3,52	-1100	1	4	✔		
L 180 x 180 x 19	51,1	1955	152,1	5,48	3106	6,91	803,8	3,51	-1151	1	4	✔		
L 180 x 180 x 20	53,7	2043	159,4	5,47	3244	6,89	841,3	3,51	-1202	1	3	✔		

Cornières à ailes égales▾ (suite)

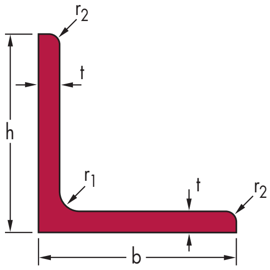
Dimensions: EN 10056-1: 1998 / ASTM A6/A6M - 02‹
Tolérances: EN 10056-2: 1994
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

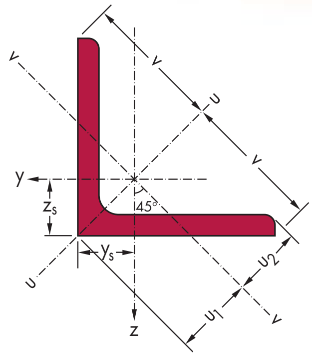
Equal leg angles▾ (continued)

Dimensions: EN 10056-1: 1998 / ASTM A6/A6M - 02‹
Tolerances: EN 10056-2: 1994
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Gleichschenkliger Winkelstahl▾ (Fortsetzung)

Abmessungen: EN 10056-1: 1998 / ASTM A6/A6M - 02‹
Toleranzen: EN 10056-2: 1994
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1





Désignation Designation Bezeichnung	Dimensions Abmessungen					Position des axes Position of axes Lage der Achsen				Surface Oberfläche	
G kg/m	h = b mm	t mm	r_1 mm	r_2 mm	A mm^2	$z_s = y_s$ mm	v mm	u_1 mm	u_2 mm	A_L m^2/m	A_G m^2/t
					x 10^2	x 10	x 10	x 10	x 10		
L 200 x 200 x 15+ 45,6	200	15	18	9	58,1	5,48	14,14	7,75	7,08	0,785	17,20
L 200 x 200 x 16-/+ 48,5	200	16	18	9	61,8	5,52	14,14	7,81	7,09	0,785	16,18
L 200 x 200 x 17+ 51,4	200	17	18	9	65,5	5,56	14,14	7,87	7,10	0,785	15,27
L 200 x 200 x 18-/+ 54,3	200	18	18	9	69,1	5,60	14,14	7,93	7,12	0,785	14,46
L 200 x 200 x 19+ 57,1	200	19	18	9	72,7	5,64	14,14	7,98	7,13	0,785	13,74
L 200 x 200 x 20-/+ 59,9	200	20	18	9	76,3	5,68	14,14	8,04	7,15	0,785	13,09
L 200 x 200 x 21+ 62,8	200	21	18	9	79,9	5,72	14,14	8,09	7,16	0,785	12,50
L 200 x 200 x 22+ 65,6	200	22	18	9	83,5	5,76	14,14	8,15	7,18	0,785	11,97
L 200 x 200 x 23+ 68,3	200	23	18	9	87,1	5,80	14,14	8,20	7,19	0,785	11,48
L 200 x 200 x 24-/+ 71,1	200	24	18	9	91,0	5,84	14,14	8,26	7,21	0,785	11,03
L 200 x 200 x 25+ 73,9	200	25	18	9	94,1	5,88	14,14	8,31	7,23	0,785	10,62
L 200 x 200 x 26+ 76,6	200	26	18	9	97,6	5,91	14,14	8,36	7,25	0,785	10,24
L 250 x 250 x 20+ 75,6	250	20	18	9	96,4	6,93	17,68	9,81	8,91	0,985	13,02
L 250 x 250 x 21+ 79,2	250	21	18	9	101	6,97	17,68	9,86	8,93	0,985	12,43
L 250 x 250 x 22+ 82,8	250	22	18	9	106	7,01	17,68	9,92	8,94	0,985	11,89
L 250 x 250 x 23+ 86,4	250	23	18	9	110	7,05	17,68	9,97	8,96	0,985	11,40
L 250 x 250 x 24+ 90,0	250	24	18	9	115	7,09	17,68	10,03	8,98	0,985	10,95
L 250 x 250 x 25+ 93,5	250	25	18	9	119	7,13	17,68	10,08	8,99	0,985	10,53
L 250 x 250 x 26+ 97,0	250	26	18	9	124	7,17	17,68	10,13	9,01	0,985	10,15
L 250 x 250 x 27+ 101	250	27	18	9	128	7,20	17,68	10,19	9,03	0,985	9,79
L 250 x 250 x 28-/+ 104	250	28	18	9	133	7,24	17,68	10,24	9,04	0,985	9,47
L 250 x 250 x 35-/+ 128	250	35	18	9	163	7,50	17,68	10,61	9,17	0,985	7,69
L 203 x 203 x 19‹/+ 57,9	203	19	8	4	73,6	5,76	14,35	8,15	7,38	0,805	13,94
L 203 x 203 x 22,2‹/+ 67,0	203	22,2	8	4	85,0	5,88	14,35	8,32	7,44	0,805	12,03
L 203 x 203 x 25,4‹/+ 75,9	203	25,4	8	4	96,8	6,00	14,35	8,48	7,50	0,805	10,60
L 203 x 203 x 28,6‹/+ 84,7	203	28,6	8	4	108	6,11	14,35	8,65	7,57	0,805	9,50

▾ Autres dimensions sur demande. Le rayon r_2 peut être inférieur en fonction du procédé de laminage.
\+ Commande minimale: 40 t par profilé et qualité ou suivant accord.
\- Profilé conforme à EN 10056-1: 1998.
‹ Profilé conforme à ASTM A6/A6M - 02.

▾ Other dimensions on request. The r_2 radius may be smaller depending on the rolling process.
\+ Minimum order: 40 t per section and grade or upon agreement.
\- Section in accordance with EN 10056-1: 1998.
‹ Section in accordance with ASTM A6/A6M - 02.

▾ Andere Abmessungen auf Anfrage. Der Radius r_2 kann je nach Walzprozess kleiner sein.
\+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.
\- Profil gemäß EN 10056-1: 1998.
‹ Profil gemäß ASTM A6/A6M - 02.

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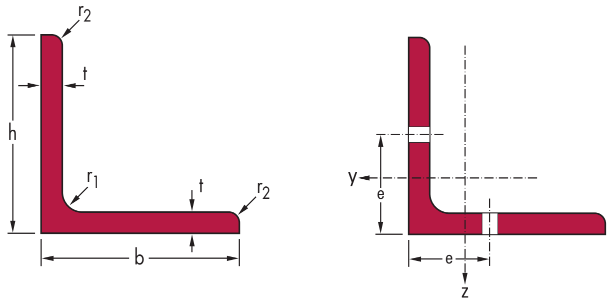
Désignation Designation Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte								Classification ENV 1993-1-1		EN 10025:1993	EN 10113-3:1993	EN 10225:2001
		axe y-y / axe z-z axis y-y / axis z-z Achse y-y / Achse z-z			axe u-u axis u-u Achse u-u		axe v-v axis v-v Achse v-v			pure compression				
	G kg/m	$I_y = I_z$ mm⁴	$W_{el.y} = W_{el.z}$ mm³	$i_y = i_y$ mm	I_u mm⁴	i_u mm	I_v mm⁴	i_v mm	I_{yz} mm⁴	S 235	S 355			
		x 10^4	x 10^3	x 10	x 10^4	x 10	x 10^4	x 10	x 10^4					
L 200 x 200 x 15	45,6	2209	152,2	6,17	3516	7,78	903,0	3,94	-1306	4	4	✔		
L 200 x 200 x 16	48,5	2341	161,7	6,16	3726	7,77	957,0	3,94	-1384	4	4	✔		
L 200 x 200 x 17	51,4	2472	171,2	6,14	3932	7,75	1011	3,93	-1461	4	4	✔		
L 200 x 200 x 18	54,3	2600	180,6	6,13	4135	7,74	1064	3,92	-1536	3	4	✔		
L 200 x 200 x 19	57,1	2726	189,9	6,12	4335	7,72	1117	3,92	-1609	2	4	✔		
L 200 x 200 x 20	59,9	2851	199,1	6,11	4532	7,70	1169	3,91	-1681	1	4	✔		
L 200 x 200 x 21	62,8	2973	208,2	6,10	4725	7,69	1221	3,91	-1752	1	4	✔		
L 200 x 200 x 22	65,6	3094	217,3	6,09	4915	7,67	1273	3,90	-1821	1	3	✔		
L 200 x 200 x 23	68,3	3213	226,3	6,08	5102	7,66	1324	3,90	-1889	1	2	✔		
L 200 x 200 x 24	71,1	3331	235,2	6,06	5286	7,64	1375	3,90	-1955	1	2	✔		
L 200 x 200 x 25	73,9	3446	244,0	6,05	5467	7,62	1426	3,89	-2020	1	1	✔		
L 200 x 200 x 26	76,6	3560	252,7	6,04	5645	7,61	1476	3,89	-2084	1	1	✔		
L 250 x 250 x 20	75,6	5743	317,9	7,72	9144	9,74	2341	4,93	-3401	4	4	✔		
L 250 x 250 x 21	79,2	5997	332,7	7,71	9548	9,73	2447	4,92	-3550	4	4	✔		
L 250 x 250 x 22	82,8	6249	347,4	7,70	9946	9,71	2551	4,92	-3697	3	4	✔		
L 250 x 250 x 23	86,4	6497	362,0	7,68	10339	9,69	2655	4,91	-3842	2	4	✔		
L 250 x 250 x 24	90,0	6743	376,5	7,67	10727	9,68	2759	4,91	-3984	2	4	✔		
L 250 x 250 x 25	93,5	6986	390,9	7,66	11110	9,66	2861	4,90	-4124	1	4	✔		
L 250 x 250 x 26	97,0	7226	405,2	7,65	11488	9,64	2963	4,90	-4262	1	4	✔		
L 250 x 250 x 27	101	7463	419,3	7,63	11861	9,62	3065	4,89	-4398	1	3	✔		
L 250 x 250 x 28	104	7697	433,4	7,62	12229	9,61	3166	4,89	-4532	1	2	✔		
L 250 x 250 x 35	128	9264	529,4	7,54	14669	9,48	3859	4,86	-5405	1	1	✔		
L 8 x 8 x 3/4	57,9	2881	198,2	6,26	4588	7,90	1174	3,99	-1707	2	4	✔		
L 8 x 8 x 7/8	67,0	3293	228,4	6,21	5236	7,84	1350	3,98	-1943	1	3	✔		
L 8 x 8 x 1	75,9	3686	257,7	6,17	5850	7,78	1522	3,97	-2164	1	1	✔		
L 8 x 8 x 1 1/8	84,7	4062	286,3	6,13	6432	7,72	1692	3,96	-2370	1	1	✔		

