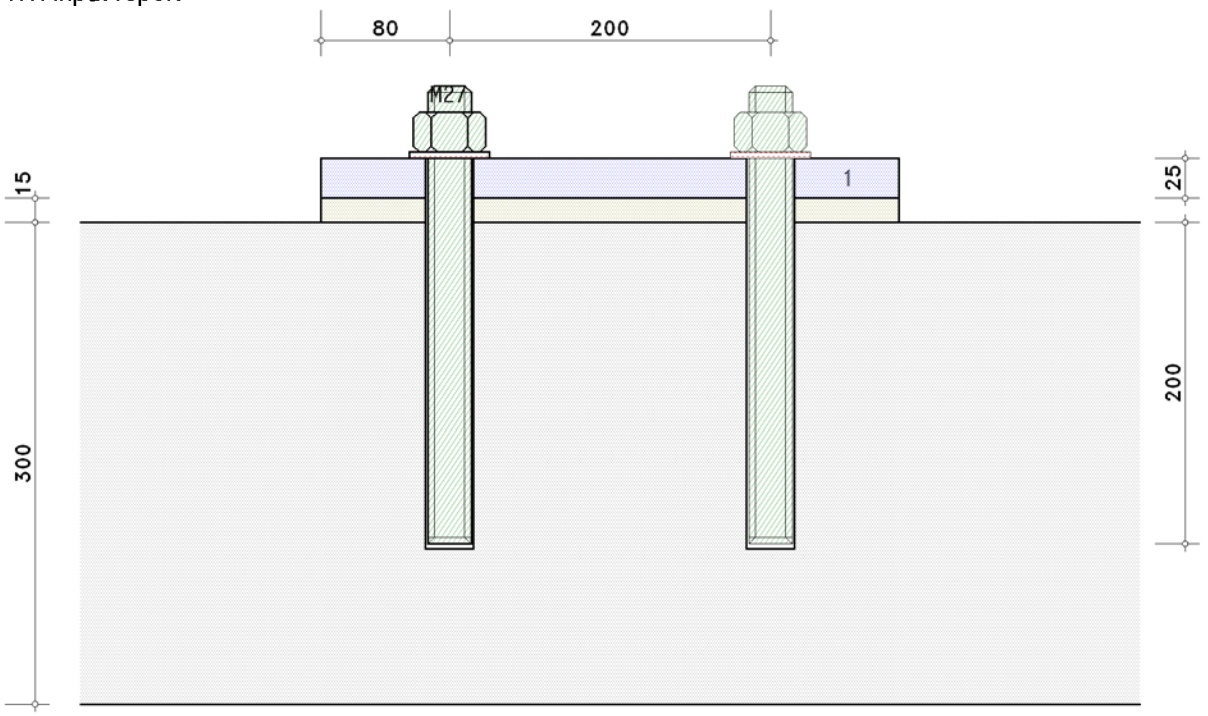
1. Bolted Connection

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

1.1. input report



connection device

anchor bolt: design as ribbed steel/thread rod with suitability tests
reinforced steel B500B, bolt size M27, bonding depth $\Delta e = 200.0$ mm
normal wrench size

connection elements

steel plate with thickness $t_p = 25.0$ mm, steel grade S235
grout layer with thickness $t_m = 15.0$ mm
concrete section with thickness $t_f = 300.0$ mm, concrete grade C20/25
note: width of cross-section > $3 \cdot \Delta e + (n_{s1}-1) \cdot p_1 = 800.0$ mm, length > $3 \cdot \Delta e + (n_{s2}-1) \cdot p_2 = 800.0$ mm !!

verifications

single shear connection
shear connection category A (shear, bearing failure):
design ultimate shear load $F_{v,Ed} = 40.0$ kN
bearing resistance in direction of load transfer:
edge distance $e_{1,1} = 80.0$ mm, pitch $p_1 = 200.0$ mm
bearing resistance across to direction of load transfer:
$e_{2,1} = 80.0$ mm, pitch $p_2 = 200.0$ mm
tension connection category D (tension):
design value of the applied tensile force $F_{t,Edr} = 7.0$ kN

partial safety factors for material

resistance of bolts, welds, plates in bearing $\gamma_{M2} = 1.25$

1.2. resistance

shear/bearing resistance

shear
anchor bolt: $\alpha_v = 0.44\text{-}0.0003 \cdot f_{yb} = 0.290$, $f_{yb} = 500.0$ N/mm², $A = 4.59$ cm²
shear resistance $F_{v,Rd} = \alpha_v \cdot f_{ub} \cdot A / \gamma_{M2} = 55.95$ kN, $f_{ub} = 525.0$ N/mm²
$F_{v,Ed} = 40.0$ kN < $F_{v,Rd} = 55.95$ kN $\Rightarrow$ U = 0.715 < 1 ok
bearing stress of steel plate and bolt
inner bolt: $\alpha_{d,i} = p_1/d_0\text{-}1/2 = 6.17$
end bolt: $\alpha_{d,a} = e_1/d_0 = 2.67$
$\Rightarrow \alpha_b = 2.67$ (smallest value of $\alpha_{d,i}$, $\alpha_{d,a}$ or $3 \cdot f_{ub}/f_u = 4.38$ or 3.0)
normal bolt $k_m = 1.0$
bearing resistance: $F_{b,Rd} = (k_m \cdot \alpha_b \cdot f_u \cdot d \cdot t) / \gamma_{M2} = 518.40$ kN, $f_u = 360.0$ N/mm², $t = 25.0$ mm, $d = 27.0$ mm
edge bolt across to direction of load transfer: $N_{u,Rd} = 2 \cdot (e_2\text{-}d_0/2) \cdot t \cdot f_u/\gamma_{M2} = 936.00$ kN > $F_{b,Rd}$ ok

