# SVENSK STANDARD
# SS-EN 1993-1-8:2005

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## Eurokod 3 : Dimensionering av stålkonstruktioner – Del 1-8: Dimensionering av knutpunkter och förband

## Eurocode 3: Design of steel structures – Part 1-8: Design of joints

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The European Standard EN 1993-1-8:2005 has the status of a Swedish Standard. This document contains the official English version of EN 1993-1-8:2005+EN 1993-1-8:2005/AC:2005.



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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

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.

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.

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

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Ref. No. EN 1993-1-8:2005: 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 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.

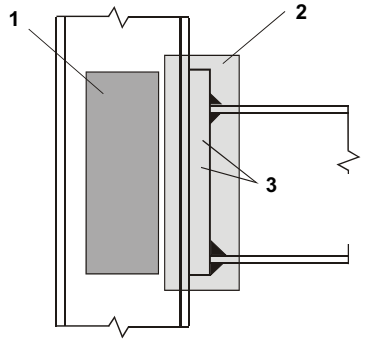
**1.4.6**
**rotational capacity**

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.

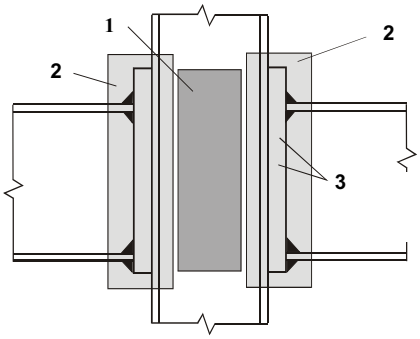
**1.4.8**
**structural properties** (of a joint)
Resistance to internal forces and moments in the connected members, rotational stiffness and rotation capacity.

**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

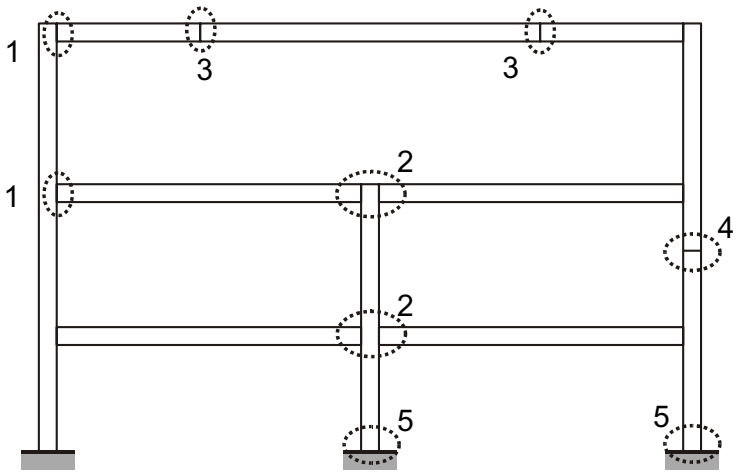



Left joint = web panel in shear + left connection
Right joint = web panel in shear + right connection

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;*

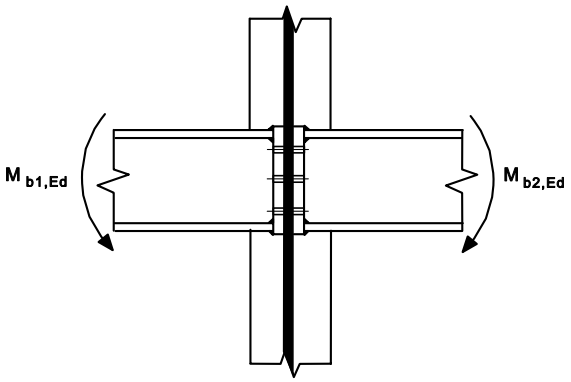
*2* *Double-sided beam-to-column joint configuration;*

*3* *Beam splice;*

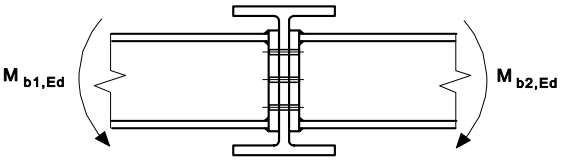
*4* *Column splice;*

*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;

$\ell_{eff}$ 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;

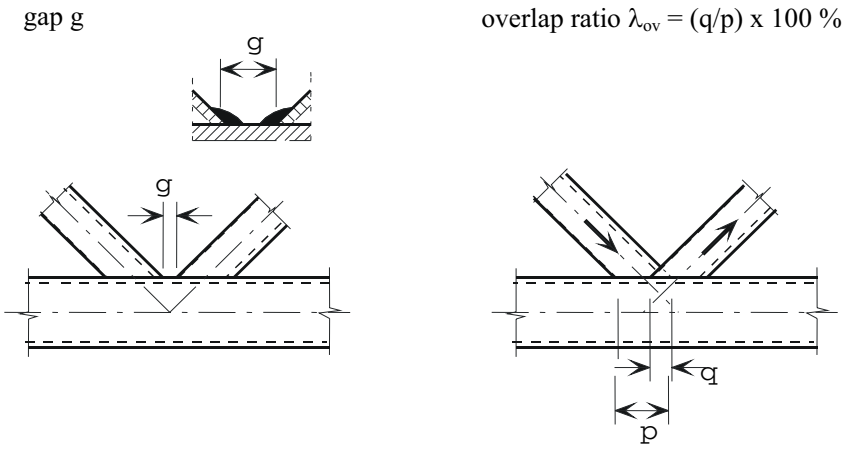
$A_0$ is the area of the rivet hole;

$A_{vc}$ 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;
$\mu$ is the slip factor;
$\phi$ 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;

$\ell$ 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;

$\alpha$ is a factor defined in the relevant table;

$\theta_i$ is the included angle between brace member $i$ and the chord ($i$ = 1, 2 or 3);

$\kappa$ is a factor defined where it occurs;

$\mu$ is a factor defined in the relevant table;

$\varphi$ is the angle between the planes in a multiplanar joint.