Steel Design to Eurocode 3

Joints

Eurocode 3 Part: 1-8

Joint Types

CL 5.2.2.2 '**Nominally pinned**' joints are capable of transmitting internal forces without developing significant moments, and capable of accepting the resulting rotations under the design loads.

CL 5.2.2.3 '**Rigid and full strength**' joints have sufficient rotational stiffness to justify analysis based on full continuity.

'**Semi-rigid**' joints lie somewhere between 'nominally pinned' and 'rigid'.

Eurocode 3

- Principles mostly the same as BS 5950
- Results are similar although EC3 results are slightly more conservative and this is due to the larger partial safety factor (γ_{M2}=1.25)

Bolt Strength

These values should be adopted as characteristic values in design calculations :

Bolt classes	4.6	5.6	8.8	10.9
f_{yb} (N/mm^2)	240	300	640	900
f_{ub} (N/mm^2)	400	500	800	1000

EN 1993-1-8 Table 3.1 - Nominal values of f_{yb} and f_{ub} for bolts

Steel Strength

Steel grade	f_y (N/mm^2)				f_u (N/mm^2)	
	Nominal thickness of element t (mm)				Nominal thickness of element t (mm)	
	t ≤ 16	16 < t ≤ 40	40 < t ≤ 63	63 < t ≤ 80	t < 3	3 ≤ t ≤ 100
S 275	275	265	255	245	430 to 580	410 to 560
S 355	355	345	335	325	510 to 680	470 to 630

Extract from Table 7 of EN 10025-2

EN 1993-1-8 Clause 2.2

- Partial safety factors, γ_M for joints are given in Table 2.1 of EC 3-8.
- Refer to NA to get the required values of the different partial safety factors
- Resistance of bolts and welds, γ_{M2} = 1.25

Bolted Joints – Table 3.4

Table 3.4 of EN 1993-1-8 gives the different checks required for individual fasteners subjected to shear and/or tension.

Checks need to be carried out for a number of possible failure modes:

- Shear resistance per shear plate
- Bearing Resistance
- Tension Resistance
- Combined shear and tension

Bolted Joints – Tension

Tension resistance for ordinary bolts:

$$F_{t,Rd} = k_2 f_{ub} \frac{A_s}{\gamma_{M2}}$$

where:

- A_s is the tensile stress area of the bolt
- γ_{M2} = 1.25
- f_{ub} is the ultimate tensile strength of the bolt
- k_2 = 0.63 for countersunk bolt, otherwise k_2 = 0.9

Bolted Joints – Shear

Shear resistance per shear plane for ordinary bolts where the shear plane passes through the threaded portion of the bolt:

$$F_{v,Rd} = \alpha_v f_{ub} \frac{A_s}{\gamma_{M2}}$$

where:

- A_s is the tensile stress area of the bolt
- f_{ub} is the ultimate tensile strength of the bolt
- γ_{M2} = 1.25

Bolt classes	4.6	4.8	5.6	5.8	6.8	8.8	10.9
α_v	0.6	0.5	0.6	0.5	0.5	0.6	0.5

Shear resistance per shear plane for ordinary bolts where the shear plane passes through the unthreaded portion of the bolt:

$$F_{v,Rd} = 0.6 f_{ub} \frac{A}{\gamma_{M2}}$$

where:

- A is the gross cross-section of the bolt
- f_{ub} is the ultimate tensile strength of the bolt
- $\gamma_{M2} = 1.25$

Bolted Joints – Bearing

Bearing resistance for ordinary bolts:

$$F_{b,Rd} = k_1 \alpha_b f_u \frac{dt}{\gamma_{M2}}$$

where:

- d is the bolt diameter
- t is the thickness
- γ_{M2} = 1.25
- f_u is the ultimate tensile strength
- $\alpha_b = min\left(\frac{e_1}{3d_0}; \frac{f_{ub}}{f_u}; 1.0\right)$ for end bolts
- $\alpha_b = min\left(\frac{p_1}{3d_0} - \frac{1}{4}; \frac{f_{ub}}{f_u}; 1.0\right)$ for inner bolts

Perpendicular to the direction of load transfer:

- $k_1 = min\left(2.8\frac{e_2}{d_0} - 1.7; 2.5\right)$ for edge bolts
- $k_1 = min\left(1.4\frac{p_2}{d_0} - 1.7; 2.5\right)$ for inner bolts

Bolted Joints – Position of Holes

Table 3.3 of EN 1993-1-8 gives the maximum and minimum spacing, end and edge distances

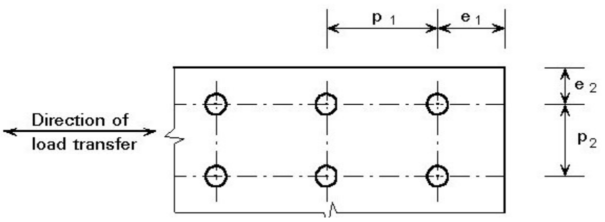

Image Source: ESDEP

	Minimum distance
End distance e_1	$1.2d_0$
Edge distance e_2	$1.2d_0$
Spacing p1	2.2d0
Spacing p2	2.4d0

where d_0 =hole diameter

Welded Joints

Simplified method for design resistance of fillet weld (CL 4.5.3.3 and Table 4.1 EN 1993-1-8)

$$F_{w,Ed} \leq F_{w,Rd} \qquad (4.2)$$

$F_{w,Ed}$ is the design value of the weld force per unit length

$F_{w,Rd}$ is the design resistance per unit length

$$F_{w,Rd} = f_{vw,d}a$$

$f_{vw,d}$ is the design shear strength of the weld

a is the effective throat thickness (see Figure 1)

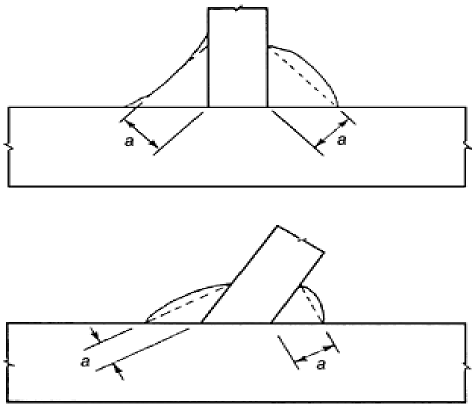

Figure 1 – effective throat thickness
Image Source: Design of Structural Elements (Arya, 2009) Page 421

$$f_{vw,d} = \frac{f_u/\sqrt{3}}{\beta_w \gamma_{M2}} \qquad (4.4)$$

f_u is the minimum ultimate tensile strength of the connected parts

β_w is a correlation factor (See Table 4.1)

$\gamma_{M2} = 1.25$

Steel grade	Correlation factor β_w
S275	0.85
S355	0.90

*Extract from **Table 4.1** from EN 1993-1-8: Values for correlation factor β_w*