bc 5, end-plate in bending
EC 3-1-8 (12.10), NA: Deutschland

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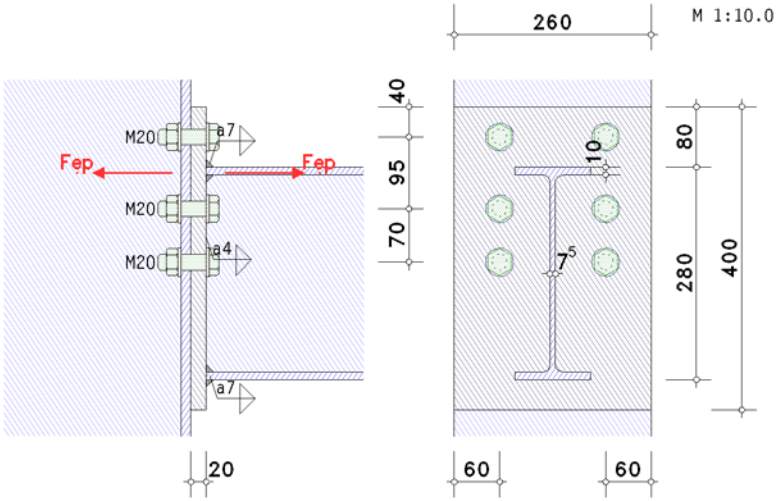
1. input report



end-plate:
thickness t_{ep} = 20.0 mm, width b_{ep} = 260.0 mm, length l_{ep} = 400.0 mm, steel grade S275
beam:
height h_b = 280.0 mm, flange thickness t_{fb} = 10.0 mm, web thickness t_{wb} = 7.5 mm
width of column flange b_{fc} = 260.0 mm
projection of end-plate $h_{pü}$ = 80.0 mm
weld between end-plate and beam flange a_f = 7.0 mm
weld between end-plate and beam web a_w = 4.0 mm
connection device:
bolt class 8.8, bolt size M20
large wrench size (high strength bolt), preloaded (for info: preloading $F_{p,C}^* = 0.7 \cdot f_{yb} \cdot A_s$ = 109.8 kN)
in total 3 bolt-rows, of these maximum 3 bolt-rows for the bolt group
distance of external bolts from the lateral edge of end plate e_2 = 60.0 mm
distance of first bolt-row from tensile edge of end-plate e_1 = 40.0 mm
distance between bolt-rows p_{1-2} = 95.0 mm, p_{2-3} = 70.0 mm
calculation of T-stub-resistance with the alternative method.
partial safety factors for material: γ_{M0} = 1.00, γ_{M2} = 1.25, γ_{M7} = 1.10 (standard)
stress:
lc 1 : $F_{ep,Ed}$ = 50.0 kN per bolt

