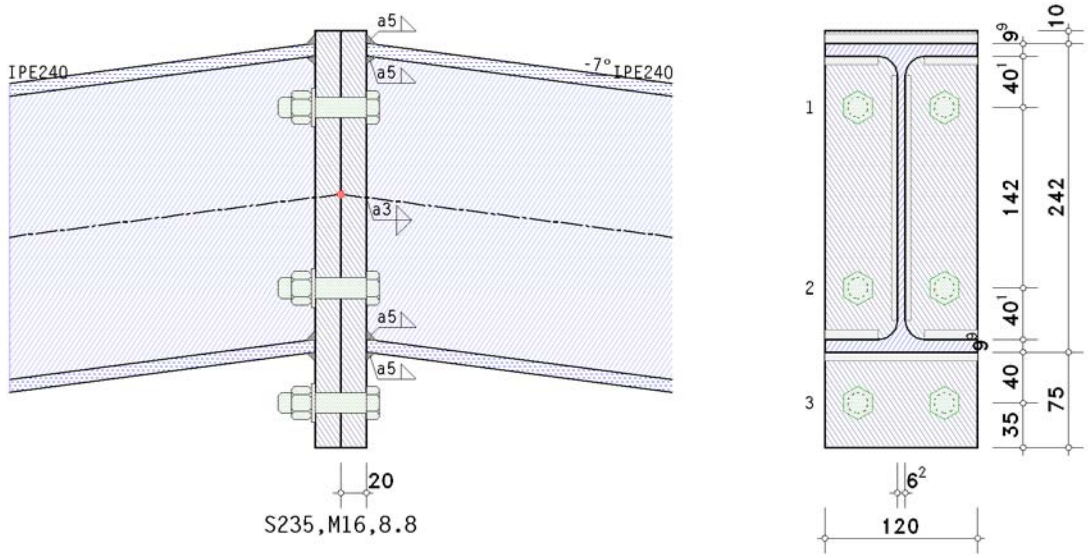
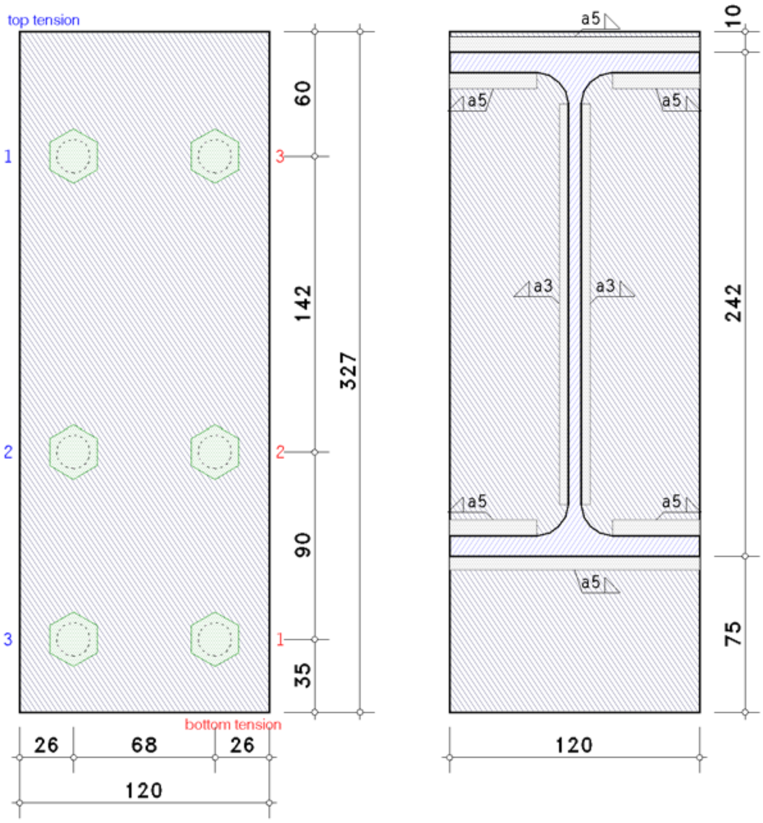
4H-ec3BT version: 4/2013-5I

