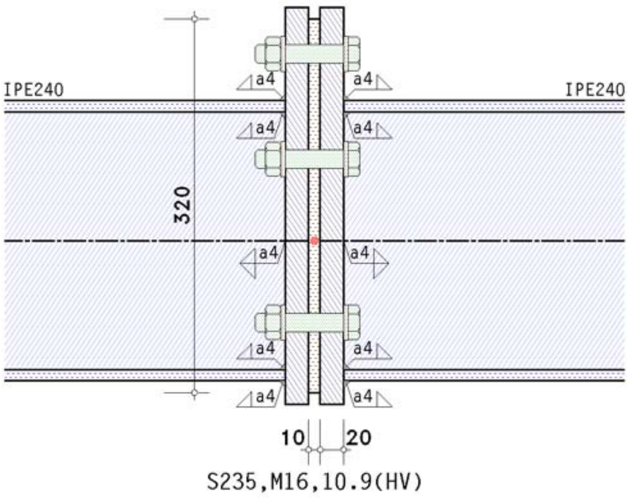
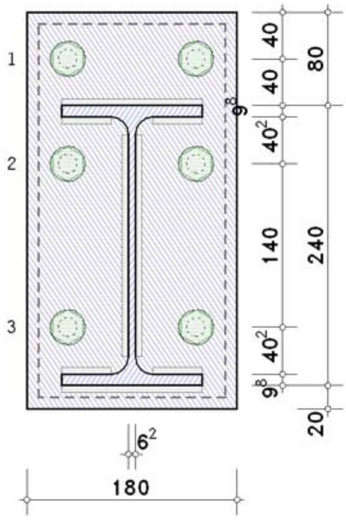
POS. 67: IMPORTBEISPIEL

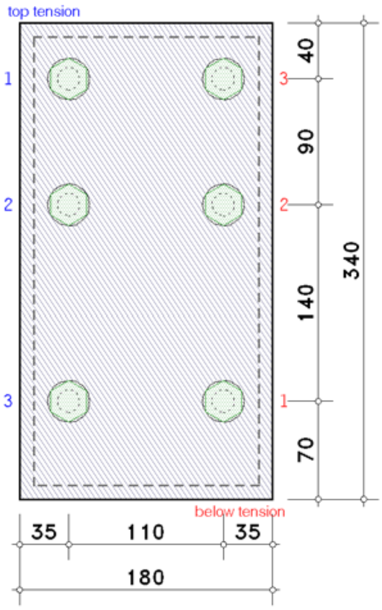
rigid splice with thermal separation layer EC 3-1-8 (12.10), NA: Deutschland 4H-EC3TT version: 4/2025-1b

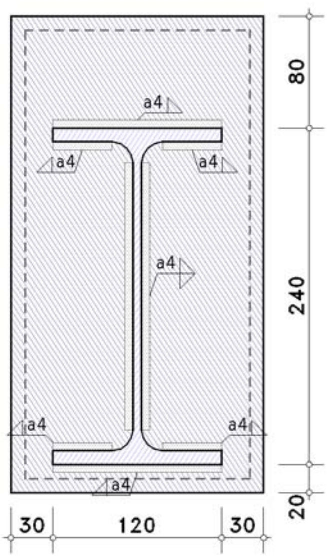
1. input report





details





steel grade
steel grade S235
bolts
bolt class 10.9, bolt size M16
large wrench size (high strength bolt), preloaded (for info: preloading $F_{p,C}* = 0.7 \cdot f_{yb} \cdot A_s$ = 98.9 kN)
shear plane passes through the unthreaded portion of the bolt
beam parameters
section IPE240
verification parameters
bolted end-plate connection
end-plate: thickness t_p = 20.0 mm, width b_p = 180.0 mm, length l_p = 340.0 mm
projections $h_{p,o}$ = 80.0 mm, $h_{p,u}$ = 20.0 mm
thermal separation layer (according to Kerncompactlager of Calenberg Ingenieure GmbH, approval until 2029):
thickness t_e = 10.0 mm, width b_e = 160.0 mm, length l_e = 320.0 mm
edge distance $ü_e$ = 10.0 mm, safety factor of material γ_e = 1.00, preload force per bolt $F_{p,C}$ = 0.0 kN
bolts in connection:
- 3 bolt-rows with 2 bolts
- all bolt-rows considered individually
- all bolt-rows for shear transfer (rows 1-3)
- bolt groups generated automatically, considering the decisive group
- centre distance of the bolts to the lateral edge of the end-plate e_2 = 35.0 mm

