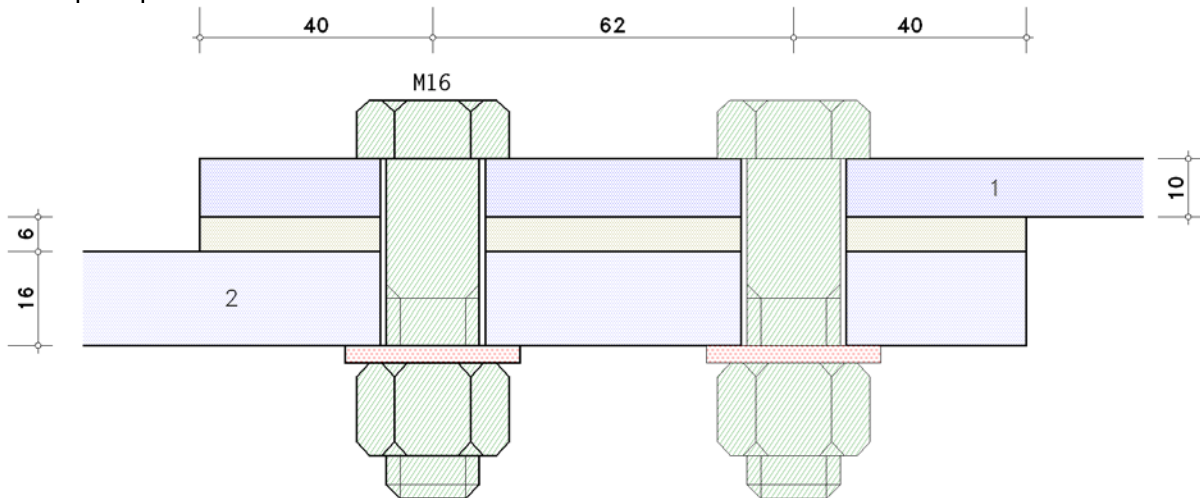


1. Bolted Connection

EC 3-1-8 (04.25), NA: Deutschland

1.1. input report



connection device

bolt: bolt class 8.8, bolt size M16, normal wrench size

connection plates

plate 1 with thickness $t_1 = 10.0$ mm

plate 2 with thickness $t_2 = 16.0$ mm

packing with thickness $t_p = 6.0$ mm

steel grade S235

verifications

single shear connection

shear connection category A (shear, bearing failure):

design ultimate shear load per bolt $F_{v,Ed} = 50.0$ kN

shear: shear plane passes through the unthreaded portion of the bolt

bearing resistance in direction of load transfer:

edge distance $e_{1,1} = 40.0$ mm, $e_{1,2} = 40.0$ mm, pitch $p_1 = 62.0$ mm

long connection with $L_j = 400.0$ mm

bearing resistance across to direction of load transfer:

$e_{2,1} = 30.0$ mm, $e_{2,2} = 30.0$ mm, pitch $p_2 = 45.0$ mm

bearing resistance: limitation of bearing deformation

tension connection category D (tension, punching):

design value of the applied tensile force per bolt $F_{t,Ed} = 30.0$ kN

partial safety factors for material

resistance of bolts, welds, plates in bearing $\gamma_{M2} = 1.25$

1.2. resistance

edge dist.:	$e_1 = 40.0$ mm > $1.2 \cdot d_0 = 21.6$ mm,	$e_1 = 40.0$ mm < $4 \cdot t_1 + 40$ mm = 80.0 mm
edge dist.:	$e_1 = 40.0$ mm > $1.2 \cdot d_0 = 21.6$ mm,	$e_1 = 40.0$ mm < $4 \cdot t_2 + 40$ mm = 104.0 mm
pitch:	$p_1 = 62.0$ mm > $2.2 \cdot d_0 = 39.6$ mm,	$p_1 = 62.0$ mm < $\min(14 \cdot t_{min}, 200$ mm) = 140.0 mm
edge dist.:	$e_2 = 30.0$ mm > $1.2 \cdot d_0 = 21.6$ mm,	$e_2 = 30.0$ mm < $4 \cdot t_{min} + 40$ mm = 80.0 mm
pitch:	$p_2 = 45.0$ mm > $2.4 \cdot d_0 = 43.2$ mm,	$p_2 = 45.0$ mm < $\min(14 \cdot t_{min}, 200$ mm) = 140.0 mm

shear connection category A: shear/bearing resistance

shear

shear plane passes through the unthreaded portion of the bolt: $\alpha_v = 0.6$, $A = 2.01$ cm²

shear resistance $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A / \gamma_{M2} = 77.21$ kN, $f_{ub} = 800.0$ N/mm²

packing with $t_p = 6.0$ mm > $d/3 = 5.3$ mm: reduction factor $\beta_p = 9 \cdot d / (8 \cdot d + 3 \cdot t_p) = 0.99 \Rightarrow F_{v,Rd} = 76.150$ kN

long connection in direction of load transfer: $\beta_{Lf} = 1 - (L_j - 15 \cdot d) / (200 \cdot d) = 0.950 \Rightarrow F_{v,Rd} = \beta_{Lf} \cdot 76.15 = 72.34$ kN

