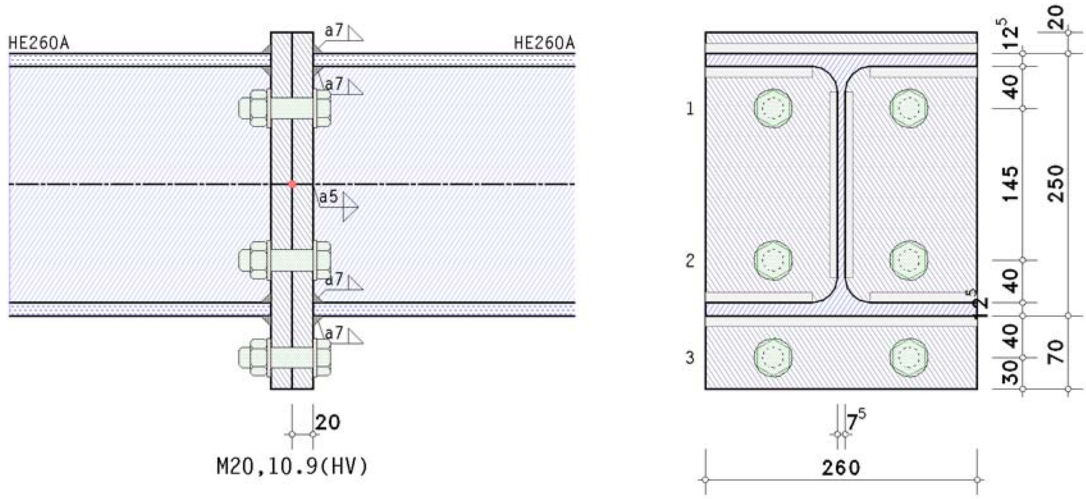
POS. 152: KINDMANN 3.6.6

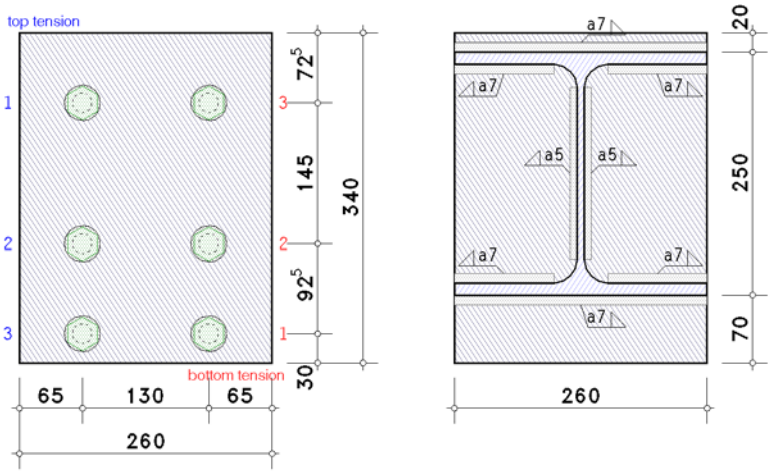
4H-ec3BT version: 4/2013-5l

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

1. input report

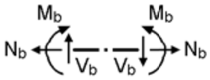


details (section A - A)



bolts
bolt class 10.9, bolt size M20
large wrench size (high strength bolt), preloaded (for info: preloading $F_{p,C}* = 0.7 \cdot f_{yb} \cdot A_s$ = 154.3 kN)
shear plane passes through the unthreaded portion of the bolt
beam parameters
section HE260A, steel grade S235
verification parameters
bolted end-plate connection:
thickness t_p = 20.0 mm, width b_p = 260.0 mm, length l_p = 340.0 mm, steel grade S355
projections $h_{p,o}$ = 20.0 mm, $h_{p,u}$ = 70.0 mm
bolts in connection:
 3 bolt-rows with 2 bolts
 of these 1 bolt-row top in tension (row 1)
  and 1 bolt-row for shear transfer top (row 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 = 65.0 mm
 centre distance of the first bolt-row to the upper edge of the end-plate (end row) e_o = 72.5 mm
 centre distance of the last bolt-row to the bottom edge of the end-plate (end row) e_u = 30.0 mm
 centre distance of the bolt-rows from each other $p_{1\text{-}2}$ = 145.0 mm, $p_{2\text{-}3}$ = 92.5 mm
welds at the connection point:
 beam flange top: fillet weld, weld thickness a = 7.0 mm
 beam web: fillet weld, weld thickness a = 5.0 mm
 beam flange bottom: fillet weld, weld thickness a = 7.0 mm