centre distance of the first bolt-row to the upper edge of the end-plate (end row) e_o = 40.0 mm
centre distance of the last bolt-row to the bottom edge of the end-plate (end row) e_u = 70.0 mm
centre distance of the bolt-rows from each other p_{1-2} = 90.0 mm, p_{2-3} = 140.0 mm

welds at the connection point:
beam flange top: fillet weld, weld thickness a = 4.0 mm
beam web: fillet weld, weld thickness a = 4.0 mm
beam flange below: fillet weld, weld thickness a = 4.0 mm

internal forces and moments in the intersection point of system axes

Lc 1: $N_{j,b,Ed}$ = -20.61 kN $M_{j,b,Ed}$ = -16.76 kNm $V_{j,b,Ed}$ = 8.68 kN
Lc 2: $N_{j,b,Ed}$ = -15.77 kN $M_{j,b,Ed}$ = -17.14 kNm $V_{j,b,Ed}$ = -2.71 kN
Lc 3: $N_{j,b,Ed}$ = -21.38 kN $M_{j,b,Ed}$ = -16.72 kNm $V_{j,b,Ed}$ = 16.60 kN

partial safety factors for material

resistance of cross-sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25

note
connection is verified due to EC 3-1-8 regardless of preloading.
however, connections may be constructed with prestressed high strength bolts.

check of data

ok

distances between bolts at end-plate

horizontal:	e_2 = 35.0 mm > 1.2·d_0 = 21.6 mm,	e_2 = 35.0 mm < 4·t + 40 mm = 120.0 mm
horizontal:	p_2 = 110.0 mm > 2.4·d_0 = 43.2 mm,	p_2 = 110.0 mm < min(14·t, 200 mm) = 200.0 mm
top-below:	e_1 = 40.0 mm > 1.2·d_0 = 21.6 mm,	e_1 = 40.0 mm < 4·t + 40 mm = 120.0 mm
top-below:	p_1 = 90.0 mm > 2.2·d_0 = 39.6 mm,	p_1 = 90.0 mm < min(14·t, 200 mm) = 200.0 mm
top-below:	p_1 = 140.0 mm > 2.2·d_0 = 39.6 mm,	p_1 = 140.0 mm < min(14·t, 200 mm) = 200.0 mm
top-below:	e_1 = 70.0 mm > 1.2·d_0 = 21.6 mm,	e_1 = 70.0 mm < 4·t + 40 mm = 120.0 mm

2. table of results

utilization

Lc	$U_{\sigma,b}$	U_m	U_v	U_{sb}	U	U_{tt}	U_{ts}
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1	0.206	0.306	0.016	0.322	0.322	0.288	0.193
2	0.211	0.335	0.005	0.324	0.335	0.301	0.060
3	0.207	0.302	0.030	0.322	0.369*	0.286	0.369

$U_{\sigma,b}$: stress utilization at the beam; U_m: utilization due to bending; U_v: utilization due to shear/bearing resistance
U_{sb}: utilization due to weld; U: utilization of the connection; U_{tt}: utilization of thermal separation layer
U_{ts}: utilization of bolts (separation layer)
*) maximum utilization

