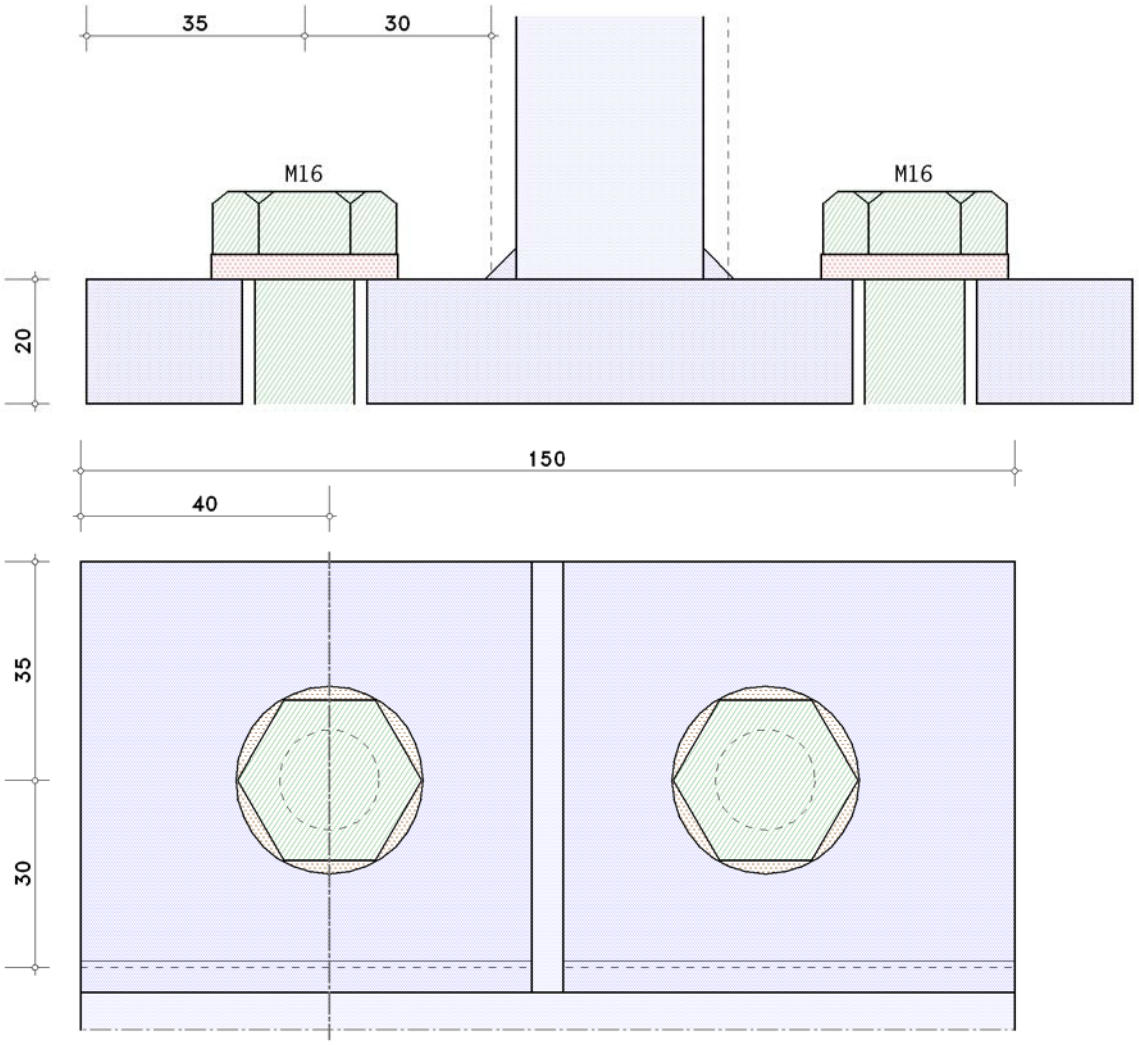
1. T-stub in tension

EC 3-1-8 (04.25), NA: Deutschland

1.1. input report



T-stub flange with thickness t_f = 20.0 mm, length l_f = 150.0 mm, steel grade S235

connection device

bolt class 10.9, bolt size M16

large wrench size (high strength bolt), preloaded (for info: preloading $F_{p,C}$* = 0.7·f_{yb}·A_s = 98.7 kN)

loading

design value of the tensile force per bolt $F_{t,Ed}$ = 80.0 kN

verification parameters

verification of the extended part of the connection plate (end-plate)

additional stiffener in the end plate projection: height of the stiffener should correspond to the projection height. thickness of stiffener should not be smaller than the thickness of beam web.