Cornières à ailes égales▼
Dimensions: EN 10056-1: 1998
Tolérances: EN 10056-2: 1994
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Equal leg angles▼
Dimensions: EN 10056-1: 1998
Tolerances: EN 10056-2: 1994
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Gleichschenkliger Winkelstahl▼
Abmessungen: EN 10056-1: 1998
Toleranzen: EN 10056-2: 1994
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung		Dimensions Abmessungen					Dimensions de construction Dimensions for detailing Konstruktionsmaße			
	G kg/m	h = b mm	t mm	r_1 mm	r_2 mm	A mm^2	Ø	e_{min} mm	e_{max} mm	A_{net} mm^2
						x 10^2				x 10^2
L 20 x 20 x 3[-]	0,882	20	3	3,5	2	1,12	-	-	-	-
L 25 x 25 x 3[x/-]	1,12	25	3	3,5	2	1,42	-	-	-	-
L 25 x 25 x 4[x/-]	1,45	25	4	3,5	2	1,85	-	-	-	-
L 30 x 30 x 3[x/-]	1,36	30	3	5	2,5	1,74	-	-	-	-
L 30 x 30 x 4[x/-]	1,78	30	4	5	2,5	2,27	-	-	-	-
L 35 x 35 x 4[x/-]	2,09	35	4	5	2,5	2,67	-	-	-	-
L 40 x 40 x 4[x/-]	2,42	40	4	6	3	3,08	-	-	-	-
L 40 x 40 x 5[x/-]	2,97	40	5	6	3	3,79	-	-	-	-
L 45 x 45 x 4,5[x/-]	3,06	45	4,5	7	3,5	3,90	-	-	-	-
L 50 x 50 x 4[x/-]	3,06	50	4	7	3,5	3,89	-	-	-	-
L 50 x 50 x 5[x/-]	3,77	50	5	7	3,5	4,80	-	-	-	-
L 50 x 50 x 6[x/-]	4,47	50	6	7	3,5	5,69	-	-	-	-
L 60 x 60 x 5[x/-]	4,57	60	5	8	4	5,82	M 12	35	40,5	5,17
L 60 x 60 x 6[x/-]	5,42	60	6	8	4	6,91	M 12	36	40,5	6,13
L 60 x 60 x 8[x/-]	7,09	60	8	8	4	9,03	M 12	38	40,5	7,99
L 65 x 65 x 7[-]	6,83	65	7	9	4,5	8,70	M 16	37	38	7,44
L 70 x 70 x 6[-]	6,38	70	6	9	4,5	8,13	M 16	36	43	7,05
L 70 x 70 x 7[-]	7,38	70	7	9	4,5	9,40	M 16	37	43	8,14
L 75 x 75 x 6[-]	6,85	75	6	10	5	8,73	M 16	36	48	7,67
L 75 x 75 x 8[-]	8,99	75	8	10	5	11,4	M 16	38	48	10,03

▼ Autres dimensions sur demande. Le rayon r_2 peut être inférieur en fonction du procédé de laminage.
x Avec arêtes vives sur commande.
\- Profilé conforme à EN 10056-1: 1998.

▼ Other dimensions on request. The r_2 radius may be smaller depending on the rolling process.
x Available with sharp edges.
\- Section in accordance with EN 10056-1: 1998.

▼ Andere Abmessungen auf Anfrage. Der Radius r_2 kann je nach Walzprozess kleiner sein.
x Auch mit scharfen Kanten erhältlich.
\- Profil gemäß EN 10056-1: 1998.

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Désignation Designation Bezeichnung		**Dimensions Abmessungen**					**Dimensions de construction Dimensions for detailing Konstruktionsmaße**			
	G kg/m	h = b mm	t mm	r_1 mm	r_2 mm	A mm^2	Ø	e_{min} mm	e_{max} mm	A_{net} mm^2
						x 10^2				x 10^2
L 80 x 80 x 8[-]	9,63	80	8	10	5	12,3	M 16	38	53	10,83
L 80 x 80 x 10[-]	11,9	80	10	10	5	15,1	M 16	40	53	13,31
L 90 x 90 x 7[-]	9,61	90	7	11	5,5	12,2	M 24	47	51	10,42
L 90 x 90 x 8[-]	10,9	90	8	11	5,5	13,9	M 24	48	51	11,81
L 90 x 90 x 9[-]	12,2	90	9	11	5,5	15,5	M 24	49	51	13,18
L 90 x 90 x 10[-]	13,4	90	10	11	5,5	17,1	M 24	50	51	14,53
L 100 x 100 x 8[*/+/-]	12,2	100	8	12	6	15,5	M 27	48	53	13,11
L 100 x 100 x 10[*/+/-]	15,0	100	10	12	6	19,2	M 27	50	53	16,15
L 100 x 100 x 12[*/+/-]	17,8	100	12	12	6	22,7	M 27	52	53	19,11
L 110 x 110 x 10[*/+]	16,6	110	10	13	6,5	21,2	M 27	50	62	18,18
L 110 x 110 x 12[*]	19,7	110	12	13	6,5	25,1	M 27	52	62	21,54
L 120 x 120 x 10[-]	18,2	120	10	13	6,5	23,2	M 27	50	72	20,18
L 120 x 120 x 11	19,9	120	11	13	6,5	25,4	M 27	51	72	22,07
L 120 x 120 x 12[-]	21,6	120	12	13	6,5	27,5	M 27	52	72	23,94
L 120 x 120 x 13	23,3	120	13	13	6,5	29,7	M 27	53	72	25,79
L 120 x 120 x 15	26,6	120	15	13	6,5	33,9	M 27	55	72	29,43
L 130 x 130 x 12[-/*]	23,6	130	12	14	7	30,0	M 27	52	82	26,37
L 140 x 140 x 10[*]	21,4	140	10	15	7,5	27,2	M 27	51	92	24,24
L 140 x 140 x 13[*]	27,4	140	13	15	7,5	35,0	M 27	54	92	31,05

- Profilé conforme à EN 10056-1: 1998.
+ Commande minimale: 40 t par profilé et qualité ou suivant accord.
* Tonnage minimum et conditions de livraison nécessitent un accord préalable.

- Section in accordance with EN 10056-1: 1998.
+ Minimum order: 40 t per section and grade or upon agreement.
* Minimum tonnage and delivery conditions upon agreement.

- Profil gemäß EN 10056-1: 1998.
+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.
* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

Cornières à ailes égales▼ (suite)

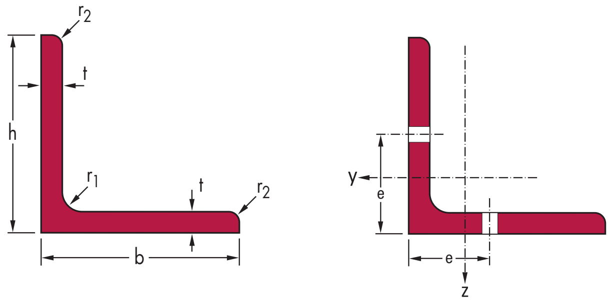
Dimensions: EN 10056-1: 1998 / ASTM A6/A6M - 02∢
Tolérances: EN 10056-2: 1994
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Equal leg angles▼ (continued)

Dimensions: EN 10056-1: 1998 / ASTM A6/A6M - 02∢
Tolerances: EN 10056-2: 1994
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Gleichschenkliger Winkelstahl▼ (Fortsetzung)

Abmessungen: EN 10056-1: 1998 / ASTM A6/A6M - 02∢
Toleranzen: EN 10056-2: 1994
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung		Dimensions Abmessungen					Dimensions de construction Dimensions for detailing Konstruktionsmaße			
	G kg/m	h = b mm	t mm	r_1 mm	r_2 mm	A mm^2	Ø	e_{min} mm	e_{max} mm	A_{net} mm^2
						x 10^2				x 10^2
L 150 x 150 x 10 -/+	23,0	150	10	16	8	29,3	M 27	52	102	26,27
L 150 x 150 x 12 -/+	27,3	150	12	16	8	34,8	M 27	54	102	31,23
L 150 x 150 x 14 +	31,6	150	14	16	8	40,3	M 27	56	102	36,11
L 150 x 150 x 15 -/+	33,8	150	15	16	8	43,0	M 27	57	102	38,52
L 150 x 150 x 18 +	40,1	150	18	16	8	51,0	M 27	61	102	45,63
L 160 x 160 x 14 +	33,9	160	14	17	8,5	43,2	M 27	57	111	38,95
L 160 x 160 x 15 -/+	36,2	160	15	17	8,5	46,1	M 27	58	111	41,56
L 160 x 160 x 16 +	38,4	160	16	17	8,5	49,0	M 27	60	111	44,15
L 160 x 160 x 17 +	40,7	160	17	17	8,5	51,8	M 27	61	111	46,72
L 180 x 180 x 13 +	35,7	180	13	18	9	45,5	M 27	57	131	41,56
L 180 x 180 x 14 +	38,3	180	14	18	9	48,8	M 27	58	131	44,59
L 180 x 180 x 15 +	40,9	180	15	18	9	52,1	M 27	59	131	47,6
L 180 x 180 x 16 -/+	43,5	180	16	18	9	55,4	M 27	61	131	50,59
L 180 x 180 x 17 +	46,0	180	17	18	9	58,7	M 27	62	131	53,56
L 180 x 180 x 18 -/+	48,6	180	18	18	9	61,9	M 27	63	131	56,51
L 180 x 180 x 19 +	51,1	180	19	18	9	65,1	M 27	64	131	59,44
L 180 x 180 x 20 +	53,7	180	20	18	9	68,4	M 27	65	131	62,35

▼ Autres dimensions sur demande. Le rayon r_2 peut être inférieur en fonction du procédé de laminage.
\- Profilé conforme à EN 10056-1: 1998.
\+ Commande minimale: 40 t par profilé et qualité ou suivant accord.