3. final result

thermal separation layer [Lc 3]:	max U_e = 0.369 < 1 ok
maximum utilization [Lc 3]:	max U = 0.369 < 1 ok

verification succeeded

4. 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

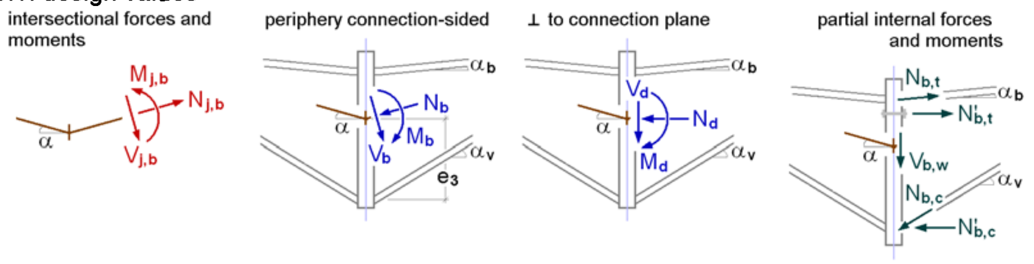
EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2005 + AC:2009, Ausgabe Dezember 2010
EN 1993-1-1/A1, Ergänzungen zur EN 1993-1-1, Ausgabe Juli 2014
EN 1993-1-1/NA, Nationaler Anhang zur EN 1993-1-1, Ausgabe Dezember 2018

EN 1993-1-8, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-8: Bemessung von Anschlüssen;
Deutsche Fassung EN 1993-1-8:2005 + AC:2009, Ausgabe Dezember 2010
EN 1993-1-8/NA, Nationaler Anhang zur EN 1993-1-8, Ausgabe Dezember 2010

Druckschrift Kerncompactlager, Calenberg Ingenieure GmbH, Salzhemmendorf,
www.calenberg-ingenieure.de

5. Lc 3 (decisive)

5.1. design values



slope angle: $\alpha_b = \alpha = \alpha_v = 0°$

internal forces and moments perpendicular to the connection planes

periphery beam

$N_d = 21.38$ kN, $M_d = 16.63$ kNm, $V_d = 16.60$ kN

partial internal forces and moments

internal forces and moments in the periphery end-plate-beam: $M'_d = M_d - V_d \cdot t_p = 16.30$ kNm

$N_{b,t} = -N_d \cdot z_{bu}/z_b + M'_d/z_b = 60.12$ kN, $z_b = 230.2$ mm, $z_{bu} = 115.1$ mm

$N_{b,c} = N_d \cdot z_{bo}/z_b + M'_d/z_b = 81.50$ kN, $z_b = 230.2$ mm, $z_{bo} = 115.1$ mm

$V_{b,t} = -N_{b,t} \cdot \sin(\alpha_b) = 0.00$ kN, $V_{b,c} = N_{b,c} \cdot \sin(\alpha_v) = 0.00$ kN, $V_{b,w} = V_d - V_{b,t} - V_{b,c} = 16.60$ kN

5.2. resistance of cross-section in the periphery

plastic verification for $N = -21.38$ kN, $M_y = -16.30$ kNm, $V_z = 16.60$ kN

main bending: $N = -21.38$ kN, resistance forces $N_{max} = 886.89$ kN, $N_{min} = -886.89$ kN $\Rightarrow U_N = 0.024$

$M_y = -16.30$ kNm, resistance moments $M_{y,max} = 82.77$ kNm, $M_{y,min} = -82.77$ kNm $\Rightarrow U_{My} = 0.197$

total (possibly due to load increase): max $U = 0.207 < 1$ ok

c/t-ratio: outstand flange: utilization $U_{c/t} = 0.148 < 1$ ok

internal compression parts: utilization $U_{c/t} = 0.135 < 1$ ok

5.3. connection capacity

5.3.1. moment resistance

distance of tension-bolt-rows from centre of compression: $h_1 = 275.1$ mm, $h_2 = 185.1$ mm, $h_3 = 45.1$ mm

resistance per bolt-row (tension)

