bc 4, column flange in bending

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

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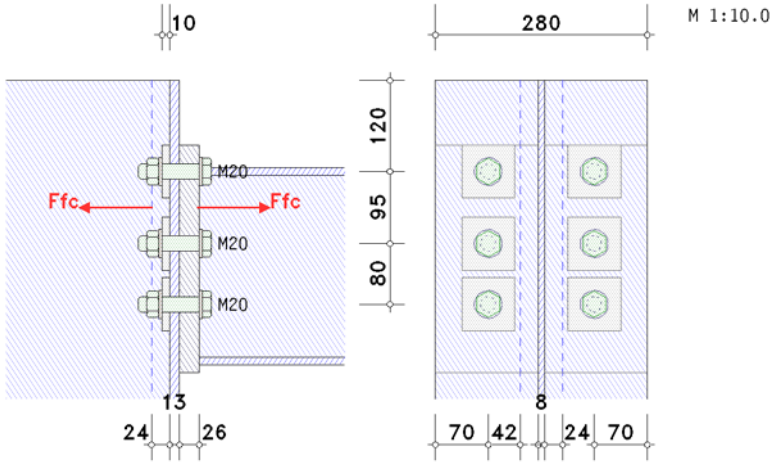
1. input report



column flange:
thickness t_{fc} = 13.0 mm, width b_{fc} = 280.0 mm, steel grade S275
thickness of column web t_{wc} = 8.0 mm
root resp. leg length of the web weld s_c = 24.0 mm
width of end-plate or flange cleat b_{ep} = 280.0 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·f_{yb}·A_s = 109.8 kN)
flange reinforcement: thickness t_{bp} = 10.0 mm
in total 3 bolt-rows, of these maximum 3 bolt-rows for the bolt group
distance of first bolt-row to the free edge of the column e_{1s} = 120.0 mm
distance between bolt-rows p_{1-2} = 95.0 mm, p_{2-3} = 80.0 mm
distance of external bolts from the lateral edge of column flange e_{2s} = 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 : $F_{fc,Ed}$ = 50.0 kN per bolt

2. calculation

2.1. resistance

equivalent T-stub flange (each individual bolt-row):
here: number of bolt-rows n_b = 1
row 1
effective length of the T-stub flange (column flange):
in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp})$ = 257.4 mm, $l_{eff,cp}$ = 294.1 mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc}$ = 257.4 mm
tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0}$ = 2.99 kNm
flange reinforcement: $M_{bp,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_{bp}^2 \cdot f_y) / \gamma_{M0}$ = 1.77 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
$F_{T,2,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd} + 4 \cdot n \cdot M_{bp,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n))$ = 390.54 kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n)$ = 213.59 kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd}$ = 282.24 kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd})$ = 213.59 kN
row 2
effective length of the T-stub flange (column flange):
in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp})$ = 274.7 mm, $l_{eff,cp}$ = 294.1 mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc}$ = 274.7 mm
tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0}$ = 3.19 kNm
flange reinforcement: $M_{bp,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_{bp}^2 \cdot f_y) / \gamma_{M0}$ = 1.89 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
$F_{T,2,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd} + 4 \cdot n \cdot M_{bp,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n)) = 416.87$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 217.42$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 282.24$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 217.42$ kN

row 3

effective length of the T-stub flange (column flange):
in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 274.7$ mm, $l_{eff,cp} = 294.1$ mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 274.7$ mm

tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.19$ kNm
flange reinforcement: $M_{bp,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_{bp}^2 \cdot f_y) / \gamma_{M0} = 1.89$ 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
$F_{T,2,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd} + 4 \cdot n \cdot M_{bp,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n)) = 416.87$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 217.42$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 282.24$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 217.42$ kN

resistances and effective lengths of column flange in bending (per bolt-row)

$F_{t,fc,Rd,1} = 213.59$ kN, $l_{eff,1} = 257.4$ mm
$F_{t,fc,Rd,2} = 217.42$ kN, $l_{eff,2} = 274.7$ mm
$F_{t,fc,Rd,3} = 217.42$ kN, $l_{eff,3} = 274.7$ mm

equivalent T-stub flange (group of bolt-rows):

here: number of bolt-rows $n_b = 3$

effective length of the T-stub flange (column flange):
in mode 1: $\Sigma l_{eff,1} = \min(\Sigma l_{eff,nc}, \Sigma l_{eff,cp}) = 432.4$ mm, $\Sigma l_{eff,cp} = 644.1$ mm
in mode 2: $\Sigma l_{eff,2} = \Sigma l_{eff,nc} = 432.4$ mm

tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 5.02$ kNm
flange reinforcement: $M_{bp,Rd} = (0.25 \cdot \Sigma l_{eff,1} \cdot t_{bp}^2 \cdot f_y) / \gamma_{M0} = 2.97$ kNm
$F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 141.12$ kN, $k_2 = 0.90$
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 846.72$ kN
mode 1: complete yielding of the T-stub flange
$F_{T,2,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd} + 4 \cdot n \cdot M_{bp,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n)) = 656.11$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 565.81$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 846.72$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 565.81$ kN
effective length: $\Sigma l_{eff} = 432.4$ mm, 3 rows

2.2. verification

lc 1: per bolt-row: $F_{Ed} = 2 \cdot F_{fc,Ed} = 100.0$ kN
row 1: $F_{Ed} = 100.0$ kN $<$ $F_{Rd} = 213.6$ kN $\Rightarrow$ $U = 0.468 < 1$ ok
row 2: $F_{Ed} = 100.0$ kN $<$ $F_{Rd} = 217.4$ kN $\Rightarrow$ $U = 0.460 < 1$ ok
row 3: $F_{Ed} = 100.0$ kN $<$ $F_{Rd} = 217.4$ kN $\Rightarrow$ $U = 0.460 < 1$ ok
group of bolts: $F_{Ed} = 2 \cdot 3 \cdot F_{fc,Ed} = 300.0$ kN
$F_{Ed} = 300.0$ kN $<$ $F_{Rd} = 565.8$ kN $\Rightarrow$ $U = 0.530 < 1$ ok

verification succeeded