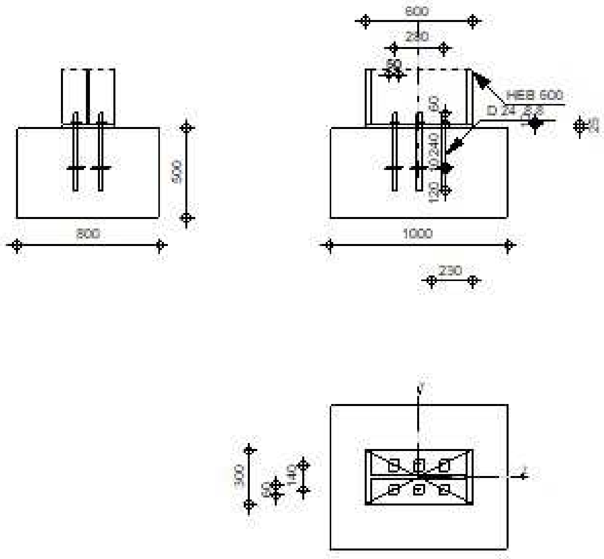
Robot Structural Analysis Professional 2024

Eurocode 3: EN 1993-1-8:2005/AC:2009 + CEB Design Guide: Design of fastenings in concrete

OK

Ratio
0,48



GEOMETRY

COLUMN

Section: HEB 600

L_c =	5,00	[m]	Column length
α =	0,00	[Deg]	Inclination angle
h_c =	600	[mm]	Height of column section
b_{fc} =	300	[mm]	Width of column section
t_{wc} =	16	[mm]	Thickness of the web of column section
t_{fc} =	30	[mm]	Thickness of the flange of column section
r_c =	27	[mm]	Radius of column section fillet
A_c =	269,96	[cm^2]	Cross-sectional area of a column
I_{yc} =	171041,00	[cm^4]	Moment of inertia of the column section

Material: S355

f_{yc} =	355,00	[MPa]	Resistance
f_{uc} =	490,00	[MPa]	Yield strength of a material

COLUMN BASE

l_{pd} =	600	[mm]	Length
b_{pd} =	300	[mm]	Width
t_{pd} =	25	[mm]	Thickness

Material: S235

f_{ypd} =	235,00	[MPa]	Resistance
f_{upd} =	360,00	[MPa]	Yield strength of a material

ANCHORAGE

The shear plane passes through the UNTHREADED portion of the bolt.

Class =	8.8		Anchor class
f_{yb} =	640,00	[MPa]	Yield strength of the anchor material
f_{ub} =	800,00	[MPa]	Tensile strength of the anchor material
d =	24	[mm]	Bolt diameter
A_s =	3,53	[cm^2]	Effective section area of a bolt
A_v =	4,52	[cm^2]	Area of bolt section
n_H =	3		Number of bolt columns
n_V =	2		Number of bolt rows

Horizontal spacing e_{Hi} = 140 [mm]

Vertical spacing e_{Vi} = 140 [mm]

Anchor dimensions

L_1 =	60	[mm]
L_2 =	240	[mm]
L_3 =	120	[mm]

Anchor plate

l_p =	100	[mm]	Length
b_p =	100	[mm]	Width
t_p =	10	[mm]	Thickness

Material: S235

f_y =	235,00	[MPa]	Resistance

Washer

l_{wd} =	50	[mm]	Length
b_{wd} =	60	[mm]	Width
t_{wd} =	10	[mm]	Thickness

MATERIAL FACTORS

γ_{M0} =	1,00	Partial safety factor
γ_{M2} =	1,25	Partial safety factor
γ_C =	1,50	Partial safety factor

SPREAD FOOTING

L =	1000	[mm]	Spread footing length
B =	800	[mm]	Spread footing width
H =	500	[mm]	Spread footing height

Concrete

Class C25/30

f_{ck} =	25,00	[MPa]	Characteristic resistance for compression

Grout layer

t_g =	0	[mm]	Thickness of leveling layer (grout)
$f_{ck,g}$ =	12,00	[MPa]	Characteristic resistance for compression
$C_{f,d}$ =	0,30		Coeff. of friction between the base plate and concrete

WELDS

a_p =	4	[mm]	Footing plate of the column base

LOADS

Case: Manual calculations.