▼ Other dimensions on request. The r_2 radius may be smaller depending on the rolling process.
\- Section in accordance with EN 10056-1: 1998.
\+ Minimum order: 40 t per section and grade or upon agreement.

▼ Andere Abmessungen auf Anfrage. Der Radius r_2 kann je nach Walzprozess kleiner sein.
\- Profil gemäß EN 10056-1: 1998.
\+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.

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Désignation Designation Bezeichnung		**Dimensions Abmessungen**					**Dimensions de construction Dimensions for detailing Konstruktionsmaße**			
	G kg/m	h = b mm	t mm	r_1 mm	r_2 mm	A mm^2	Ø	e_{min} mm	e_{max} mm	A_{net} mm^2
						x 10^2				x 10^2
L 200 x 200 x 15+	45,6	200	15	18	9	58,1	M 27	59	151	53,6
L 200 x 200 x 16-/+	48,5	200	16	18	9	61,8	M 27	61	151	56,99
L 200 x 200 x 17+	51,4	200	17	18	9	65,5	M 27	62	151	60,36
L 200 x 200 x 18-/+	54,3	200	18	18	9	69,1	M 27	63	151	63,71
L 200 x 200 x 19+	57,1	200	19	18	9	72,7	M 27	64	151	67,04
L 200 x 200 x 20-/+	59,9	200	20	18	9	76,3	M 27	65	151	70,35
L 200 x 200 x 21+	62,8	200	21	18	9	79,9	M 27	66	151	73,64
L 200 x 200 x 22+	65,6	200	22	18	9	83,5	M 27	67	151	76,91
L 200 x 200 x 23+	68,3	200	23	18	9	87,1	M 27	68	151	80,16
L 200 x 200 x 24-/+	71,1	200	24	18	9	91,0	M 27	69	151	83,39
L 200 x 200 x 25+	73,9	200	25	18	9	94,1	M 27	70	151	86,6
L 200 x 200 x 26+	76,6	200	26	18	9	97,6	M 27	71	151	89,79
L 250 x 250 x 20+	75,6	250	20	18	9	96,4	M 27	40	240	96,35
L 250 x 250 x 21+	79,2	250	21	18	9	101	M 27	41	246	100,94
L 250 x 250 x 22+	82,8	250	22	18	9	106	M 27	42	246	105,51
L 250 x 250 x 23+	86,4	250	23	18	9	110	M 27	43	246	110,06
L 250 x 250 x 24+	90,0	250	24	18	9	115	M 27	44	246	114,59
L 250 x 250 x 25+	93,5	250	25	18	9	119	M 27	45	246	119,1
L 250 x 250 x 26+	97,0	250	26	18	9	124	M 27	46	246	123,59
L 250 x 250 x 27+	101	250	27	18	9	128	M 27	47	246	128,06
L 250 x 250 x 28-/+	104	250	28	18	9	133	M 27	48	246	132,51
L 250 x 250 x 35-/+	128	250	35	18	9	163	M 27	78	205	152,6
L 203 x 203 x 19</+	57,9	203	19	8	4	73,6	M 27	64	155	67,9
L 203 x 203 x 22,2</+	67,0	203	22,2	8	4	85,0	M 27	67	155	78,61
L 203 x 203 x 25,4</+	75,9	203	25,4	8	4	96,8	M 27	70	155	89,12
L 203 x 203 x 28,6</+	84,7	203	28,6	8	4	108	M 27	73	155	99,43

\+ Commande minimale: 40 t par profilé et qualité ou suivant accord.
\- Profilé conforme à EN 10056-1: 1998.
< Profilé conforme à ASTM A6/A6M - 02.

\+ Minimum order: 40 t per section and grade or upon agreement.
\- Section in accordance with EN 10056-1: 1998.
< Section in accordance with ASTM A6/A6M - 02.

\+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.
\- Profil gemäß EN 10056-1: 1998.
< Profil gemäß ASTM A6/A6M - 02.

Cornières à ailes inégales▼

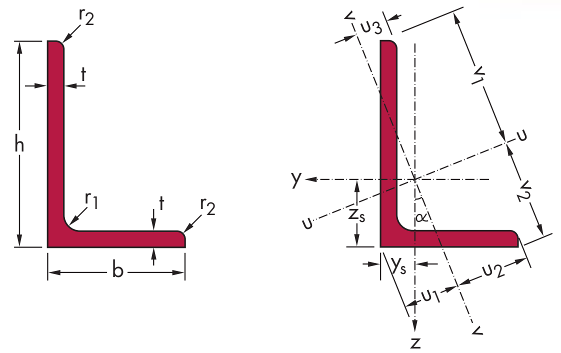
Dimensions: EN 10056-1: 1998
Tolérances: EN 10056-2: 1994
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Unequal leg angles▼

Dimensions: EN 10056-1: 1998
Tolerances: EN 10056-2: 1994
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Ungleichschenkliger Winkelstahl▼

Abmessungen: EN 10056-1: 1998
Toleranzen: EN 10056-2: 1994
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



Désignation Designation Bezeichnung		Dimensions Abmessungen						Position des axes Position of axes Lage der Achsen							Surface Oberfläche	
	G kg/m	h mm	b mm	t mm	r_1 mm	r_2 mm	A mm^2	z_s mm	y_s mm	v_1 mm	v_2 mm	u_1 mm	u_2 mm	u_3 mm	A_L m^2/m	A_G m^2/t
							x 10^2	x 10	x 10	x 10	x 10	x 10	x 10	x 10		
L 120 x 80 x 8*	12,2	120	80	8	11	5,5	15,5	3,83	1,87	8,23	5,97	3,25	4,19	2,09	0,391	32,12
L 120 x 80 x 10*	15,0	120	80	10	11	5,5	19,1	3,92	1,95	8,19	6,01	3,35	4,17	2,15	0,391	26,01
L 120 x 80 x 12*	17,8	120	80	12	11	5,5	22,7	4,00	2,03	8,14	6,04	3,45	4,16	2,20	0,391	21,93
L 150 x 75 x 9+	15,4	150	75	9	12	6	19,6	5,26	1,57	9,82	6,59	2,85	4,41	1,61	0,440	28,59
L 150 x 75 x 10+	17,0	150	75	10	12	6	21,7	5,31	1,61	9,78	6,62	2,90	4,39	1,65	0,440	25,87
L 150 x 75 x 11+	18,6	150	75	11	12	6	23,7	5,35	1,65	9,75	6,65	2,95	4,37	1,68	0,440	23,64
L 150 x 75 x 12+	20,2	150	75	12	12	6	25,7	5,40	1,69	9,72	6,68	2,99	4,36	1,72	0,440	21,78
L 150 x 90 x 10-/+	18,2	150	90	10	12	6	23,2	5,00	2,04	10,10	7,07	3,61	4,97	2,20	0,470	25,84
L 150 x 90 x 11+	19,9	150	90	11	12	6	25,3	5,04	2,08	10,07	7,09	3,66	4,95	2,23	0,470	23,61
L 150 x 100 x 10-/+	19,0	150	100	10	12	6	24,2	4,81	2,34	10,27	7,48	4,08	5,25	2,64	0,490	25,83
L 150 x 100 x 12-/+	22,5	150	100	12	12	6	28,7	4,90	2,42	10,23	7,52	4,18	5,23	2,70	0,490	21,72
L 150 x 100 x 14+	26,1	150	100	14	12	6	33,2	4,98	2,50	10,19	7,55	4,28	5,22	2,75	0,490	18,79
L 200 x 100 x 10-/+	23,0	200	100	10	15	7,5	29,2	6,93	2,01	13,15	8,74	3,72	5,94	2,09	0,587	25,58
L 200 x 100 x 12-/+	27,3	200	100	12	15	7,5	34,8	7,03	2,10	13,08	8,81	3,82	5,89	2,17	0,587	21,49
L 200 x 100 x 14+	31,6	200	100	14	15	7,5	40,3	7,12	2,18	13,01	8,86	3,91	5,85	2,24	0,587	18,57

▼ Autres dimensions sur demande. Le rayon r_2 peut être inférieur en fonction du procédé de laminage.
\+ Commande minimale: 40 t par profilé et qualité ou suivant accord.
\- Profilé conforme à EN 10056-1: 1998.
* Tonnage minimum et conditions de livraison nécessitent un accord préalable.

▼ Other dimensions on request. The r_2 radius may be smaller depending on the rolling process.
\+ Minimum order: 40 t per section and grade or upon agreement.
\- Section in accordance with EN 10056-1: 1998.
* Minimum tonnage and delivery conditions upon agreement.

▼ Andere Abmessungen auf Anfrage. Der Radius r_2 kann je nach Walzprozess kleiner sein.
\+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.
\- Profil gemäß EN 10056-1: 1998.
* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

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Désignation Designation Bezeichnung		Valeurs statiques / Section properties / Statische Kennwerte												Classification ENV 1993-1-1				
		axe y-y axis y-y Achse y-y			axe z-z axis z-z Achse z-z			axe u-u axis u-u Achse u-u		axe v-v axis v-v Achse v-v				pure compression		EN 10025:1993	EN 10113-3:1993	EN 10225:2001
	G kg/m	I_y mm^4	$W_{el.y}$ mm^3	i_y mm	I_z mm^4	$W_{el.z}$ mm^3	i_z mm	I_u mm^4	i_u mm	I_v mm^4	i_v mm	I_{yz} mm^4	α °	S 235	S 355			
		x 10^4	x 10^3	x 10	x 10^4	x 10^3	x 10	x 10^4	x 10	x 10^4	x 10	x 10^4						
L 120 x 80 x 8	12,2	225,7	27,63	3,82	80,76	13,17	2,28	260,0	4,10	46,39	1,73	-78,50	23,65	4	4	✔		
L 120 x 80 x 10	15,0	275,5	34,10	3,80	98,11	16,21	2,26	317,0	4,07	56,60	1,72	-95,34	23,53	3	4	✔		
L 120 x 80 x 12	17,8	322,8	40,37	3,77	114,3	19,14	2,24	370,7	4,04	66,46	1,71	-110,8	23,37	1	4	✔		
L 150 x 75 x 9	15,4	455,2	46,74	4,82	77,91	13,14	1,99	483,2	4,97	49,95	1,60	-106,4	14,72	4	4	✔		
L 150 x 75 x 10	17,0	500,6	51,65	4,81	85,37	14,50	1,99	531,1	4,95	54,87	1,59	-116,6	14,66	3	4	✔		
L 150 x 75 x 11	18,6	545,0	56,49	4,80	92,57	15,83	1,98	577,9	4,94	59,70	1,59	-126,3	14,59	3	4	✔		
L 150 x 75 x 12	20,2	588,4	61,27	4,78	99,55	17,14	1,97	623,5	4,92	64,45	1,58	-135,6	14,51	3	4	✔		
L 150 x 90 x 10	18,2	533,1	53,29	4,80	146,1	20,98	2,51	591,3	5,05	87,93	1,95	-160,9	19,87	4	4	✔		
L 150 x 90 x 11	19,9	580,7	58,30	4,79	158,7	22,91	2,50	643,7	5,04	95,71	1,94	-174,7	19,81	3	4	✔		
L 150 x 100 x 10	19,0	552,6	54,23	4,78	198,5	25,92	2,87	637,3	5,14	113,8	2,17	-192,8	23,72	4	4	✔		
L 150 x 100 x 12	22,5	650,5	64,38	4,76	232,6	30,69	2,85	749,3	5,11	133,9	2,16	-225,8	23,61	3	4	✔		
L 150 x 100 x 14	26,1	744,4	74,27	4,74	264,9	35,32	2,82	855,9	5,08	153,4	2,15	-256,8	23,48	2	4	✔		
L 200 x 100 x 10	23,0	1219	93,24	6,46	210,3	26,33	2,68	1294	6,65	134,5	2,14	-286,8	14,82	4	4	✔		
L 200 x 100 x 12	27,3	1440	111,0	6,43	247,2	31,28	2,67	1529	6,63	158,5	2,13	-337,3	14,74	4	4	✔		
L 200 x 100 x 14	31,6	1654	128,4	6,41	282,2	36,08	2,65	1755	6,60	181,7	2,12	-384,8	14,65	3	4	✔		