$F_{v,Ed}$ = 40.0 kN < $F_{b,Rd}$ = 518.40 kN ⇒ U = 0.077 < 1 ok

concrete pryout failure

resistance against concrete pryout failure: $V_{Rk,cp} = k_8 \cdot N_{Rk,c}$ = 97.40 kN, k_8 = 1.0

resistance against concrete cone failure $N_{Rk,c} = N_{Rk,c}^0 \cdot A_{c,N}/A_{c,N}^0 \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \cdot \psi_{M,N}$ = 97.40 kN

$\psi_{s,N}$ = 1.0, $\psi_{re,N}$ = 1.0, $\psi_{ec,N}$ = 1.0, $\psi_{M,N}$ = 1.0, $A_{c,N}/A_{c,N}^0$ = 1.0, $N_{Rk,c}^0$ = 97.40 kN

$V_{Rd,cp} = V_{Rk,cp}/\gamma_{Mc}$ = 64.93 kN, $\gamma_{Mc} = \gamma_c$ = 1.50

$F_{v,Ed}$ = 40.0 kN < $V_{Rd,cp}$ = 64.93 kN ⇒ U = 0.616 < 1 ok

tension connection

tensile failure

tension resistance of one bolt: $F_{t,Rd} = (k_2 \cdot f_{ub} \cdot A_s) / \gamma_{M2}$ = 173.65 kN, k_2 = 0.90, f_{ub} = 525.0 N/mm²

bond strength of anchor bolt: $F_{bd} = \Delta e \cdot A_s \cdot f_{bd} \cdot 4/d$ = 22.11 kN, Δe = 200.0 mm

bond strength $f_{bd} = 2.25 \cdot \eta_1 \cdot \eta_2 \cdot f_{ctd}$ = 1.62 N/mm², η_1 = 0.7 (moderate bond), η_2 = 1.0, f_{ctd} = 1.03 N/mm²

additional resistance of anchor bolt for $F_{bd} < F_{t,Rd}$: $F_{t,Rd}$ = 22.11 kN

$F_{t,Ed}$ = 7.0 kN < $F_{t,Rd}$ = 22.11 kN ⇒ U = 0.317 < 1 ok

concrete cone failure

resistance against concrete cone failure: $N_{Rk,c} = N_{Rk,c}^0 \cdot A_{c,N}/A_{c,N}^0 \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \cdot \psi_{M,N}$ = 97.40 kN

$\psi_{s,N}$ = 1.0, $\psi_{re,N}$ = 1.0, $\psi_{ec,N}$ = 1.0, $\psi_{M,N}$ = 1.0, $A_{c,N}/A_{c,N}^0$ = 1.0

$N_{Rk,c}^0 = k_1 \cdot f_{ck}^{1/2} \cdot h_{ef}^{3/2}$ = 97.40 kN, k_1 = 7.7, f_{ck} = 20.0 N/mm², h_{ef} = 200.0 mm

$N_{Rd,c} = N_{Rk,c}/\gamma_{Mc}$ = 64.93 kN, $\gamma_{Mc} = \gamma_c$ = 1.50

$F_{t,Ed}$ = 7.0 kN < $N_{Rd,c}$ = 64.93 kN ⇒ U = 0.108 < 1 ok

combination of shear and tension (steel failure)

$F_{v,Ed}/F_{v,Rd} + F_{t,Ed}/(1.4 \cdot F_{t,Rd})$ = 0.941 < 1 ok

combination of transverse loading in tension (concrete failure)

$(F_{v,Ed}/V_{Rd,cp})^{1.5} + (F_{t,Ed}/N_{Rd,c})^{1.5}$ = 0.519 or $(F_{v,Ed}/V_{Rd,cp} + F_{t,Ed}/N_{Rd,c})/1.2$ = 0.603

⇒ utilization U = 0.519 < 1 ok

maximum utilization U_{max} = 0.941 < 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

EN 1992-4, Eurocode 2: Bemessung und Konstruktion von Stahlbeton- und Spannbetontragwerken -
part 4: Bemessung der Verankerung von Befestigungen in Beton;
Deutsche Fassung EN 1992-4:2018, Ausgabe April 2019
EN 1992-4/NA, Nationaler Anhang zur EN 1992-4, Ausgabe April 2019