internal forces and moments in the intersection point of system axes



Lk 1: $M_{j,b,Ed}$ = 145.00 kNm $V_{j,b,Ed}$ = 100.00 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 = 65.0 mm > $1.2 \cdot d_0$ = 26.4 mm,	e_2 = 65.0 mm < $4 \cdot t$ + 40 mm = 120.0 mm
horizontal:	p_2 = 130.0 mm > $2.4 \cdot d_0$ = 52.8 mm,	p_2 = 130.0 mm < min($14 \cdot t$, 200 mm) = 200.0 mm
vertical:	e_1 = 72.5 mm > $1.2 \cdot d_0$ = 26.4 mm,	e_1 = 72.5 mm < $4 \cdot t$ + 40 mm = 120.0 mm
vertical:	p_1 = 145.0 mm > $2.2 \cdot d_0$ = 48.4 mm,	p_1 = 145.0 mm < min($14 \cdot t$, 200 mm) = 200.0 mm
vertical:	p_1 = 92.5 mm > $2.2 \cdot d_0$ = 48.4 mm,	p_1 = 92.5 mm < min($14 \cdot t$, 200 mm) = 200.0 mm
vertical:	e_1 = 30.0 mm > $1.2 \cdot d_0$ = 26.4 mm,	e_1 = 30.0 mm < $4 \cdot t$ + 40 mm = 120.0 mm

notes

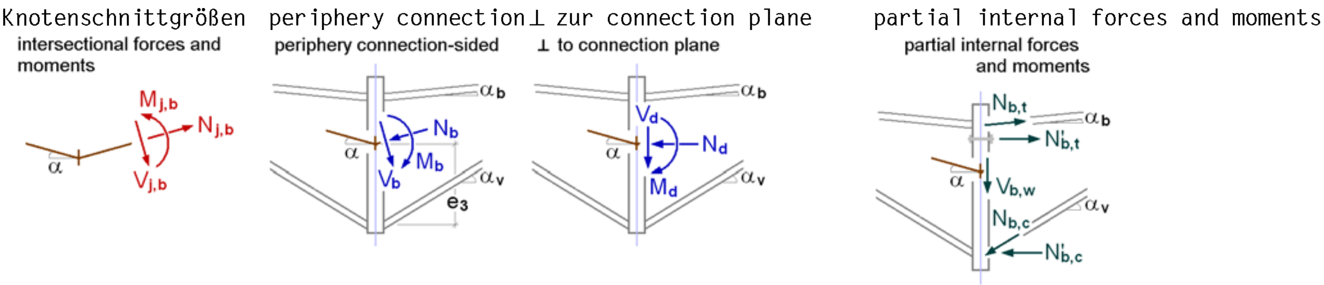
there are several basic components selected which perhaps do not ensure the total loading capacity of the joint.
no verfication for welds within the connection.

2. Lk 1

notes

connection is verified due to EC 3-1-8 regardless of preloading.
however, connections may be constructed with prestressed high strength bolts.
calculation of T-stub-resistance with the standard method.

2.1. design values



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

internal forces and moments perpendicular to the connection planes

periphery beam

M_d = -145.00 kNm, V_d = 100.00 kN
negative internal moment M_d ⇒ mirrored model
M_d = 145.00 kNm, V_d = -100.00 kN

partial internal forces and moments refering to the mirrored model

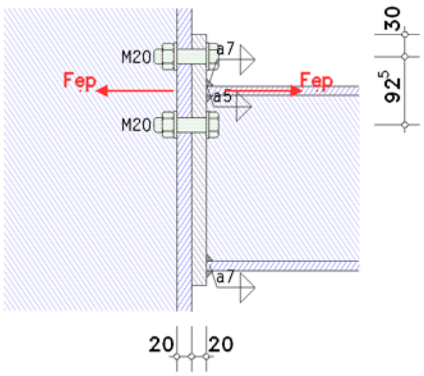
internal forces and moments in the periphery end-plate-beam: $M'_d = M_d - V_d \cdot t_{ep}$ = 147.00 kNm
$N_{b,t} = -N_d \cdot z_{bu}/z_b + M'_d/z_b$ = 618.95 kN, z_b = 237.5 mm, z_{bu} = 118.8 mm
$N_{b,c} = N_d \cdot z_{bo}/z_b + M'_d/z_b$ = 618.95 kN, z_b = 237.5 mm, z_{bo} = 118.8 mm
$V_{b,w} = V_d$ = -100.00 kN

