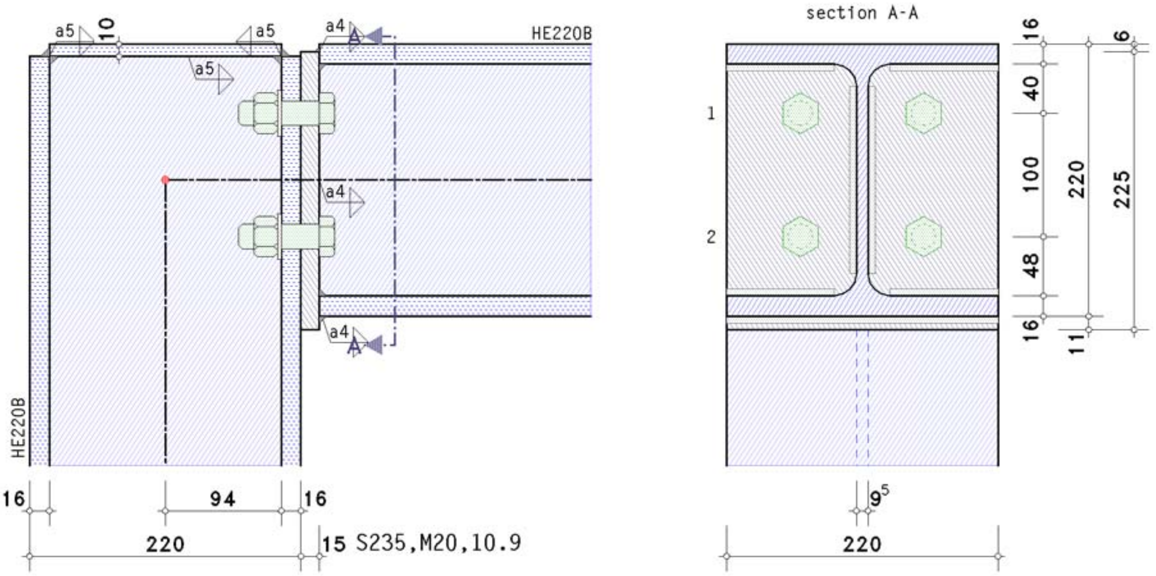
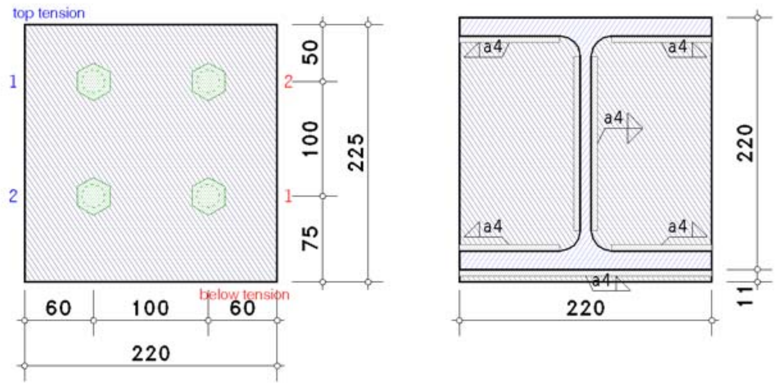
POS. 8: KOMMENTAR IV.4 BSP.4

frame corner EC 3-1-8 (04.25), NA: Deutschland 4H-EC3RE version: 2/2020-2q

1. input report



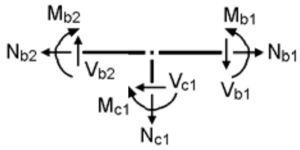
details (section A - A)



steel grade
steel grade S235
column parameters
section HE220B
cap plate t_k = 10.0 mm (structurally effective), welds $a_{k,f}$ = 5.0 mm, $a_{k,w}$ = 5.0 mm
bolts
bolt class 10.9, bolt size M20, normal wrench size
shear plane passes through the unthreaded portion of the bolt
beam parameters
section HE220B
verification parameters
<u>bolted end-plate connection</u>
thickness t_p = 15.0 mm, width b_p = 220.0 mm, length l_p = 225.0 mm
projections $h_{p,o}$ = -6.0 mm, $h_{p,u}$ = 11.0 mm
bolts in connection:
- 2 bolt-rows with 2 bolts
- all bolt-rows considered individually
- all bolt-rows for shear transfer (rows 1-2)
- bolt groups generated automatically, considering all groups reg. row 1
- centre distance of the bolts to the lateral edge of the end-plate e_2 = 60.0 mm
- centre distance of the first bolt-row to the upper edge of the end-plate (end row) e_o = 50.0 mm
- centre distance of the last bolt-row to the bottom edge of the end-plate (end row) e_u = 75.0 mm
- centre distance of the first bolt-row to the free edge of the column (end row) e_1' = 50.0 mm
- centre distance of the bolt-rows from each other p_{1-2} = 100.0 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: $M_{j,b,Ed}$ = -20.00 kNm $V_{j,b,Ed}$ = 20.00 kN
$N_{j,c1,Ed}$ = -20.00 kN $M_{j,c1,Ed}$ = -20.00 kNm (calculated)