Cornières à ailes inégales▼ (suite)

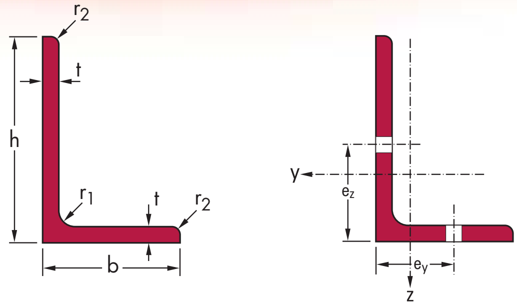
Dimensions: EN 10056-1: 1998
Tolérances: EN 10056-2: 1994
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Unequal leg angles▼ (continued)

Dimensions: EN 10056-1: 1998
Tolerances: EN 10056-2: 1994
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Ungleichschenkliger Winkelstahl▼ (Fortsetzung)

Abmessungen: EN 10056-1: 1998
Toleranzen: EN 10056-2: 1994
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



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Désignation / Designation / Bezeichnung		Dimensions / Abmessungen						Dimensions de construction / Dimensions for detailing / Konstruktionsmaße							
								aile longue / long leg / langer Schenkel				aile courte / short leg / kurzer Schenkel			
	G	h	b	t	r_1	r_2	A	$\varnothing_z$	$e_{z.\ min}$	$e_{z.\ max}$	$A_{z.\ net}$	$\varnothing_y$	$e_{y.\ min}$	$e_{y.\ max}$	$A_{y.net}$
	kg/m	mm	mm	mm	mm	mm	mm^2		mm	mm	mm^2		mm	mm	mm^2
							x 10^2				x 10^2				x 10^2
L 120 x 80 x 8*	12,2	120	80	8	11	5,5	15,49	M 27	48	72	13,09	M 16	38	51	14,05
L 120 x 80 x 10*	15,0	120	80	10	11	5,5	19,13	M 27	50	72	16,13	M 16	40	51	17,33
L 120 x 80 x 12*	17,8	120	80	12	11	5,5	22,69	M 27	52	72	19,09	M 16	42	51	20,53
L 150 x 75 x 9+	15,4	150	75	9	12	6	19,6	M 27	47	102	16,89	M 16	37	46	17,97
L 150 x 75 x 10+	17,0	150	75	10	12	6	21,7	M 27	48	102	18,65	M 16	38	46	19,85
L 150 x 75 x 11+	18,6	150	75	11	12	6	23,7	M 27	49	102	20,39	M 16	39	46	21,71
L 150 x 75 x 12+	20,2	150	75	12	12	6	25,7	M 27	50	102	22,11	M 16	40	46	23,55
L 150 x 90 x 10-/+	18,2	150	90	10	12	6	23,15	M 27	50	102	20,15	M 24	47	49	20,55
L 150 x 90 x 11+	19,9	150	90	11	12	6	25,34	M 27	51	102	22,04	M 24	48	49	22,48
L 150 x 100 x 10-/+	19,0	150	100	10	12	6	24,15	M 27	50	102	21,15	M 27	50	53	21,15
L 150 x 100 x 12-/+	22,5	150	100	12	12	6	28,71	M 27	52	102	25,11	M 27	52	53	25,11
L 150 x 100 x 14+	26,1	150	100	14	12	6	33,19	M 27	54	102	28,99	M 24	51	59	29,55
L 200 x 100 x 10-/+	23,0	200	100	10	15	7,5	29,24	M 27	54	150	26,24	M 27	51	53	26,24
L 200 x 100 x 12-/+	27,3	200	100	12	15	7,5	34,80	M 27	54	150	31,2	M 27	53	53	31,2
L 200 x 100 x 14+	31,6	200	100	14	15	7,5	40,28	M 27	55	151	36,08	M 24	52	59	36,64

▼ Autres dimensions sur demande. Le rayon r_2 peut être inférieur en fonction du procédé de
\+ Commande minimale: 40 t par profilé et qualité ou suivant accord.
\- Profilé conforme à EN 10056-1: 1998.
* Tonnage minimum et conditions de livraison nécessitent un accord préalable.

▼ Other dimensions on request. The r_2 radius may be smaller depending on the rolling process.
\+ Minimum order: 40 t per section and grade or upon agreement.
\- Section in accordance with EN 10056-1: 1998.
* Minimum tonnage and delivery conditions upon agreement.

▼ Andere Abmessungen auf Anfrage. Der Radius r_2 kann je nach Walzprozess kleiner sein.
\+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.
\- Profil gemäß EN 10056-1: 1998.
* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.

Larges plats

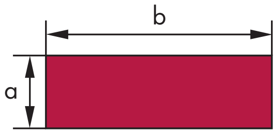
Dimensions: EU 79-69 et EU 58-78 (Fers plats)
Tolérances: EU 58-78 Fers plats
EU 91-82 Larges plats
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Flat bars

Dimensions: EU 79-69 and EU 58-78 (Narrow flats)
Tolerances: EU 58-78 Narrow flats
EU 91-82 Wide flats
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Flachstahl

Abmessungen: EU 79-69 und EU 58-78 (Flachstahl)
Toleranzen: EU 58-78 Flachstahl
EU 91-82 Breitflachstahl
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



	Masse / Mass / Masse kg/m																
	Largeur Width Breite b mm	**Epaisseur Thickness Dicke** a mm															EN 10025:1993
		5	6	7	8	10	12	14	15	16	18	20	25	30	35	40	
Fers plats Narrow flat bars Flachstahl	→40	1,57	1,88	2,20	2,51	3,14	3,77	4,40	4,71								✔
	→50	1,96	2,36	2,75	3,14	3,93	4,71	5,50	5,89								✔
	→60	2,36	2,83	3,30	3,77	4,71	5,65	6,59	7,07								✔
	→70	2,75	3,30	3,85	4,40	5,50	6,59	7,69	8,24								✔
	→80	3,14	3,77	4,40	5,02	6,28	7,54	8,79	9,42								✔
	→90	3,53	4,24	4,95	5,65	7,07	8,48	9,89	10,60								✔
	→100	3,93	4,71	5,50	6,28	7,85	9,42	10,99	11,78	12,56	14,13	15,70	19,63				✔
	→110				6,91	8,64	10,36	12,09	12,95	13,82	15,54	17,27	21,59				✔
	→120				7,54	9,42	11,30	13,19	14,13	15,07	16,96	18,84	23,55				✔
	→130				8,16	10,21	12,25	14,29	15,31	16,33	18,37	20,41	25,51				✔
	→140				8,79	10,99	13,19	15,39	16,49	17,58	19,78	21,98	27,48				✔
	→150				9,42	11,78	14,13	16,49	17,66	18,84	21,20	23,55	29,44				✔
Larges plats Flat bars Breitflachstahl	→160				10,05	12,56	15,07	17,58	18,84	20,10	22,61	25,12	31,40				✔
	→180				11,30	14,13	16,96	19,78	21,20	22,61	25,43	28,26	35,33				✔
	→200				12,56	15,70	18,84	21,98	23,55	25,12	28,26	31,40	39,25	47,1	55,0	62,8	✔
	*220					17,27	20,72		25,91			34,54	43,18	51,8	60,4	69,1	✔
	*250					19,63	23,55		29,44			39,25	49,06	58,9	68,7	78,5	✔
	*300					23,55	28,26		35,33			47,10	58,88	70,7	82,4	94,2	✔
	*350					27,48	32,97		41,21			54,95	68,69	82,4	96,2	109,9	✔
	*400					31,40	37,68		47,10			62,80	78,50	94,2	109,9	125,6	✔

* Tonnage minimum et conditions de livraison nécessitent un accord préalable.
→ Autres dimensions sur demande. Longueur: 6 m. Poids d'un paquet: ±200 kg.

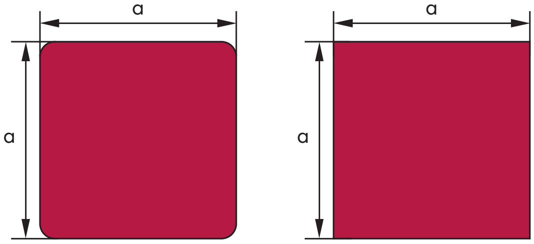
* Minimum tonnage and delivery conditions upon agreement.
→ Other dimensions on request. Length: 6 m. Bundle weight: ±200 kg.

* Die Mindestmengen pro Bestellung sowie die Lieferbedingungen sind im Voraus zu vereinbaren.
→ Andere Abmessungen auf Anfrage. Länge: 6 m. Bündelgewicht: ±200 kg.