2.2. resistance of cross-section

plastic cross-sectional check for M_y = -147.00 kNm, V_z = -100.00 kN
valid normal/shear stress: zul σ_{Rd} = 23.50 kN/cm², zul τ_{Rd} = 13.57 kN/cm²
top flange: resistance forces $N_{max,O}$ = 763.75 kN, $N_{min,O}$ = -763.75 kN
bottom flange: resistance forces $N_{max,U}$ = 763.75 kN, $N_{min,U}$ = -763.75 kN
web: shear force V_S = -100.00 kN, shear stress τ_S = 5.61 kN/cm² ⇒ $U_{\tau,S}$ = 0.414
resistance forces $N_{max,S}$ = 381.08 kN, $N_{min,S}$ = -381.08 kN
main bending: moment M_y = -147.00 kNm, resistance moments $M_{y,max}$ = 204.02 kNm, $M_{y,min}$ = -204.02 kNm ⇒ U_{My} = 0.721
total (possibly due to load increase): max U = 0.732 < 1 ok
utilizations: resistance U_σ = 0.732 < 1 ok, c/t-ratio $U_{c/t}$ = 0.501 < 1 ok

2.3. basic components

2.3.1. 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: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 130.0$ mm, $l_{eff,cp} = 201.6$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 130.0$ mm

tension resistance of the T-stub flange:

in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 4.62$ kNm

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 352.80$ kN

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 575.43$ kN

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 319.17$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 352.80$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 319.17$ kN

resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2}) = 360.0$ N/mm²

tension resistance of welds: $F_{T,w,Rd} = 2^{1/2} \cdot f_{1w,d} \cdot a \cdot l_{eff} = 463.30$ kN (≥ 319.17 kN, not decisive)

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

$F_{t,ep,Rd,1} = 319.17$ kN, $l_{eff,1} = 130.0$ 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: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 349.3$ mm, $l_{eff,cp} = 349.3$ mm

in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 386.2$ mm

tension resistance of the T-stub flange:

in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 12.40$ kNm

in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 13.71$ kNm

in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 352.80$ kN

mode 1: complete yielding of the T-stub flange

$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 892.21$ kN

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

$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 417.51$ kN

mode 3: bolt failure

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 352.80$ kN

tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 352.80$ kN

resistance of a weld (req.1): $f_{1w,d} = f_u / (\beta_w \cdot \gamma_{M2}) = 360.0$ N/mm²

tension resistance of welds: $F_{T,w,Rd} = 2^{1/2} \cdot f_{1w,d} \cdot a \cdot l_{eff} = 889.18$ kN (≥ 352.80 kN, not decisive)

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

$F_{ep,Rd,2} = 352.80$ kN, $l_{eff,2} = 349.3$ mm

2.4. verifications

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

tension force in the bolt-rows:

$N'_{b,t} = (-N_d \cdot z_{bu} + M_d) / z = 610.53$ kN, $z = z_{eq} = 237.5$ mm, $z_{bu} = 118.8$ mm

Gk 5: $F_{Rd} = \Sigma F_{t,ep,Rd,i} = 665.4$ kN, $F_{Ed} = N'_{b,t} = 610.53$ kN

$F_{Ed} = 610.5$ kN $<$ $F_{Rd} = 665.4$ kN $\Rightarrow$ $U = 0.918 < 1$ ok

utilization partial internal forces and moments $U_{Gk} = 0.918 < 1$ ok

2.4.2. verification result

maximum utilization: max U = 0.918 < 1 ok

3. final result

utilization of the connection

Lk	U_j	Gleichgewicht ΣH	ΣV	ΣM	
--		kN	kN	kNm	
1	0.918*	0.00	100.00	145.00	!!

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

maximum utilization: max U = 0.918 < 1 ok

verification succeeded