partial safety factors for material
resistance of cross-sections γ_{M0} = 1.00
resistance of members in stability failure γ_{M1} = 1.10
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25
prestressing of high strength bolts γ_{M7} = 1.10

notes
no verification for cross-sections.
welds are not regarded by calculation the T-stub resistance.
local resistance of weld is not respected.
plated structures- and shear buckling is not investigated.
calculation of T-stub-resistance with the standard method.

check of data
ok
distances between bolts at end-plate
horizontal: e_2 = 60.0 mm > 1.2·d_0 = 26.4 mm, e_2 = 60.0 mm < 4·t + 40 mm = 100.0 mm
horizontal: p_2 = 100.0 mm > 2.4·d_0 = 52.8 mm, p_2 = 100.0 mm < min(14·t, 200 mm) = 200.0 mm
top-below: e_1 = 50.0 mm > 1.2·d_0 = 26.4 mm, e_1 = 50.0 mm < 4·t + 40 mm = 100.0 mm
top-below: e_1 = 50.0 mm > 1.2·d_0 = 26.4 mm, e_1 = 50.0 mm < 4·t + 40 mm = 100.0 mm
top-below: p_1 = 100.0 mm > 2.2·d_0 = 48.4 mm, p_1 = 100.0 mm < min(14·t, 200 mm) = 200.0 mm
top-below: e_1 = 75.0 mm > 1.2·d_0 = 26.4 mm, e_1 = 75.0 mm < 4·t + 40 mm = 100.0 mm
bolt distance from column edge
horizontal: e_2 = 60.0 mm > 1.2·d_0 = 26.4 mm, e_2 = 60.0 mm < 4·t + 40 mm = 100.0 mm

2. table of results

utilization/rotation

Lc	U_m	U_v	U_{wp}	U_{bw}	U_{ep}	U_{sb}	U	$S_{j,ini}$	S_j	φ_j
--	---	---	---	---	---	---	---	MNm/rad	MNm/rad	°
1	0.406	0.038	0.323	0.102	0.065	0.214	0.406*	7.7	7.7	0.132

U_m: utilization due to bending; U_v: utilization due to shear/bearing resistance; U_{wp}: utilization due to shear in column web
U_{bw}: utilization due to shear in beam web; U_{ep}: utilization due to shear in end-plate; U_{sb}: utilization due to weld
U: utilization of the connection; $S_{j,ini}$: initial rotational stiffness; S_j: rotational stiffness
φ_j: rotation
*) maximum utilization

3. final result

maximum utilization: max U = 0.406 < 1 ok
minimum rotational stiffness: min S_j = 7.7 MNm/rad, $S_{j,ini}$ = 7.7 MNm/rad, φ_j = 0.132°

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

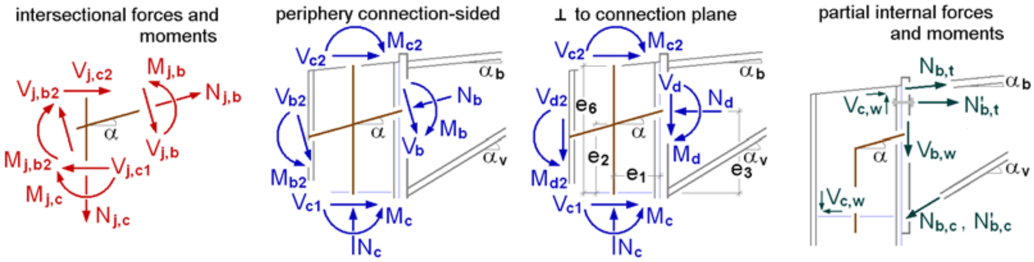
EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2022, Ausgabe April 2025
EN 1993-1-1/NA, Nationaler Anhang zur EN 1993-1-1, Ausgabe April 2026

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 April 2026

EN 1993-1-5, Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-5: Plattenförmige Bauteile;
Deutsche Fassung EN 1993-1-5:2006 + AC:2009 + A1:2017 + A2:2019, Ausgabe Oktober 2019
EN 1993-1-5/NA, Nationaler Anhang zur EN 1993-1-5, Ausgabe Dezember 2010