Carrés
Dimensions: EU 79-69
Tolérances: EU 59-78
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

Square bars
Dimensions: EU 79-69
Tolerances: EU 59-78
Surface condition according to EN 10163-3: 1991, class C, subclass 1

Vierkantstahl
Abmessungen: EU 79-69
Toleranzen: EU 59-78
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



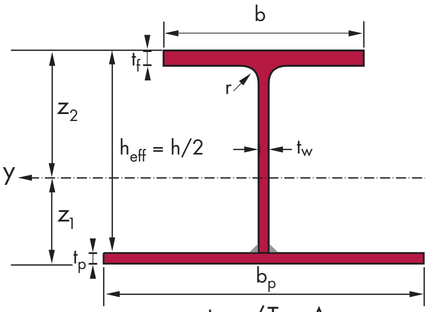
a x a	Bords arrondis Rounded edges Gerundete Kanten	Bords pointus Sharp edges Scharfe Kanten	EN 10025:1993
	Masse / Mass / Masse kg/m	Masse / Mass / Masse kg/m	
45 x 45+	15,7		✔
50 x 50+	19,4		✔
55 x 55+	23,5		✔
60 x 60+	27,9		✔
65 x 65+	32,7		✔
70 x 70+	38,0		✔
80 x 80+	49,6		✔
85 x 85+	56,0		✔
90 x 90+		63,6	✔
95 x 95+	69,9		✔
100 x 100+	77,5	78,5	✔
110 x 110+		95,0	✔
120 x 120+		113	✔
130 x 130+		133	✔
140 x 140+	153		✔
150 x 150+	173		✔
160 x 160+	200		✔

+ Commande minimale: 40 t par profilé et qualité ou suivant accord.
+ Minimum order: 40 t per section and grade or upon agreement.
+ Mindestbestellmenge: 40 t pro Profil und Güte oder nach Vereinbarung.

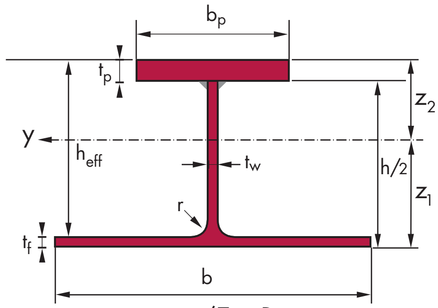
Poutrelles IFB
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

IFB beams
Surface condition according to EN 10163-3: 1991, class C, subclass 1

IFB-Träger
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



type/Typ A



type/Typ B

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung				**Dimensions Abmessungen**						**Valeurs statiques Section properties Statische Kennwerte**			
	$b_p \times t_p$ mm x mm	type Typ	G kg/m	h_{eff} mm	b mm	t_w mm	t_f mm	r mm	A mm^2	I_y mm^4	$W_{el.y}$ mm^3	z_1 mm	z_2 mm
									x 10^2	x 10^4	x 10^3	x 10	x 10
1/2 IPE 400	380 x 10	A	63,0	200,0	180,0	8,6	13,5	21,0	80,2	6558	543	8,9	12,1
1/2 IPE 0 400	390 x 12	A	74,6	202,0	182,0	9,7	15,5	21,0	95,0	7893	627	8,8	12,6
1/2 IPE 450	390 x 12	A	75,5	225,0	190,0	9,4	14,6	21,0	96,2	9857	707	9,8	13,9
1/2 IPE 0 450	400 x 12	A	83,9	228,0	192,0	11,0	17,6	21,0	106,8	11230	833	10,5	13,5
1/2 IPE 500	400 x 12	A	83,0	250,0	200,0	10,2	16,0	21,0	105,8	13332	895	11,3	14,9
1/2 IPE 0 500	410 x 15	A	101,9	253,0	202,0	12,0	19,0	21,0	129,9	16701	1071	11,2	15,6
1/2 IPE 550	410 x 15	A	101,0	275,0	210,0	11,1	17,2	24,0	128,7	19499	1145	12,0	17,0
1/2 IPE 0 550	420 x 15	A	110,7	278,0	212,0	12,7	20,2	24,0	141,0	21825	1318	12,7	16,6
1/2 IPE 600	420 x 15	A	110,7	300,0	220,0	12,0	19,0	24,0	141,0	25375	1420	13,6	17,9
1/2 IPE 0 600	430 x 15	A	127,9	305,0	224,0	15,0	24,0	24,0	162,9	29830	1749	14,9	17,1
1/2 IPE 0 600	430 x 20	A	144,7	305,0	224,0	15,0	24,0	24,0	184,4	34206	1816	13,7	18,8
1/2 HE 220 M	430 x 15	A	109,3	120,0	226,0	15,5	26,0	18,0	139,2	4209	581	6,3	7,2
1/2 HE 240 M	450 x 20	A	149,0	135,0	248,0	18,0	32,0	21,0	189,8	7323	873	7,1	8,4
1/2 HE 260 B	460 x 12	A	89,8	130,0	260,0	10,0	17,5	24,0	114,4	4251	554	6,5	7,7
1/2 HE 260 M	470 x 20	A	160,0	145,0	268,0	18,0	32,5	24,0	203,8	9087	1038	7,7	8,8
1/2 HE 280 M	500 x 20	A	172,8	155,0	288,0	18,5	33,0	24,0	220,1	11218	1219	8,3	9,2
1/2 HE 280 M	500 x 25	A	192,4	155,0	288,0	18,5	33,0	24,0	245,1	12853	1275	7,9	10,1
1/2 HE 300 B	500 x 15	A	117,4	150,0	300,0	11,0	19,0	27,0	149,5	7482	820	7,4	9,1
1/2 HE 300 M	500 x 25	A	217,1	170,0	310,0	21,0	39,0	27,0	276,5	17044	1675	9,3	10,2
1/2 HE 320 B	500 x 15	A	122,2	160,0	300,0	11,5	20,5	27,0	155,7	8805	932	8,1	9,4
1/2 HE 320 M	500 x 25	A	220,6	179,5	309,0	21,0	40,0	27,0	281,0	19208	1812	9,9	10,6
1/2 HE 320 M	500 x 30	A	240,2	179,5	309,0	21,0	40,0	27,0	306,0	21543	1885	9,5	11,4
1/2 HE 340 B	500 x 15	A	126,0	170,0	300,0	12,0	21,5	27,0	160,4	10173	1034	8,7	9,8
1/2 HE 340 M	500 x 25	A	222,1	188,5	309,0	21,0	40,0	27,0	282,9	21298	1928	10,3	11,0
1/2 HE 340 M	500 x 30	A	241,7	188,5	309,0	21,0	40,0	27,0	307,9	23848	2002	9,9	11,9
1/2 HE 360 B	500 x 15	A	129,8	180,0	300,0	12,5	22,5	27,0	165,3	11660	1142	9,3	10,2
1/2 HE 360 M	500 x 25	A	223,3	197,5	308,0	21,0	40,0	27,0	284,4	23466	2039	10,7	11,5
1/2 HE 360 M	500 x 30	A	242,9	197,5	308,0	21,0	40,0	27,0	309,4	26233	2115	10,3	12,4

IFB = "Integrated Floor Beam"

IFB

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung				Dimensions Abmessungen						Valeurs statiques Section properties Statische Kennwerte			
	$b_p \times t_p$	type	G	h_{eff}	b	t_w	t_f	r	A	I_y	$W_{el.y}$	z_1	z_2
	mm x mm	Typ	kg/m	mm	mm	mm	mm	mm	mm^2	mm^4	mm^3	mm	mm
									$x\ 10^2$	$x\ 10^4$	$x\ 10^3$	x 10	x 10
1/2 HE 400 B	500 x 20	A	156,1	200,0	300,0	13,5	24,0	27,0	198,9	17419	1408	9,6	12,4
1/2 HE 400 M	500 x 25	A	226,0	216,0	307,0	21,0	40,0	27,0	287,9	28310	2274	11,6	12,5
1/2 HE 400 M	500 x 30	A	245,6	216,0	307,0	21,0	40,0	27,0	312,9	31558	2354	11,2	13,4
1/2 HE 450 B	500 x 20	A	164,1	225,0	300,0	14,0	26,0	27,0	209,0	22963	1708	11,1	13,4
1/2 HE 450 M	500 x 25	A	229,8	239,0	307,0	21,0	40,0	27,0	292,7	35066	2578	12,8	13,6
1/2 HE 450 M	500 x 30	A	249,4	239,0	307,0	21,0	40,0	27,0	317,7	38977	2663	12,3	14,6
1/2 HE 500 A	500 x 20	A	156,0	245,0	300,0	12,0	23,0	27,0	198,8	25944	1722	11,4	15,1
1/2 HE 500 B	500 x 20	A	172,2	250,0	300,0	14,5	28,0	27,0	219,3	29447	2035	12,5	14,5
1/2 HE 500 M	500 x 25	A	233,3	262,0	306,0	21,0	40,0	27,0	297,1	42529	2879	13,9	14,8
1/2 HE 500 M	500 x 30	A	252,9	262,0	306,0	21,0	40,0	27,0	322,1	47154	2970	13,3	15,9
1/2 HE 550 A	500 x 20	A	161,6	270,0	300,0	12,5	24,0	27,0	205,9	32356	1991	12,7	16,3
1/2 HE 550 B	500 x 20	A	178,2	275,0	300,0	15,0	29,0	27,0	227,0	36479	2336	13,9	15,6
1/2 HE 550 B	500 x 25	A	197,8	275,0	300,0	15,0	29,0	27,0	252,0	40971	2407	13,0	17,0
1/2 HE 550 M	500 x 25	A	237,2	286,0	306,0	21,0	40,0	27,0	302,2	51213	3206	15,1	16,0
1/2 HE 550 M	500 x 30	A	256,8	286,0	306,0	21,0	40,0	27,0	327,2	56660	3303	14,4	17,2
1/2 HE 550 M	500 x 35	A	276,5	286,0	306,0	21,0	40,0	27,0	352,2	61669	3388	13,9	18,2
1/2 HE 600 A	500 x 20	A	167,4	295,0	300,0	13,0	25,0	27,0	213,2	39636	2276	14,1	17,4
1/2 HE 600 B	500 x 20	A	184,5	300,0	300,0	15,5	30,0	27,0	235,0	44424	2654	15,3	16,7
1/2 HE 600 B	500 x 25	A	204,1	300,0	300,0	15,5	30,0	27,0	260,0	49850	2733	14,3	18,2
1/2 HE 600 M	500 x 30	A	260,5	310,0	305,0	21,0	40,0	27,0	331,8	66995	3631	15,5	18,5
1/2 HE 600 M	500 x 35	A	280,1	310,0	305,0	21,0	40,0	27,0	356,8	72791	3721	14,9	19,6
1/2 HE 650 A	500 x 20	A	173,3	320,0	300,0	13,5	26,0	27,0	220,8	47825	2578	15,5	18,5
1/2 HE 650 B	500 x 25	A	210,5	325,0	300,0	16,0	31,0	27,0	268,2	59791	3078	15,6	19,4
1/2 HE 650 M	500 x 25	A	244,8	334,0	305,0	21,0	40,0	27,0	311,9	71097	3863	17,5	18,4
1/2 HE 650 M	500 x 30	A	264,4	334,0	305,0	21,0	40,0	27,0	336,9	78374	3973	16,7	19,7
1/2 HE 650 M	500 x 35	A	284,1	334,0	305,0	21,0	40,0	27,0	361,9	85034	4069	16,0	20,9