Rigid beam splice EC 3-1-8 (12.10), NA: Deutschland

1. input report



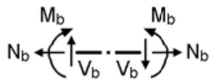
details (section A - A)



steel grade
steel grade S235
bolts
bolt class 8.8, bolt size M16, normal wrench size
shear plane passes through the unthreaded portion of the bolt
beam parameters
section IPE240
slope angle of section about the horizontal axis α_b = -7.40°
verification parameters
bolted end-plate connection:
thickness t_p = 20.0 mm, width b_p = 120.0 mm, length l_p = 327.0 mm
projections $h_{p,o}$ = 10.0 mm, $h_{p,u}$ = 75.0 mm

bolts in connection:
3 bolt-rows with 2 bolts
of these 1 bolt-row top in tension (row 1)
and 3 bolt-rows for shear transfer top (rows 1-3)
of these 2 bolt-rows bottom in tension (rows 2-3)
and 1 bolt-row for shear transfer bottom (row 3)
centre distance of the bolts to the lateral edge of the end-plate e_2 = 26.0 mm
centre distance of the first bolt-row to the upper edge of the end-plate (end row) e_o = 60.0 mm
centre distance of the last bolt-row to the bottom edge of the end-plate (end row) e_u = 35.0 mm
centre distance of the bolt-rows from each other p_{1-2} = 142.0 mm, p_{2-3} = 90.0 mm
welds at the connection point:
beam flange top: fillet weld, weld thickness a = 5.0 mm, angle φ = 97°
beam web: fillet weld, weld thickness a = 3.0 mm
beam flange bottom: fillet weld, weld thickness a = 5.0 mm, angle φ = 83°

internal forces and moments in the intersection point of system axes



Lk 1: $N_{j,b,Ed}$ = -24.30 kN $M_{j,b,Ed}$ = 55.00 kNm $V_{j,b,Ed}$ = 3.20 kN

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

check of data

ok

distances between bolt-rows at end-plate

horizontal:	e_2 = 26.0 mm > 1.2·d_0 = 21.6 mm,	e_2 = 26.0 mm < 4·t + 40 mm = 120.0 mm
horizontal:	p_2 = 68.0 mm > 2.4·d_0 = 43.2 mm,	p_2 = 68.0 mm < min(14·t, 200 mm) = 200.0 mm
vertical:	e_1 = 60.0 mm > 1.2·d_0 = 21.6 mm,	e_1 = 60.0 mm < 4·t + 40 mm = 120.0 mm
vertical:	p_1 = 142.0 mm > 2.2·d_0 = 39.6 mm,	p_1 = 142.0 mm < min(14·t, 200 mm) = 200.0 mm
vertical:	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
vertical:	e_1 = 35.0 mm > 1.2·d_0 = 21.6 mm,	e_1 = 35.0 mm < 4·t + 40 mm = 120.0 mm

notes

there are several basic components selected which perhaps do not ensure the total loading capacity of the joint.
no verification for cross-sections.
no verfication for welds within the connection.

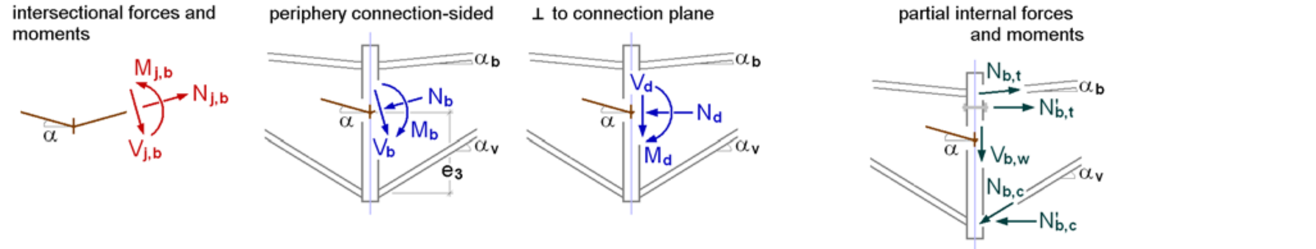
2. Lk 1

notes

calculation of T-stub-resistance with the standard method.

2.1. design values

Knotenschnittgrößen periphery connection⊥ zur connection plane partial internal forces and moments



slope angle: $\alpha_b = \alpha_v = \alpha$ = -7.40°

internal forces and moments perpendicular to the connection planes

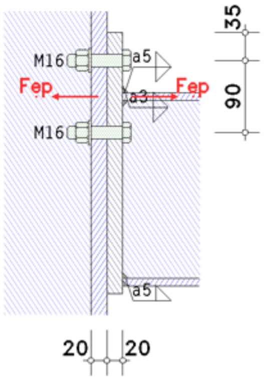
periphery beam
N_d = 24.51 kN, M_d = -55.00 kNm, V_d = 0.04 kN
negative internal moment M_d $\Rightarrow$ mirrored model ($\alpha_b = \alpha_v = \alpha$ = 7.40°)
N_d = 24.51 kN, M_d = 55.00 kNm, V_d = -0.04 kN