5. Lc 1 (decisive)

5.1. design values



slope angle: $\alpha_b = \alpha = \alpha_v = 0°$
distances: $e_1 = 110.0$ mm, $e_3 = 102.0$ mm, $e_2 = 102.0$ mm, $e_6 = 202.0$ mm

internal forces and moments perpendicular to the connection planes
periphery beam
$M_d = 17.80$ kNm, $V_d = 20.00$ kN
periphery column (below, calculated)
$N_c = 20.00$ kN, $M_c = 20.00$ kNm

partial internal forces and moments
internal forces and moments in the periphery end-plate-beam: $M'_d = M_d - V_d \cdot t_p = 17.50$ kNm
$N_{b,t} = -N_d \cdot z_{bu}/z_b + M'_d/z_b = 87.06$ kN, $z_b = 201.0$ mm, $z_{bu} = 102.0$ mm
$N_{b,c} = N_d \cdot z_{bo}/z_b + M'_d/z_b = 87.06$ kN, $z_b = 201.0$ mm, $z_{bo} = 99.0$ mm
$V_{b,t} = -N_{b,t} \cdot \sin(\alpha_b) = 0.00$ kN, $V_{b,c} = N_{b,c} \cdot \sin(\alpha_b) = 0.00$ kN, $V_{b,w} = V_d - V_{b,t} - V_{b,c} = 20.00$ kN

5.2. connection capacity

transformation parameter: $\beta_j = 1.00$

5.2.1. moment resistance

distance of tension-bolt-rows from centre of compression: $h_1 = 156.0$ mm, $h_2 = 56.0$ mm

resistance per bolt-row (tension)
row 1: $F_{tr,Rd} = 274.5$ kN
row 2: $F_{tr,Rd} = 90.2$ kN
$\Sigma F_{tr,Rd}^* = 364.8$ kN

resistance per bolt-row (bending)
row 1: $F_{tr,Rd} = 274.5$ kN
row 2: $F_{tr,Rd} = 18.5$ kN
$\Sigma F_{tr,Rd} = 293.0$ kN
potential failure by basic component 2, 3, 5

resistance of flanges (compression)
$\Sigma F_{c,Rd}^* = 571.3$ kN

moment resistance
$M_{j,Rd} = \Sigma(F_{tr,Rd} \cdot h_r) = 43.9$ kNm
tension resistance
$N_{j,t,Rd} = \Sigma F_{tr,Rd}^* = 364.8$ kN
compression resistance
$N_{j,c,Rd} = \Sigma F_{c,Rd}^* = 571.3$ kN

5.2.2. shear/bearing resistance

resistance per bolt-row (shear/bearing resistance)
row 1: $F_{vr,Rd} = 133.8$ kN
row 2: $F_{vr,Rd} = 290.3$ kN
$\Sigma F_{vr,Rd} = 424.1$ kN

shear/bearing resistance
$V_{j,Rd} = \Sigma F_{vr,Rd} = 424.1$ kN

5.2.3. shear resistance

shear resistance of end plate
end-plate: $V_{ep,Rd} = 309.34$ kN

shear resistance of the beam web
beam web: $V_{bw,Rd} = 195.92$ kN

shear resistance of column web
$V_{wp,Rd} = 424.89$ kN

5.2.4. total

$M_{j,Rd} = 43.9$ kNm $N_{j,t,Rd} = 364.8$ kN $N_{j,c,Rd} = 571.3$ kN $V_{j,Rd} = 424.1$ kN $V_{wp,Rd} = 424.9$ kN $V_{ep,Rd} = 309.3$ kN
$V_{bw,Rd} = 195.9$ kN

5.3. verifications

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

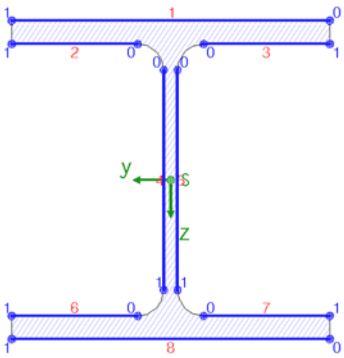
internal moment:	$M_{Ed} = M_d = 17.80$ kNm
shear force:	$V_{Ed} = \lvert V_d \rvert = 20.00$ kN
shear force:	$V_{c,w,Ed} = (M_{d1}-M_{d2})/z - V_c/2 = 137.36$ kN, $z = 129.6$ mm
shear force:	$V_{b,w,Ed} = 20.00$ kN

$M_{Ed}/M_{j,Rd} = 0.406 < 1$ ok
$V_{Ed}/V_{j,Rd} = 0.047 < 1$ ok
$V_{c,w,Ed}/V_{wp,Rd} = 0.323 < 1$ ok
$V_{b,w,Ed}/V_{bw,Rd} = 0.102 < 1$ ok
$V_{b,w,Ed}/V_{ep,Rd} = 0.065 < 1$ ok