$F_{v,Ed} = 50.0$ kN < $F_{v,Rd} = 72.34$ kN $\Rightarrow U = 0.691 < 1$ **ok**

bearing resistance of plate 1 and bolt

inner bolt: $\alpha_{d,i} = p_1 / d_0 - 1/2 = 2.94$

end bolt: $\alpha_{d,a} = e_1 / d_0 = 2.22$

$\Rightarrow \alpha_b = 2.22$ (smallest value of $\alpha_{d,i}$, $\alpha_{d,a}$ or $3 \cdot f_{ub} / f_u = 6.67$ or 3.0)

limitation of bearing deformation: $\alpha_b = 1.8$

normal bolt $k_m = 1.0$

bearing resistance: $F_{b,Rd} = (k_m \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 81.92 \text{ kN}$, $f_u = 360.0 \text{ N/mm}^2$, $t = 10.0 \text{ mm}$, $d = 16.0 \text{ mm}$
edge bolt across to direction of load transfer: $N_{u,Rd} = 2 \cdot (e_2 - d_0/2) \cdot t \cdot f_u / \gamma_{M2} = 120.96 \text{ kN} > F_{b,Rd}$ **ok**
packing with $t_p = 6.0 \text{ mm} > d/3 = 5.3 \text{ mm}$: $\beta_p = 9 \cdot d / (8 \cdot d + 3 \cdot t_p) = 0.986 \Rightarrow F_{b,Rd} = 80.80 \text{ kN}$
long connection in direction of load transfer: $\beta_{Lf} = 1 - (L_j - 15 \cdot d) / (200 \cdot d) = 0.950 \Rightarrow F_{b,Rd} = \beta_{Lf} \cdot 80.80 = 76.76 \text{ kN}$
 $F_{v,Ed} = 50.0 \text{ kN} < F_{b,Rd} = 76.76 \text{ kN} \Rightarrow U = 0.651 < 1$ **ok**

bearing resistance of plate 2 and bolt

inner bolt: $\alpha_{d,i} = p_1/d_0 - 1/2 = 2.94$

end bolt: $\alpha_{d,a} = e_1/d_0 = 2.22$

$\Rightarrow \alpha_b = 2.22$ (smallest value of $\alpha_{d,i}$, $\alpha_{d,a}$ or $3 \cdot f_{ub}/f_u = 6.67$ or 3.0)

limitation of bearing deformation: $\alpha_b = 1.8$

normal bolt $k_m = 1.0$

bearing resistance: $F_{b,Rd} = (k_m \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 131.07 \text{ kN}$, $f_u = 360.0 \text{ N/mm}^2$, $t = 16.0 \text{ mm}$, $d = 16.0 \text{ mm}$

edge bolt across to direction of load transfer: $N_{u,Rd} = 2 \cdot (e_2 - d_0/2) \cdot t \cdot f_u / \gamma_{M2} = 193.54 \text{ kN} > F_{b,Rd}$ **ok**

packing with $t_p = 6.0 \text{ mm} > d/3 = 5.3 \text{ mm}$: $\beta_p = 9 \cdot d / (8 \cdot d + 3 \cdot t_p) = 0.986 \Rightarrow F_{b,Rd} = 129.28 \text{ kN}$

long connection in direction of load transfer: $\beta_{Lf} = 1 - (L_j - 15 \cdot d) / (200 \cdot d) = 0.950 \Rightarrow F_{b,Rd} = \beta_{Lf} \cdot 129.28 = 122.81 \text{ kN}$

$F_{v,Ed} = 50.0 \text{ kN} < F_{b,Rd} = 122.81 \text{ kN} \Rightarrow U = 0.407 < 1$ **ok**

tension connection category D: not preloaded

tensile failure

tension resistance of one bolt: $F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 90.26 \text{ kN}$, $k_2 = 0.90$, $f_{ub} = 800.0 \text{ N/mm}^2$

$F_{t,Ed} = 30.0 \text{ kN} < F_{t,Rd} = 90.26 \text{ kN} \Rightarrow U = 0.332 < 1$ **ok**

punching shear failure

punching shear load capacity of a bolt: $B_{p,Rd} = (0.6 \cdot \pi \cdot d_m \cdot t_p \cdot f_u) / \gamma_{M2} = 136.18 \text{ kN}$, $d_m = 25.1 \text{ mm}$, $t_p = 10.0 \text{ mm}$

$F_{t,Ed} = 30.0 \text{ kN} < B_{p,Rd} = 136.18 \text{ kN} \Rightarrow U = 0.220 < 1$ **ok**

combination of shear and tension

$F_{v,Ed} / F_{v,Rd} + F_{t,Ed} / (1.4 \cdot F_{t,Rd}) = 0.929 < 1$ **ok**

maximum utilization $U_{\max} = 0.929 < 1$ **ok**

verification succeeded

2. Regulations

EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;

Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010

EN 1990/NA, Nationaler Anhang zur EN 1990, Ausgabe Dezember 2010

EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -

Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;

Deutsche Fassung EN 1993-1-1:2022, Ausgabe April 2025

EN 1993-1-1/A1, Ergänzungen zur EN 1993-1-1, Ausgabe Juli 2014

EN 1993-1-1/NA, Nationaler Anhang zur EN 1993-1-1, Ausgabe Oktober 2022

EN 1993-1-8, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -

Teil 1-8: Bemessung von Anschlüssen;

Deutsche Fassung EN 1993-1-8:2024, Ausgabe April 2025

EN 1993-1-8/NA, Nationaler Anhang zur EN 1993-1-8, Ausgabe November 2020