partial internal forces and moments refering to the mirrored model

internal forces and moments in the periphery end-plate-beam: $M'_d = M_d + N_d \cdot t_{ep} \cdot \tan(\alpha) - V_d \cdot t_{ep}$ = 55.06 kNm
$N_{b,t} = (-N_d \cdot z_{bu}/z_b + M'_d/z_b) / \cos(\alpha_b)$ = 226.85 kN, z_b = 232.1 mm, z_{bu} = 116.1 mm
$N_{b,c} = (N_d \cdot z_{bo}/z_b + M'_d/z_b) / \cos(\alpha_b)$ = 251.56 kN, z_b = 232.1 mm, z_{bo} = 116.1 mm
$V_{b,w} = V_d + N_{b,c} \cdot \sin(\alpha_v)$ = 3.14 kN

2.2. basic components

2.2.1. Gk 5: end-plate in bending



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

extended part of end-plate

in the extended part of the end-plate only one bolt-row is considered ($n_b = 1$).

effective length of the T-stub flange (end-plate):

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 60.0$ mm, $l_{eff,cp} = 159.8$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 60.0$ mm

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 1.41$ kNm

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 180.86$ kN

$L_b = 56.0$ mm ≤ 116.4 mm $= L_b^*$ $\Rightarrow$ prying forces may develop !

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 164.30$ kN

mode 2: bolt failure simultaneously with yielding of the T-stub flange

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 132.00$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 180.86$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 132.00$ kN

resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2}) = 360.0$ N/mm^2

tension resistance of welds: $F_{T,w,Rd} = 2^{1/2} \cdot f_{1w,d} \cdot a \cdot l_{eff} = 152.74$ kN (≥ 132.00 kN, not decisive)

resistance and effective length of end-plate in bending (projection)

$F_{t,ep,Rd,1} = 132.00$ kN, $l_{eff,1} = 60.0$ mm

part of end-plate between beam flanges

equivalent T-stub flange (each individual bolt-row):

here: number of bolt-rows $n_b = 1$

row 2

effective length of the T-stub flange (end-plate):

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 147.7$ mm, $l_{eff,cp} = 172.8$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 147.7$ mm

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.47$ kNm

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 180.86$ kN

$L_b = 56.0$ mm > 24.3 mm $= L_b^*$ $\Rightarrow$ no prying forces !

mode 1 and 2: complete yielding of the T-stub flange and possibly coincident bolt failure

$F_{T,1\text{-}2,Rd} = (2 \cdot M_{pl,1,Rd}) / m = 252.33$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 180.86$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1\text{-}2,Rd}, F_{T,3,Rd}) = 180.86$ kN

resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2}) = 360.0$ N/mm^2

tension resistance of welds: $F_{T,w,Rd} = 2^{1/2} \cdot f_{1w,d} \cdot a \cdot l_{eff} = 225.55$ kN (≥ 180.86 kN, not decisive)

resistances and effective lengths of end-plate in bending (per bolt-row):

$F_{ep,Rd,2} = 180.86$ kN, $l_{eff,2} = 147.7$ mm

2.3. verifications

2.3.1. verification of the connection capacity with partial internal forces and moments

tension force in the bolt-rows:

$N'_{b,t} = (-N_d \cdot z_{bu} + M_d) / z = 225.02$ kN, $z = z_{eq} = 232.1$ mm, $z_{bu} = 113.5$ mm

Gk 5: $F_{Rd} = \Sigma F_{t,ep,Rd,i} = 303.4$ kN, $F_{Ed} = N'_{b,t} = 225.02$ kN

$F_{Ed} = 225.0$ kN $<$ $F_{Rd} = 303.4$ kN $\Rightarrow$ $U = 0.742 < 1$ ok

utilization partial internal forces and moments $U_{Gk} = 0.742 < 1$ ok

2.3.2. verification result

maximum utilization: max U = 0.742 < 1 ok

3. final result

utilization of the connection

Lk	U_j	Gleichgewicht ΣH	ΣV	ΣM	
--		kN	kN	kNm	
1	0.742*	24.51	0.04	55.00	!!

U_j: utilization of the connection; tolerances of equilibrium 1 kN / 1 kNm
*) maximum utilization

maximum utilization: max U = 0.742 < 1 ok

verification succeeded