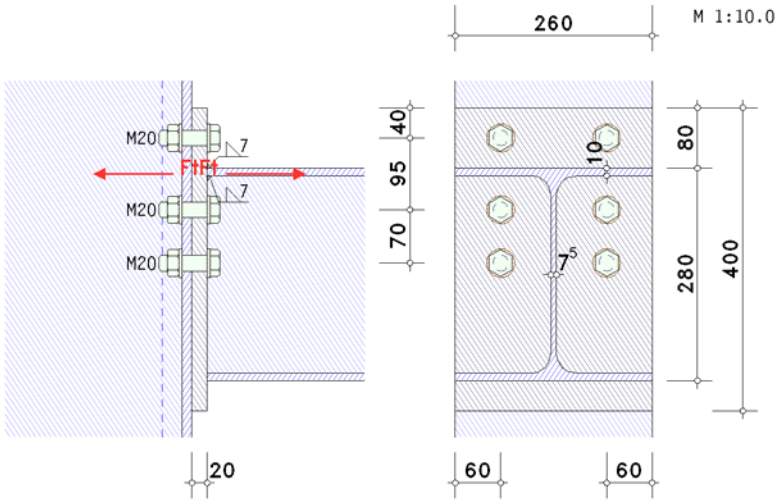
POS. 27: END-PLATE IN BENDING

end-plate in bending

Basic component 5

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



end-plate:
plate thickness t_p = 20.0 mm, length l_p = 400.0 mm, width b_p = 260.0 mm, steel grade S 275
beam:
height h_b = 280.0 mm, flange thickness t_{fb} = 10.0 mm, web thickness t_{wb} = 7.5 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, property class 8.8, bolt size M20
large width across flats (high tensile bolt), preloaded
number of bolt-rows in tension n_z = 3
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
distance of outer bolts from lateral edge of end-plate e_2 = 60.0 mm
partial safety factors for material: γ_{M0} = 1.00, γ_{M2} = 1.25
stress:
Lk 1 : $F_{ep,Ed}$ = 50.0 kN per bolt

design resistance

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
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc}$ = 130.0 mm
design 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
tension resistance of all bolts: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd}$ = 282.24 kN, $F_{t,Rd}$ = 141.12 kN
$L_b \le L_b^*$ $\Rightarrow$ prying forces may develop
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m$ = 445.75 kN
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n)$ = 255.82 kN, n = 40.0 mm, m = 32.1 mm
$F_{T,3,Rd} = \Sigma F_{t,Rd}$ = 282.24 kN
tension resistance of T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd})$ = 255.82 kN
design resistance of end-plate in bending (projection)
$F_{t,ep,Rd,1}$ = 255.8 kN, ass. l_{eff} = 130.0 mm

part of end-plate between beam flanges

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

here: number of bolt rows n_b = 1

row 2

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

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 321.9$ mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 321.9$ mm
design 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
tension resistance of all bolts: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 282.24$ kN, $F_{t,Rd} = 141.12$ kN
$L_b \le L_b^* \Rightarrow$ prying forces may develop
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 573.66$ kN
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 284.57$ kN, $n = 60.0$ mm
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 282.24$ kN
tension resistance of T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 282.24$ kN

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
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 321.9$ mm
design 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
tension resistance of all bolts: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 282.24$ kN, $F_{t,Rd} = 141.12$ kN
$L_b \le L_b^* \Rightarrow$ prying forces may develop
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 573.66$ kN
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 284.57$ kN, $n = 60.0$ mm
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 282.24$ kN
tension resistance of T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 282.24$ kN

design resistances of end-plate in bending (per bolt-row):

$F_{ep,Rd,2} = 282.2$ kN, ass. $l_{eff} = 321.9$ mm
$F_{ep,Rd,3} = 282.2$ kN, ass. $l_{eff} = 321.9$ mm

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

here: number of bolt rows $n_b = 2$

effective length of the T-stub flange (end-plate):
in mode 1: $\Sigma l_{eff,1} = \min(\Sigma l_{eff,nc}, \Sigma l_{eff,cp}) = 140.0$ mm, $\Sigma l_{eff,cp} = 280.0$ mm
in mode 2: $\Sigma l_{eff,2} = \Sigma l_{eff,nc} = 140.0$ mm
design tension resistance of the T-stub flange:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.85$ kNm
tension resistance of all bolts: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 564.48$ kN, $F_{t,Rd} = 141.12$ kN
$L_b \le L_b^* \Rightarrow$ prying forces may develop
$F_{T,1,Rd} = (4 \cdot M_{pl,1,Rd}) / m = 249.50$ kN
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 341.50$ kN, $n = 60.0$ mm
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 564.48$ kN
tension resistance of T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 249.50$ kN
design resistance of end-plate in bending (group of bolts, 2 row(s))
$F_{t,ep,Rd} = 249.5$ kN, ass. $l_{eff} = 140.0$ mm

verification

Lk 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 $\Rightarrow$ utilization $= 0.391 < 1$ **ok.**
row 2: $F_{Ed} = 100.0$ kN $<$ $F_{Rd} = 282.2$ kN $\Rightarrow$ utilization $= 0.354 < 1$ **ok.**
row 3: $F_{Ed} = 100.0$ kN $<$ $F_{Rd} = 282.2$ kN $\Rightarrow$ utilization $= 0.354 < 1$ **ok.**
group of bolts (between stiffeners): $F_{Ed} = 2 \cdot 2 \cdot F_{ep,Ed} = 200.0$ kN
$F_{Ed} = 200.0$ kN $<$ $F_{Rd} = 249.5$ kN $\Rightarrow$ utilization $= 0.802 < 1$ **ok.**