row 1: $F_{tr,Rd} = 175.9$ kN

row 2: $F_{tr,Rd} = 226.1$ kN

row 3: $F_{tr,Rd} = 205.9$ kN

$\Sigma F_{tr,Rd}^* = 607.8$ kN

resistance per bolt-row (bending)

row 1: $F_{tr,Rd} = 170.7$ kN

row 2: $F_{tr,Rd} = 0.0$ kN

row 3: $F_{tr,Rd} = 0.0$ kN

$\Sigma F_{tr,Rd} = 170.7$ kN

potential failure by basic component 5, 15

resistance of flanges

$\Sigma F_{c,Rd}^* = 341.5$ kN

moment resistance

$M_{j,Rd} = \Sigma(F_{tr,Rd} \cdot h_r) = 47.0$ kNm

tension resistance

$N_{j,t,Rd} = \Sigma F_{tr,Rd}^* = 607.8$ kN

compression resistance

$N_{j,c,Rd} = \Sigma F_{c,Rd}^* = 341.5$ kN

5.3.2. shear/bearing resistance

resistance per bolt-row

row 1: $F_{vr,Rd} = 88.9$ kN

row 2: $F_{vr,Rd} = 193.0$ kN

row 3: $F_{vr,Rd} = 193.0$ kN

$\Sigma F_{vr,Rd} = 474.9$ kN

shear/bearing resistance

$V_{j,Rd} = \Sigma F_{vr,Rd} = 474.9$ kN

5.3.3. total

$M_{j,Rd}$ = 47.0 kNm $N_{j,t,Rd}$ = 607.8 kN $N_{j,c,Rd}$ = 341.5 kN $V_{j,Rd}$ = 474.9 kN

5.4. verifications

5.4.1. verification of the connection capacity by means of the component method

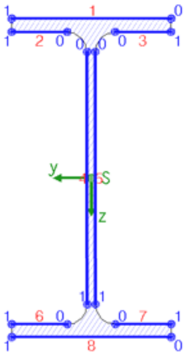
axial force: $N_{b,Ed} = |N_d| = 21.38$ kN $<$ 5%·$N_{pl,Rd}$ = 45.96 kN ⇒ moment resistance
internal moment: $M_{Ed} = M_d - N_d \cdot z_{bu}$ = 14.17 kNm, z_{bu} = 115.1 mm
shear force: $V_{Ed} = |V_d|$ = 16.60 kN
shear force: $V_{b,w,Ed}$ = 16.60 kN

$M_{Ed}/M_{j,Rd}$ = 0.302 < 1 ok
shear/bearing resistance at 30.2% utilization of moment resistance $V_{j,Rd}$ = 547.6 kN
$V_{Ed}/V_{j,Rd}$ = 0.030 < 1 ok

5.4.2. verification of welds at beam section

weld 1: beam flange in tension outer
welds 2,3: beam flange in tension inner
welds 4,5: beam web double-sided
weld 8: beam flange in compression outer
welds 6,7: beam flange in compression inner

calculation section:



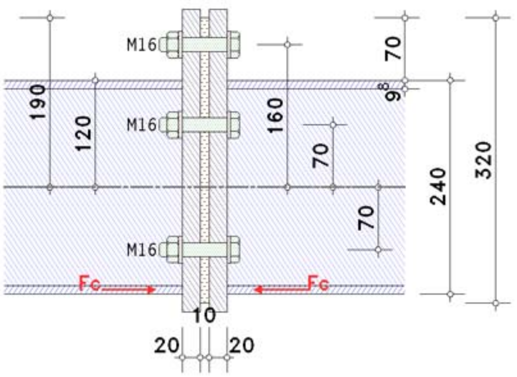
weld 1:	a_w = 4.0 mm	l_w = 120.0 mm
weld 2:	a_w = 4.0 mm	l_w = 41.9 mm
weld 3:	see weld 2	
weld 4:	a_w = 4.0 mm	l_w = 190.4 mm
weld 5:	see weld 4	
weld 6:	a_w = 4.0 mm	l_w = 41.9 mm
weld 7:	see weld 6	
weld 8:	a_w = 4.0 mm	l_w = 120.0 mm