Poutrelles IFB (suite)

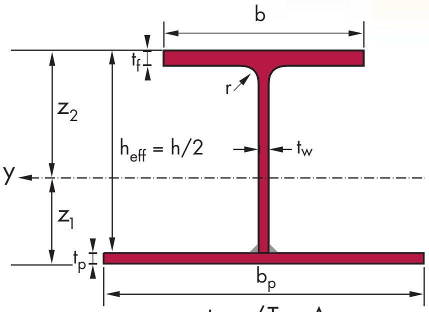
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

IFB beams (continued)

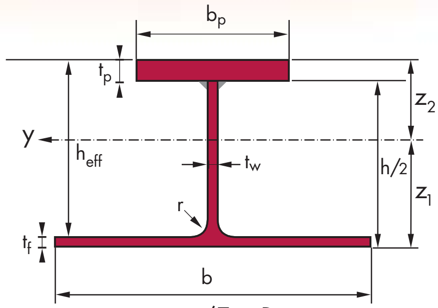
Surface condition according to EN 10163-3: 1991, class C, subclass 1

IFB-Träger (Fortsetzung)

Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



type/Typ A



type/Typ B

Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung				**Dimensions Abmessungen**						**Valeurs statiques Section properties Statische Kennwerte**			
	$b_p \times t_p$ mm x mm	type Typ	G kg/m	h_{eff} mm	b mm	t_w mm	t_f mm	r mm	A mm²	I_y mm⁴	$W_{el.y}$ mm³	z_1 mm	z_2 mm
									x 10²	x 10⁴	x 10³	x 10	x 10
1/2 HE 280 A	80 x 40	B	63,3	162,0	280,0	8,0	13,0	24,0	80,6	4004	396	7,4	10,1
1/2 HE 300 A	100 x 30	B	67,7	161,0	300,0	8,5	14,0	27,0	86,3	4375	417	7,0	10,5
1/2 HP 360x109	170 x 20	B	81,2	180,3	370,5	12,9	12,9	15,2	103,5	6739	606	8,2	11,1
1/2 HP 360x109	170 x 30	B	94,6	190,3	370,5	12,9	12,9	15,2	120,5	8714	831	9,8	10,5
1/2 HP 360x133	170 x 20	B	92,8	180,4	373,3	15,6	15,6	15,2	118,2	7509	635	7,8	11,8
1/2 HP 360x133	170 x 30	B	106,2	190,4	373,3	15,6	15,6	15,2	135,2	9768	866	9,3	11,3
1/2 HP 360x152	170 x 30	B	116,1	190,3	375,5	17,9	17,9	15,2	147,9	10583	894	9,0	11,8
1/2 HP 360x152	170 x 40	B	129,4	200,3	375,5	17,9	17,9	15,2	164,9	12904	1116	10,3	11,6
1/2 HP 400x122	190 x 20	B	91,0	180,0	390,0	14,0	14,0	15,0	116,0	7597	678	8,2	11,2
1/2 HP 400x122	190 x 30	B	105,9	190,0	390,0	14,0	14,0	15,0	135,0	9837	931	9,8	10,6
1/2 HP 400x140	190 x 30	B	114,8	190,0	392,0	16,0	16,0	15,0	146,3	10658	958	9,5	11,1
1/2 HP 400x140	190 x 40	B	129,7	200,0	392,0	16,0	16,0	15,0	165,3	12931	1199	10,8	10,8
1/2 HP 400x158	190 x 30	B	123,8	190,0	394,0	18,0	18,0	15,0	157,7	11435	984	9,2	11,6
1/2 HP 400x158	190 x 40	B	138,7	200,0	394,0	18,0	18,0	15,0	176,7	13926	1231	10,5	11,3
1/2 HP 400x176	190 x 30	B	132,8	190,0	396,0	20,0	20,0	15,0	169,2	12179	1010	8,9	12,1
1/2 HP 400x176	190 x 40	B	147,7	200,0	396,0	20,0	20,0	15,0	188,2	14874	1262	10,2	11,8
1/2 HP 400x194	190 x 30	B	141,9	190,0	398,0	22,0	22,0	15,0	180,7	12899	1036	8,7	12,5
1/2 HP 400x194	190 x 40	B	156,8	200,0	398,0	22,0	22,0	15,0	199,7	15785	1292	10,0	12,2

Poutrelles SFB

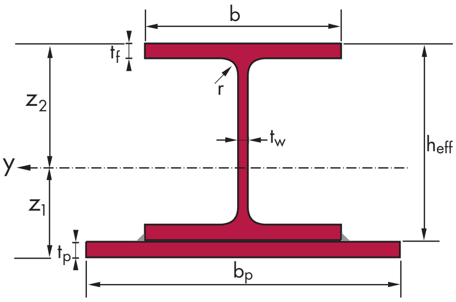
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

SFB beams

Surface condition according to EN 10163-3: 1991, class C, subclass 1

SFB-Träger

Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



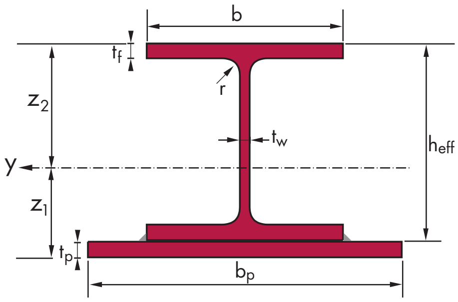
Notations pages 211-215 / Bezeichnungen Seiten 211-215

Désignation Designation Bezeichnung			Dimensions Abmessungen						Valeurs statiques Section properties Statische Kennwerte			
	$b_p \times t_p$ mm x mm	G kg/m	h_{eff} mm	b mm	t_w mm	t_f mm	r mm	A mm²	I_y mm⁴	$W_{el.y}$ mm³	z_1 mm	z_2 mm
								x 10²	x 10⁴	x 10³	x 10	x 10
HEB 140	340 x 10	60,4	140,0	140,0	7,0	12,0	12,0	77,0	2580	250	4,7	10,3
HEM 140	350 x 10	90,7	160,0	146,0	13,0	22,0	12,0	115,6	5057	478	6,4	10,6
HEM 140	350 x 15	104,4	160,0	146,0	13,0	22,0	12,0	133,1	5735	501	6,0	11,5
HEM 140	350 x 20	118,2	160,0	146,0	13,0	22,0	12,0	150,6	6348	521	5,8	12,2
HEB 160	360 x 10	70,8	160,0	160,0	8,0	13,0	15,0	90,3	4058	356	5,6	11,4
HEM 160	370 x 10	105,2	180,0	166,0	14,0	23,0	15,0	134,1	7519	647	7,4	11,6
HEM 160	370 x 15	119,8	180,0	166,0	14,0	23,0	15,0	152,6	8465	675	7,0	12,5
HEM 160	370 x 20	134,3	180,0	166,0	14,0	23,0	15,0	171,1	9322	699	6,7	13,3
HEM 160	370 x 25	148,8	180,0	166,0	14,0	23,0	15,0	189,6	10122	723	6,5	14,0
HEB 180	380 x 10	81,1	180,0	180,0	8,5	14,0	15,0	103,3	6002	480	6,5	12,5
HEB 180	380 x 15	96,0	180,0	180,0	8,5	14,0	15,0	122,3	6734	497	6,0	13,5
HEM 180	390 x 10	119,5	200,0	186,0	14,5	24,0	15,0	152,3	10685	842	8,3	12,7
HEM 180	390 x 15	134,8	200,0	186,0	14,5	24,0	15,0	171,8	11952	875	7,8	13,7
HEM 180	390 x 20	150,1	200,0	186,0	14,5	24,0	15,0	191,3	13098	904	7,5	14,5
HEM 180	390 x 25	165,4	200,0	186,0	14,5	24,0	15,0	210,8	14165	932	7,3	15,2
HEB 200	400 x 10	92,7	200,0	200,0	9,0	15,0	18,0	118,1	8616	636	7,4	13,6
HEB 200	400 x 15	108,4	200,0	200,0	9,0	15,0	18,0	138,1	9628	656	6,8	14,7
HEM 200	410 x 10	135,2	220,0	206,0	15,0	25,0	18,0	172,3	14777	1076	9,3	13,7
HEM 200	410 x 15	151,3	220,0	206,0	15,0	25,0	18,0	192,8	16436	1114	8,8	14,7
HEM 200	410 x 20	167,4	220,0	206,0	15,0	25,0	18,0	213,3	17937	1149	8,4	15,6
HEM 200	410 x 25	183,5	220,0	206,0	15,0	25,0	18,0	233,8	19333	1181	8,1	16,4
HEM 200	410 x 30	199,6	220,0	206,0	15,0	25,0	18,0	254,3	20656	1212	8,0	17,0
HEB 220	420 x 10	104,4	220,0	220,0	9,5	16,0	18,0	133,0	11895	813	8,4	14,6
HEB 220	420 x 15	120,9	220,0	220,0	9,5	16,0	18,0	154,0	13243	838	7,7	15,8
HEB 220	420 x 20	137,4	220,0	220,0	9,5	16,0	18,0	175,0	14410	860	7,2	16,8
HEM 220	430 x 10	151,1	240,0	226,0	15,5	26,0	18,0	192,4	19826	1340	10,2	14,8
HEM 220	430 x 15	167,9	240,0	226,0	15,5	26,0	18,0	213,9	21941	1385	9,7	15,8
HEM 220	430 x 20	184,8	240,0	226,0	15,5	26,0	18,0	235,4	23859	1425	9,3	16,7
HEM 220	430 x 25	201,7	240,0	226,0	15,5	26,0	18,0	256,9	25638	1461	9,0	17,5
HEM 220	430 x 30	218,6	240,0	226,0	15,5	26,0	18,0	278,4	27320	1497	8,7	18,3