5.3.2. verification of welds at beam section

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

calculation section:



weld 1:	$a_w = 4.0$ mm	$l_w = 220.0$ mm
weld 2:	$a_w = 4.0$ mm	$l_w = 87.3$ mm
weld 3:	see weld 2	
weld 4:	$a_w = 4.0$ mm	$l_w = 152.0$ mm
weld 5:	see weld 4	
weld 6:	$a_w = 4.0$ mm	$l_w = 87.3$ mm
weld 7:	see weld 6	
weld 8:	$a_w = 4.0$ mm	$l_w = 220.0$ mm

design values refering to centroid of the section:
$M_{y,Ed} = -17.80$ kNm, $V_{z,Ed} = 20.00$ kN
cross-sectional properties refering to centroid of the line cross-section:
$\Sigma A_w = 43.72$ cm², $A_{w,z} = 12.16$ cm², $\Sigma l_w = 109.3$ cm
$I_{w,y} = 3597.23$ cm⁴, $I_{w,z} = 1416.20$ cm⁴, $\Delta z_w = 0.0$ mm
verifications in weld edges:

weld 1,	pt. 0:	$\sigma_{w,x} = 54.43$ N/mm²		$\Rightarrow U_w = 0.214 < 1$ ok
weld 2,	pt. 0:	$\sigma_{w,x} = 46.51$ N/mm²		$\Rightarrow U_w = 0.183 < 1$ ok
weld 4,	pt. 0:	$\sigma_{w,x} = 37.61$ N/mm²	$\tau_{w,z} = 16.45$ N/mm²	$\Rightarrow U_w = 0.168 < 1$ ok
	pt. 1:	$\sigma_{w,x} = -37.61$ N/mm²	$\tau_{w,z} = 16.45$ N/mm²	$\Rightarrow U_w = 0.168 < 1$ ok
weld 6,	pt. 0:	$\sigma_{w,x} = -46.51$ N/mm²		$\Rightarrow U_w = 0.183 < 1$ ok
weld 8,	pt. 0:	$\sigma_{w,x} = -54.43$ N/mm²		$\Rightarrow U_w = 0.214 < 1$ ok

Result:
weld 1, pt. 0: $\sigma_{w,x} = 54.43$ N/mm²
Max: $\sigma_{1,w,Ed} = 76.98$ N/mm² $< f_{1w,d} = 360.00$ N/mm²,
$\sigma_{2,w,Ed} = 38.49$ N/mm² $< f_{2w,d} = 259.20$ N/mm² $\Rightarrow U_w = 0.214 < 1$ ok

5.3.3. verification result

maximum utilization: max U = 0.406 $<$ 1 ok

5.4. rotational stiffness

stiffness coefficients
equivalent stiffness coefficient for 2 tension-bolt-rows:
1: k_3 = 8.48 mm, k_4 = 24.34 mm, k_5 = 11.51 mm, k_{10} = 7.87 mm $\Rightarrow$ $k_{eff,1} = 1 / \Sigma(1/k_{i,1})$ = 2.682 mm
2: k_3 = 8.48 mm, k_4 = 24.34 mm, k_5 = 11.51 mm, k_{10} = 7.87 mm $\Rightarrow$ $k_{eff,2} = 1 / \Sigma(1/k_{i,2})$ = 2.682 mm
equivalent internal lever arm $z_{eq} = \Sigma(k_{eff,r} \cdot h_r^2) / \Sigma(k_{eff,r} \cdot h_r)$ = 129.58 mm
equivalent stiffness coefficient $k_{eq} = \Sigma(k_{eff,r} \cdot h_r) / z_{eq}$ = 4.387 mm
$k_1 = 0.38 \cdot A_{vc} / (\beta \cdot z)$ = 8.19 mm
$k_2 = 0.7 \cdot b_{eff,c,wc} \cdot t_{wc} / d_c$ = 9.52 mm
rotational stiffness
initial rotational stiffness: $S_{j,ini} = (E \cdot z^2) / \Sigma(1/k_i)$ = 7748.6 kNm/rad, $z = z_{eq}$ = 129.6 mm, $\Sigma(1/k_i)$ = 0.455 mm^{-1}
$|M_{j,Ed}|$ = 17.80 kNm $\leq$ 2/3 $M_{j,Rd}$ = 29.24 kNm $\Rightarrow$ μ = 1
rotational stiffness: $S_{j,Rd} = S_{j,ini} / \mu$ = 7748.6 kNm/rad
rotation: $\varphi_{j,Ed} = M_{j,Ed} / S_{j,Rd}$ = 0.132°