2. calculation

2.1. resistance

the lateral distance of bolt centre-line to the edge of beam flange is Δe_2 = -20.0 mm < 0.
validity of the method is not guaranteed !!
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: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0}$ = 3.57 kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2}$ = 141.12 kN, k_2 = 0.90
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd}$ = 282.24 kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n))$ = 567.39 kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n)$ = 255.82 kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd}$ = 282.24 kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd})$ = 255.82 kN
shear strength: $f_{vw,d} = (f_u / 3^{1/2}) / (\beta_w \cdot \gamma_{M2})$ = 207.8 N/mm²
tension resistance of welds: $F_{T,w,Rd} = 2 \cdot f_{vw,d} \cdot a \cdot l_{eff}$ = 378.28 kN (≥ 255.82 kN, not decisive)
resistance and effective length of end-plate in bending (projection)
$F_{t,ep,Rd,1}$ = 255.82 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: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp})$ = 387.8 mm, $l_{eff,cp}$ = 387.8 mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc}$ = 388.9 mm
tension resistance of the T-stub flange:
in mode 1: $M_{pl,1,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_f^2 \cdot f_y) / \gamma_{M0}$ = 10.67 kNm
in mode 2: $M_{pl,2,Rd} = (0.25 \cdot \Sigma l_{eff,2} \cdot t_f^2 \cdot f_y) / \gamma_{M0}$ = 10.70 kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2}$ = 141.12 kN, k_2 = 0.90
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd}$ = 282.24 kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n))$ = 783.64 kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n)$ = 314.86 kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd}$ = 282.24 kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd})$ = 282.24 kN
shear strength: $f_{vw,d} = (f_u / 3^{1/2}) / (\beta_w \cdot \gamma_{M2})$ = 207.8 N/mm²
tension resistance of welds: $F_{T,w,Rd} = 2 \cdot f_{vw,d} \cdot a \cdot l_{eff}$ = 644.87 kN (≥ 282.24 kN, not decisive)
row 3
effective length of the T-stub flange (end-plate):
in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp})$ = 321.9 mm, $l_{eff,cp}$ = 387.8 mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc}$ = 321.9 mm
tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0}$ = 8.85 kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2}$ = 141.12 kN, k_2 = 0.90
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd}$ = 282.24 kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n))$ = 650.42 kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n)$ = 284.57 kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd}$ = 282.24 kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd})$ = 282.24 kN
shear strength: $f_{vw,d} = (f_u / 3^{1/2}) / (\beta_w \cdot \gamma_{M2})$ = 207.8 N/mm²
tension resistance of welds: $F_{T,w,Rd} = 2 \cdot f_{vw,d} \cdot a \cdot l_{eff}$ = 535.24 kN (≥ 282.24 kN, not decisive)
resistances and effective lengths of end-plate in bending (per bolt-row):
$F_{ep,Rd,2}$ = 282.24 kN, $l_{eff,2}$ = 387.8 mm
$F_{ep,Rd,3}$ = 282.24 kN, $l_{eff,3}$ = 321.9 mm

equivalent T-stub flange (group of bolt-rows):
here: number of bolt-rows n_b = 2 (R2+R3)
effective length of the T-stub flange (end-plate):
in mode 1: $\Sigma l_{eff,1} = \min(\Sigma l_{eff,nc}, \Sigma l_{eff,cp})$ = 458.9 mm, $\Sigma l_{eff,cp}$ = 527.8 mm
in mode 2: $\Sigma l_{eff,2} = \Sigma l_{eff,nc}$ = 458.9 mm
tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0}$ = 12.62 kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2}$ = 141.12 kN, k_2 = 0.90
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd}$ = 564.48 kN
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n))$ = 927.33 kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n)$ = 485.61 kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd}$ = 564.48 kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd})$ = 485.61 kN
shear strength: $f_{vw,d} = (f_u / 3^{1/2}) / (\beta_w \cdot \gamma_{M2})$ = 207.8 N/mm²
tension resistance of welds: $F_{T,w,Rd} = 2 \cdot f_{vw,d} \cdot a \cdot l_{eff}$ = 763.12 kN (≥ 485.61 kN, not decisive)
effective length: Σl_{eff} = 458.9 mm, 2 rows

2.2. verification

lc 1: per bolt-row: $F_{Ed} = 2 \cdot F_{ep,Ed}$ = 100.0 kN
row 1: F_{Ed} = 100.0 kN < F_{Rd} = 255.8 kN ⇒ U = 0.391 < 1 ok
row 2: F_{Ed} = 100.0 kN < F_{Rd} = 282.2 kN ⇒ U = 0.354 < 1 ok
row 3: F_{Ed} = 100.0 kN < F_{Rd} = 282.2 kN ⇒ U = 0.354 < 1 ok
group of bolts (between den flangesn, 2 rows): $F_{Ed} = 2 \cdot 2 \cdot F_{ep,Ed}$ = 200.0 kN
F_{Ed} = 200.0 kN < F_{Rd} = 485.6 kN ⇒ U = 0.412 < 1 ok

verification succeeded