Poutrelles SFB (suite)
Etat de surface conforme à EN 10163-3: 1991, classe C, sous-classe 1

SFB beams (continued)
Surface condition according to EN 10163-3: 1991, class C, subclass 1

SFB-Träger (Fortsetzung)
Oberflächenbeschaffenheit gemäß EN 10163-3: 1991, Klasse C, Untergruppe 1



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Désignation Designation Bezeichnung			Dimensions Abmessungen						Valeurs statiques Section properties Statische Kennwerte			
	b_p x t_p mm x mm	G kg/m	h_{eff} mm	b mm	t_w mm	t_f mm	r mm	A mm^2	I_y mm^4	$W_{el.y}$ mm^3	z_1 mm	z_2 mm
								x 10^2	x 10^4	x 10^3	x 10	x 10
HEB 240	440 x 10	117,7	240,0	240,0	10,0	17,0	21,0	150,0	16121	1029	9,3	15,7
HEB 240	440 x 15	135,0	240,0	240,0	10,0	17,0	21,0	172,0	17883	1059	8,6	16,9
HEB 240	440 x 20	152,3	240,0	240,0	10,0	17,0	21,0	194,0	19414	1085	8,1	17,9
HEM 240	450 x 10	192,0	270,0	248,0	18,0	32,0	21,0	244,6	31491	1959	11,9	16,1
HEM 240	450 x 15	209,7	270,0	248,0	18,0	32,0	21,0	267,1	34545	2020	11,4	17,1
HEM 240	450 x 20	227,3	270,0	248,0	18,0	32,0	21,0	289,6	37361	2075	11,0	18,0
HEM 240	450 x 25	245,0	270,0	248,0	18,0	32,0	21,0	312,1	40001	2126	10,7	18,8
HEM 240	450 x 30	262,6	270,0	248,0	18,0	32,0	21,0	334,6	42510	2174	10,4	19,6
HEM 240	450 x 35	280,3	270,0	248,0	18,0	32,0	21,0	357,1	44923	2221	10,3	20,2
HEM 240	450 x 40	298,0	270,0	248,0	18,0	32,0	21,0	379,6	47268	2267	10,1	20,9
HEB 260	460 x 10	129,1	260,0	260,0	10,0	17,5	24,0	164,4	20962	1249	10,2	16,8
HEB 260	460 x 15	147,1	260,0	260,0	10,0	17,5	24,0	187,4	23176	1283	9,4	18,1
HEB 260	460 x 20	165,2	260,0	260,0	10,0	17,5	24,0	210,4	25099	1313	8,9	19,1
HEM 260	470 x 10	209,3	290,0	268,0	18,0	32,5	24,0	266,6	40022	2334	12,9	17,1
HEM 260	470 x 15	227,8	290,0	268,0	18,0	32,5	24,0	290,1	43732	2402	12,3	18,2
HEM 260	470 x 20	246,2	290,0	268,0	18,0	32,5	24,0	313,6	47153	2463	11,9	19,1
HEM 260	470 x 25	264,7	290,0	268,0	18,0	32,5	24,0	337,1	50357	2519	11,5	20,0
HEM 260	470 x 30	283,1	290,0	268,0	18,0	32,5	24,0	360,6	53396	2573	11,2	20,8
HEM 260	470 x 35	301,6	290,0	268,0	18,0	32,5	24,0	384,1	56312	2624	11,0	21,5
HEM 260	470 x 40	320,0	290,0	268,0	18,0	32,5	24,0	407,6	59136	2675	10,9	22,1
HEB 280	480 x 10	140,8	280,0	280,0	10,5	18,0	24,0	179,4	26666	1491	11,1	17,9
HEB 280	480 x 15	159,6	280,0	280,0	10,5	18,0	24,0	203,4	29402	1530	10,3	19,2
HEB 280	480 x 20	178,5	280,0	280,0	10,5	18,0	24,0	227,4	31782	1563	9,7	20,3
HEM 280	490 x 10	227,0	310,0	288,0	18,5	33,0	24,0	289,2	49970	2744	13,8	18,2
HEM 280	490 x 15	246,2	310,0	288,0	18,5	33,0	24,0	313,7	54422	2819	13,2	19,3
HEM 280	490 x 20	265,5	310,0	288,0	18,5	33,0	24,0	338,2	58528	2886	12,7	20,3
HEM 280	490 x 25	284,7	310,0	288,0	18,5	33,0	24,0	362,7	62371	2948	12,3	21,2
HEM 280	490 x 30	303,9	310,0	288,0	18,5	33,0	24,0	387,2	66010	3007	12,0	22,0
HEM 280	490 x 35	323,2	310,0	288,0	18,5	33,0	24,0	411,7	69494	3063	11,8	22,7
HEM 280	490 x 40	342,4	310,0	288,0	18,5	33,0	24,0	436,2	72860	3118	11,6	23,4

SFB = "Slim Floor Beam"

SFB

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Désignation Designation Bezeichnung			Dimensions Abmessungen						Valeurs statiques Section properties Statische Kennwerte			
	$b_p \times t_p$ mm x mm	G kg/m	h_{eff} mm	b mm	t_w mm	t_f mm	r mm	A mm^2	I_y mm^4	$W_{el.y}$ mm^3	z_1 mm	z_2 mm
								x 10^2	x 10^4	x 10^3	x 10	x 10
HEB 300	500 x 10	156,3	300,0	300,0	11,0	19,0	27,0	199,1	34165	1808	12,1	18,9
HEB 300	500 x 15	175,9	300,0	300,0	11,0	19,0	27,0	224,1	37557	1853	11,2	20,3
HEB 300	500 x 20	195,5	300,0	300,0	11,0	19,0	27,0	249,1	40521	1891	10,6	21,4
HEB 300	500 x 25	215,2	300,0	300,0	11,0	19,0	27,0	274,1	43185	1927	10,1	22,4
HEM 300	510 x 10	278,0	340,0	310,0	21,0	39,0	27,0	354,1	72574	3718	15,5	19,5
HEM 300	510 x 15	298,0	340,0	310,0	21,0	39,0	27,0	379,6	78460	3813	14,9	20,6
HEM 300	510 x 20	318,0	340,0	310,0	21,0	39,0	27,0	405,1	83961	3899	14,5	21,5
HEM 300	510 x 25	338,0	340,0	310,0	21,0	39,0	27,0	430,6	89158	3980	14,1	22,4
HEM 300	510 x 30	358,0	340,0	310,0	21,0	39,0	27,0	456,1	94113	4056	13,8	23,2
HEM 300	510 x 35	378,0	340,0	310,0	21,0	39,0	27,0	481,6	98877	4129	13,6	23,9
HEM 300	510 x 40	398,1	340,0	310,0	21,0	39,0	27,0	507,1	103490	4199	13,4	24,6
HEB 320	500 x 10	165,9	320,0	300,0	11,5	20,5	27,0	211,3	41220	2071	13,1	19,9
HEB 320	500 x 15	185,5	320,0	300,0	11,5	20,5	27,0	236,3	45202	2121	12,2	21,3
HEB 320	500 x 20	205,2	320,0	300,0	11,5	20,5	27,0	261,3	48699	2164	11,5	22,5
HEB 320	500 x 25	224,8	320,0	300,0	11,5	20,5	27,0	286,3	51847	2203	11,0	23,5

Notations et formules

Notations and formulae

Bezeichnungen und Formeln

Dans la mesure du possible, les désignations sont celles de l'Eurocode.

Les formules imprimées sur fond de couleur se rapportent uniquement aux poutrelles I et H à ailes parallèles.

Where possible, the designations correspond to those of the Eurocode.

The formulae printed on a coloured background are only valid for I and H sections with parallel flanges.

Die verwendeten Formeln stimmen so weit wie möglich mit denjenigen des Eurocode überein.

Die Formeln auf farbiger Unterlage beziehen sich auf parallelflanschige I- und H-Träger.

A — **aire de section** / **area of section** / **Querschnittsfläche**

$$A = 2\, t_f\, b + (h - 2\, t_f)\, t_w + (4 - \pi)\, r^2$$

A_G — **surface à peindre par unité de masse** / **painting surface per unit mass** / **Anstrichfläche pro Masseneinheit**

$$A_G = \frac{A_L}{A \cdot \rho_a}$$

A_L — **surface à peindre par unité de longueur** / **painting surface per unit length** / **Anstrichfläche pro Längeneinheit**

$$A_L = [4\,(b - 2\,r) + 2\,(h - t_w) + 2\,\pi\,r]\,\frac{L}{L}$$

A_m — **surface de l'élément métallique exposée au feu** par unité de longueur / **surface area of the steel section exposed to fire** per unit length / **dem Feuer ausgesetzte Fläche des Stahlträgers** pro Längeneinheit

A_{net} — **aire nette de la section** après déduction d'un trou de boulon / **net area of section** after deduction of a single bolt hole / **Netto-Querschnittsfläche** nach Abzug eines einzelnen Schraubenlochs

A_p — **surface interne de la protection contre le feu** par unité de longueur / **area of the inner surface of the fire protection material** per unit length / **innere Abwicklungsfläche der Feuerverkleidung** pro Längeneinheit

A_{vz} — **aire de cisaillement** effort parallèle à l'âme / **shear area** load parallel to web / **wirksame Schubfläche** Lastrichtung in Stegebene

$$A_{vz} = A - 2\,b\,t_f + (t_w + 2\,r)\,t_f$$

a — **inclinaison des axes principaux d'inertie** / **inclination of main axes of inertia** / **Neigung der Hauptträgheitsachsen**

b — **largeur du profilé** / **width of section** / **Profilbreite**

d — **hauteur de la portion droite de l'âme** / **depth of straight portion of web** / **Höhe des geraden Stegteils**

$$d = h - 2\,t_f - 2\,r$$

e_{min}, e_{max}
pinces admissibles
pour assemblages par boulon, calculées pour assurer une surface d'assise en dehors du rayon de congé et pour respecter les distances minimales et maximales des bords conformément à ENV 1993-1-1: 1992 § 6.5.1. Ces conditions sont également respectées pour des boulons d'un diamètre inférieur à Ø. Les valeurs sont calculées en prenant en compte des trous à jeu nominal de 2 mm pour les boulons M10 à M24, et de 3 mm pour les boulons M27.