design values refering to centroid of the section:
N_{Ed} = -21.38 kN, $M_{y,Ed}$ = -16.63 kNm, $V_{z,Ed}$ = 16.60 kN
cross-sectional properties refering to centroid of the line cross-section:
ΣA_w = 31.54 cm², $A_{w,z}$ = 15.23 cm², Σl_w = 78.8 cm
$I_{w,y}$ = 2656.70 cm⁴, $I_{w,z}$ = 228.70 cm⁴, Δz_w = 0.0 mm
verifications in weld edges:

weld 1,	pt. 0:	$\sigma_{w,x}$ = 68.35 N/mm²		⇒ U_w = 0.268 < 1 ok
weld 2,	pt. 0:	$\sigma_{w,x}$ = 62.21 N/mm²		⇒ U_w = 0.244 < 1 ok
weld 4,	pt. 0:	$\sigma_{w,x}$ = 52.82 N/mm²	$\tau_{w,z}$ = 10.90 N/mm²	⇒ U_w = 0.214 < 1 ok
	pt. 1:	$\sigma_{w,x}$ = -66.38 N/mm²	$\tau_{w,z}$ = 10.90 N/mm²	⇒ U_w = 0.266 < 1 ok
weld 6,	pt. 0:	$\sigma_{w,x}$ = -75.77 N/mm²		⇒ U_w = 0.298 < 1 ok
weld 8,	pt. 0:	$\sigma_{w,x}$ = -81.91 N/mm²		⇒ U_w = 0.322 < 1 ok

Result:
weld 8, pt. 0: $\sigma_{w,x}$ = -81.91 N/mm²
Max: $\sigma_{1,w,Ed}$ = 115.83 N/mm² < $f_{1w,d}$ = 360.00 N/mm²,
$\sigma_{2,w,Ed}$ = 57.92 N/mm² < $f_{2w,d}$ = 259.20 N/mm² ⇒ U_w = 0.322 < 1 ok

5.4.3. bc 15: end-plate with thermal separation layer



Only the essential sizes are sketched to scale.
The connection geometry is only hinted.

calculation is for structural bearings according to Kerncompactlager of Calenberg Ingenieure GmbH, approval as structural bearings until 2029.
calculation method is also appropriate for the connection of a steel girder to a reinforced concrete column
bolts are verified with the thread in the shear joint.

effective length of separation layer h_m = 75.0 mm
mean compressive stress σ_m = 5.50 N/mm²

verification of the separation layer
shape factor S = 1.970 for 2 bolts in compression zone
permissible mean compressive stress $\sigma_{md,zul}$ = 26.94 N/mm²
utilization of the separation layer 0.286 < 1 ok
verification of bolts:
shear force: $F_{Ed} = V_{Ed} / n_d$ = 8.3 kN
internal moment: $M_{Ed} = V_{Ed} \cdot t_e / n_d$ = 0.08 kNm
shear
shear resistance per shear plane $F_{v,Rd} = (0.5 \cdot f_{up} \cdot A) / \gamma_{M2}$ = 62.80 kN
$F_{v,Ed} = F_{Ed}$ = 8.3 kN < $F_{v,Rd}$ = 62.80 kN $\Rightarrow$ U = 0.132 < 1 ok
bending
bending resistance $M_{Rd} = (0.9 \cdot f_{yp} \cdot W_{el}) / \gamma_{M0}$ = 0.225 kNm
M_{Ed} = 0.08 kNm < M_{Rd} = 0.225 kNm $\Rightarrow$ U = 0.369 < 1 ok
combination of shear and bending
$(F_{v,Ed}/F_{v,Rd})^2 + (M_{Ed}/M_{Rd})^2$ = 0.154 < 1 ok

5.4.4. verification result

maximum utilization: max U = 0.369 < 1 ok