number of bolts per bolt-row n_{sr} = 2

application of method 2

distance centre-line of the bolt to the free end of the connection plate e = 40.0 mm

distance centre-line of the bolt to the tensile edge of connection plate e_1 = 35.0 mm

distance centre-line of the bolt to the periphery of the tension flange of beam m_1 = 30.0 mm

partial safety factors for material

resistance of cross-sections γ_{M0} = 1.00

1.2. resistance

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

e_x = e_1 = 35.0 mm, m_x = m_1 = 30.0 mm, stiffened, e = 40.0 mm, m = 30.0 mm

end bolt-row outside tension flange of beam, with stiffener of end plate

coefficient for stiffened column flanges and end-plates:

$\alpha = 4+1.67 \cdot e/m \cdot (m/m_2)^{2/3} = 6.23$, e = 40.0 mm, m = 30.0 mm, m_2 = 30.0 mm

$l_{eff,cp,sa} = \min(2 \cdot \pi \cdot m, \pi \cdot m + 2 \cdot e_x) = 164.2$ mm

$l_{eff,nc,sa} = \min(\alpha \cdot m - (2 \cdot m + 0.625 \cdot e) + e_x, \alpha \cdot m) = 136.8$ mm

in mode 1: $\Sigma l_{eff,1} = l_{eff,1} = \min(l_{eff,nc}, l_{eff,cp}) = 136.8$ mm
in mode 2: $\Sigma l_{eff,2} = l_{eff,2} = l_{eff,nc} = 136.8$ mm
distance centre-line of the bolt to the edge of stub flange $e_{min} = e_1 = 35.0$ mm
distance centre-line of the bolt to the stub web $m = m_1 = 30.0$ mm
tension resistance of the T-stub flange
$n = \min(e_{min}, 1.25 \cdot m) = 35.0$ mm, $e_{min} = 35.0$ mm, $m = 30.0$ mm
resisting plastic moments:
in mode 1+2: $M_{pl,Rd} = (0.25 \cdot \Sigma l_{eff} \cdot t_f^2 \cdot f_y) / \gamma_{M0} = 3.21$ kNm, $t_f = 20.0$ mm, $f_y = 235.0$ N/mm², $\gamma_{M0} = 1.00$
design value of tension resistance:
tension resistance of one bolt: $F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2} = 112.82$ kN, $k_2 = 0.90$, $f_{ub} = 1000.0$ N/mm²
in mode 3: $\Sigma F_{t,Rd} = 2 \cdot n_b \cdot F_{t,Rd} = 225.65$ kN, $n_b = 1$
prying forces always appear at preloaded bolts !
calculation with the alternative method
decisive diameter of the bolt $d_w = d_p = 30.00$ mm $\Rightarrow$ $e_w = d_w/4 = 7.5$ mm
mode 1: complete yielding of the T-stub flange
$F_{T,1,Rd} = ((8 \cdot n - 2 \cdot e_w) \cdot M_{pl,1,Rd}) / (2 \cdot m \cdot n - e_w \cdot (m+n)) = 528.32$ kN
mode 2: bolt failure simultaneously with yielding of the T-stub flange
$F_{T,2,Rd} = (2 \cdot M_{pl,2,Rd} + n \cdot \Sigma F_{t,Rd}) / (m+n) = 220.42$ kN
mode 3: bolt failure
$F_{T,3,Rd} = \Sigma F_{t,Rd} = 225.65$ kN
tension resistance of the T-stub flange: $F_{T,Rd} = \min(F_{T,1,Rd}, F_{T,2,Rd}, F_{T,3,Rd}) = 220.42$ kN
verification
$F_{T,Ed} = 2 \cdot F_{t,Ed} = 160.0$ kN $<$ $F_{T,Rd} = 220.42$ kN $\Rightarrow$ utilization $U = 0.726 < 1$ ok

maximum utilization $U_{max} = 0.726 < 1$ ok

verification succeeded

2. Regulations

EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
EN 1990/NA, Nationaler Anhang zur EN 1990, Ausgabe Dezember 2010

EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2022, Ausgabe April 2025
EN 1993-1-1/A1, Ergänzungen zur EN 1993-1-1, Ausgabe Juli 2014
EN 1993-1-1/NA, Nationaler Anhang zur EN 1993-1-1, Ausgabe Oktober 2022

EN 1993-1-8, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-8: Bemessung von Anschlüssen;
Deutsche Fassung EN 1993-1-8:2024, Ausgabe April 2025
EN 1993-1-8/NA, Nationaler Anhang zur EN 1993-1-8, Ausgabe November 2020