Il y a lieu de vérifier au cas par cas la stabilité au voilement local et, si besoin est, les critères de résistance à la corrosion.

e_{min}, e_{max}
allowable edge distances
for bolted connections, determined for an arrangement of the contact area outside the radius of the root fillet and to satisfy the requirements of ENV 1993-1-1: 1992 § 6.5.1 for minimum and maximum edge distances. These conditions are also fulfilled for bolt diameters smaller than Ø. The values are calculated considering a nominal clearance in holes of 2 mm for M10 to M24 bolts and of 3 mm for M27 bolts.

Local buckling requirements and, if applicable, the resistance to corrosion have to be checked.

e_{min}, e_{max}
zulässiger Randabstand
für geschraubte Verbindungen zur Positionierung der Auflagerfläche außerhalb der Ausrundungen sowie zur Einhaltung der minimalen und maximalen Randabstände nach ENV 1993-1-1: 1992 § 6.5.1. Diese Bedingungen sind ebenfalls für Schraubendurchmesser kleiner als Ø erfüllt. Die Werte sind für ein Nennlochspiel von 2 mm für Schraubengrößen M10 bis M24 und von 3 mm für Schraubengröße M27 berechnet.

Von Fall zu Fall müssen die örtliche Beulsicherheit und gegebenenfalls der Korrosionswiderstand geprüft werden.

G **masse par unité de longueur**

G **mass per unit length**

G **Masse pro Längeneinheit**

$$G = A\, r_a$$

h **hauteur du profilé**

h **depth of section**

h **Profilhöhe**

h_i **hauteur intérieure entre les ailes**

h_i **inner depth between flanges**

h_i **innere Höhe zwischen Flanschen**

$$h_i = h - 2\, t_f$$

I **moment d'inertie de flexion**

I **second moment of area**

I **Flächenmoment 2. Grades**

$$I_y = \frac{1}{12}\left[b\, h^3 - (b - t_w)(h - 2\, t_f)^3\right] + 0{,}03\, r^4 + 0{,}2146\, r^2 (h - 2\, t_f - 0{,}4468\, r)^2$$

$$I_z = \frac{1}{12}\left[2\, t_f\, b^3 + (h - 2\, t_f)\, t_w^3\right] + 0{,}03\, r^4 + 0{,}2146\, r^2 (t_w + 0{,}4468\, r)^2$$

i **rayon de giration**

i **radius of gyration**

i **Trägheitshalbmesser**

$$i_y = \sqrt{\frac{I_y}{A}} \qquad i_z = \sqrt{\frac{I_z}{A}} \qquad i_u = \sqrt{\frac{I_u}{A}} \qquad i_v = \sqrt{\frac{I_v}{A}}$$

I_t **moment d'inertie de torsion**

I_t **torsion constant**

I_t **Torsionsflächenmoment 2. Grades**

$$I_t = \frac{2}{3}(b - 0{,}63\; t_f)\; t_f^3 + \frac{1}{3}(h - 2\; t_f)\; t_w^3 + 2\left(\frac{t_w}{t_f}\right)\left(0{,}145 + 0{,}1\;\frac{r}{t_f}\right)\left[\frac{(r + t_w/2)^2 + (r + t_f)^2 - r^2}{2\; r + t_f}\right]^4$$

I_w **moment d'inertie de gauchissement** par rapport au centre de cisaillement

I_w **warping constant** referred to the shear centre

I_w **Wölbflächenmoment 2. Grades** bezogen auf den Schubmittelpunkt

$$I_w = \frac{t_f\, b^3}{24}\,(h-t_f)^2$$

I_{yz} **moment d'inertie composé** (moment centrifuge)

p_{min}, p_{max} **pinces admissibles** pour assemblages par boulon, calculées pour assurer une surface d'assise en dehors du rayon de congé et pour respecter les distances minimales et maximales des bords et la distance minimale des files situées de part et d'autre de l'âme conformément à ENV 1993-1-1 : 1992 § 6.5.1. Ces conditions sont également respectées pour des boulons d'un diamètre inférieur à Ø. Les valeurs sont calculées en prenant en compte des trous à jeu nominal de 2 mm pour les boulons M10 à M24, et de 3 mm pour les boulons M27.

Il est supposé que l'axe de référence pour le forage des trous est l'axe passant par l'âme à mi-épaisseur. Si tel n'est pas le cas, la valeur de pmin à appliquer peut différer légèrement en fonction des tolérances de laminage.

Il y a lieu de vérifier au cas par cas la stabilité au voilement local et, si besoin est, les critères de résistance à la corrosion.

Ø **diamètre de boulon maximal**

r, r_1 **rayon de congé**

r_2 **rayon de congé extérieur**

r_a **masse volumique de l'acier**

s_s **longueur d'appui rigide** suivant ENV 1993-1-1 § 5.7.2

I_{yz} **centrifugal moment**

p_{min}, p_{max} **allowable edge distances** for bolted connections, determined for an arrangement of the contact area outside the radius of the root fillet and to satisfy the requirements of ENV 1993-1-1 : 1992 § 6.5.1 for minimum and maximum edge distances. These conditions are also fulfilled for bolt diameters smaller than Ø. The values are calculated considering a nominal clearance in holes of 2 mm for M10 to M24 bolts and of 3 mm for M27 bolts.

It is assumed that the reference axis for drilling the holes is the centre-line of the web. If not, the applicable pmin value may differ slightly depending on the rolling tolerances.

Local buckling requirements and, if applicable, the resistance to corrosion have to be checked.

Ø **maximum bolt diameter**

r, r_1 **radius of root fillet**

r_2 **toe radius**

r_a **unit mass of steel**

s_s **length of stiff bearing** according to ENV 1993-1-1 § 5.7.2

I_{yz} **Flächenzentrifugalmoment 2. Grades**

p_{min}, p_{max} **zulässiger Randabstand** für geschraubte Verbindungen zur Positionierung der Auflagerfläche außerhalb der Ausrundungen sowie zur Einhaltung der minimalen und maximalen Randabstände nach ENV 1993-1-1 : 1992 § 6.5.1. Diese Bedingungen sind ebenfalls für Schraubendurchmesser kleiner als Ø erfüllt. Die Werte sind für ein Nennlochspiel von 2 mm für Schraubengrößen M10 bis M24 und von 3 mm für Schraubengröße M27 berechnet.

Es wird angenommen, dass die Stegachse die Bezugsachse zur Bohrung der Löcher ist. Sollte dies nicht der Fall sein, kann sich der pmin-Wert in Abhängigkeit der Walztoleranzen leicht verändern.

Von Fall zu Fall müssen die örtliche Beulsicherheit und gegebenenfalls der Korrosionswiderstand geprüft werden.

Ø **maximaler Schraubendurchmesser**

r, r_1 **Ausrundungsradius**

r_2 **Abrundungsradius**

r_a **Dichte des Stahls**

s_s **Lastverteilungsbreite** gemäß ENV 1993-1-1 § 5.7.2

$$s_s = t_w + 2\,t_f + (4-2\sqrt{2})\,r$$

La longueur d'appui rigide de l'aile est la distance sur laquelle une charge est effectivement distribuée; elle influence la résistance de l'âme sans raidisseur d'un profilé adjacent aux efforts transversaux.

The length of stiff bearing on the flange is the distance over which an applied force is effectively distributed. It influences the resistance of the unstiffened web of an adjacent section to transverse forces.

Die Lastverteilungsbreite an den Flanschen ist die Breite, die für die Annahme einer tatsächlichen Lastverteilung zugrundegelegt werden darf. Sie beeinflusst den Widerstand des nicht ausgesteiften Stegs eines angrenzenden Profils gegenüber eingeleiteten Querlasten.

t épaisseur

t_f épaisseur d'aile

t_w épaisseur d'âme

u distance de la fibre extrême à l'axe principal v/major

v distance de la fibre extrême à l'axe principal u

V volume de l'élément métallique par unité de longueur

W_{el} module de flexion élastique

t thickness

t_f flange thickness

t_w web thickness

u distance of extreme fibre to minor v-axis

v distance of extreme fibre to major u-axis

V volume of the steel member per unit length

W_{el} elastic section modulus

t Stärke

t_f Flanschdicke

t_w Stegdicke

u Abstand der äußeren Faser zur v-Hauptachse

v Abstand der äußeren Faser zur u-Hauptachse

V Volumen des Stahlprofils pro Längeneinheit

W_{el} elastisches Widerstandsmoment

$$W_y = \frac{2 \cdot I_y}{h} \qquad W_z = \frac{2 \cdot I_z}{b}$$

W_{pl} module de flexion plastique

Pour un dimensionnement plastique, la section doit appartenir à la classe 1 ou 2 selon la capacité de rotation requise.

W_{pl} plastic section modulus

For plastic design, the cross section must belong to class 1 or 2 according to the required rotation capacity.

W_{pl} plastisches Widerstandsmoment

Bei einer plastischen Bemessung muss das Profil der Klasse 1 oder 2, gemäß der erforderlichen Rotationskapazität, angehören.

$$W_{pl.y} = \frac{t_w\ h^2}{4} + (b - t_w)\ (h - t_f)\ t_f + \frac{4 - p}{2}\ r^2\ (h - 2\ t_f) + \frac{3\ p - 10}{3}\ r^3$$

$$W_{pl.z} = \frac{b^2\ t_f}{2} + \frac{h - 2\ t_f}{4}\ t_w^{\ 2} + r^3\ (\frac{10}{3} - p) + (2 - \frac{p}{2})\ t_w\ r^2$$

Pour les fers U :
Wpl.z' module de flexion plastique par rapport à l'axe neutre plastique z', parallèle à l'axe z.

For channels:
Wpl.z' plastic section modulus referred to plastic neutral z' axis which is parallel to z axis.

Für U-Profile :
Wpl.z' plastisches Widerstandsmoment bezogen auf die plastische neutrale z'-Achse, die parallel zur z-Achse ist.

y_m distance du centre de cisaillement

y_s distance du centre de gravité suivant l'axe y

z_s, z_1, z_2 distance du centre de gravité suivant l'axe z

y_m distance of shear centre

y_s distance of centre of gravity along y-axis

z_s, z_1, z_2 distance of centre of gravity along z-axis

y_m Abstand des Schubmittelpunktes

y_s Schwerpunktabstand in Richtung y-Achse

z_s, z_1, z_2 Schwerpunktabstand in Richtung z-Achse