$N_{j,Ed}$ = -685,00 [kN] Axial force
$V_{j,Ed,y}$ = 128,00 [kN] Shear force
$V_{j,Ed,z}$ = 91,00 [kN] Shear force

RESULTS

COMPRESSION ZONE

COMPRESSION OF CONCRETE

f_{cd} =	16,67	[MPa]	Design compressive resistance	EN 1992-1:[3.1.6.(1)]
f_j =	23,42	[MPa]	Design bearing resistance under the base plate	[6.2.5.(7)]

$c = t_p \sqrt{(f_{yp}/(3 \cdot f_j \cdot \gamma_{M0}))}$

c =	46	[mm]	Additional width of the bearing pressure zone	[6.2.5.(4)]
b_{eff} =	76	[mm]	Effective width of the bearing pressure zone under the flange	[6.2.5.(3)]
l_{eff} =	300	[mm]	Effective length of the bearing pressure zone under the flange	[6.2.5.(3)]
A_{c0} =	227,15	[cm^2]	Area of the joint between the base plate and the foundation	EN 1992-1:[6.7.(3)]
A_{c1} =	1817,21	[cm^2]	Maximum design area of load distribution	EN 1992-1:[6.7.(3)]

$F_{rdu} = A_{c0} \cdot f_{cd} \cdot \sqrt{(A_{c1}/A_{c0})} \le 3 \cdot A_{c0} \cdot f_{cd}$

F_{rdu} =	1070,80	[kN]	Bearing resistance of concrete	EN 1992-1:[6.7.(3)]
β_j =	0,67		Reduction factor for compression	[6.2.5.(7)]

$f_{jd} = \beta_j \cdot F_{rdu}/(b_{eff} \cdot l_{eff})$

f_{jd} =	31,43	[MPa]	Design bearing resistance	[6.2.5.(7)]
$A_{c,n}$ =	933,97	[cm^2]	Bearing area for compression	[6.2.8.2.(1)]

$F_{c,Rd,i} = A_{C,i} \cdot f_{jd}$

$F_{c,Rd,n}$ =	2935,20	[kN]	Bearing resistance of concrete for compression	[6.2.8.2.(1)]

RESISTANCES OF SPREAD FOOTING IN THE COMPRESSION ZONE

$N_{j,Rd} = F_{c,Rd,n}$

$N_{j,Rd}$ =	2935,20	[kN]	Resistance of a spread footing for axial compression	[6.2.8.2.(1)]

CONNECTION CAPACITY CHECK

$N_{j,Ed} / N_{j,Rd} \le 1,0$ (6.24)	0,23 < 1,00	verified	(0,23)

SHEAR

BEARING PRESSURE OF AN ANCHOR BOLT ONTO THE BASE PLATE

Shear force $V_{j,Ed,y}$

$\alpha_{d,y}$ =	1,03	Coeff. taking account of the bolt position - in the direction of shear	[Table 3.4]
$\alpha_{b,y}$ =	1,00	Coeff. for resistance calculation $F_{1,vb,Rd}$	[Table 3.4]
$k_{1,y}$ =	2,50	Coeff. taking account of the bolt position - perpendicularly to the direction of shear	[Table 3.4]

$F_{1,vb,Rd,y} = k_{1,y} \cdot \alpha_{b,y} \cdot f_{up} \cdot d \cdot t_p / \gamma_{M2}$

$F_{1,vb,Rd,y}$ =	432,00	[kN]	Resistance of an anchor bolt for bearing pressure onto the base plate	[6.2.2.(7)]

Shear force $V_{j,Ed,z}$

$\alpha_{d,z}$ =	2,05	Coeff. taking account of the bolt position - in the direction of shear	[Table 3.4]
$\alpha_{b,z}$ =	1,00	Coeff. for resistance calculation $F_{1,vb,Rd}$	[Table 3.4]
$k_{1,z}$ =	2,50	Coeff. taking account of the bolt position - perpendicularly to the direction of shear	[Table 3.4]

$F_{1,vb,Rd,z} = k_{1,z} \cdot \alpha_{b,z} \cdot f_{up} \cdot d \cdot t_p / \gamma_{M2}$

$F_{1,vb,Rd,z}$ =	432,00	[kN]	Resistance of an anchor bolt for bearing pressure onto the base plate	[6.2.2.(7)]

SHEAR OF AN ANCHOR BOLT

α_b =	0,25		Coeff. for resistance calculation $F_{2,vb,Rd}$	[6.2.2.(7)]
A_{vb} =	4,52	[cm^2]	Area of bolt section	[6.2.2.(7)]
f_{ub} =	800,00	[MPa]	Tensile strength of the anchor material	[6.2.2.(7)]

α_b =	0,25	Coeff. for resistance calculation $F_{2,vb,Rd}$	[6.2.2.(7)]
γ_{M2} =	1,25	Partial safety factor	[6.2.2.(7)]

$F_{2,vb,Rd} = \alpha_b * f_{ub} * A_{vb} / \gamma_{M2}$

$F_{2,vb,Rd}$ = 71,80 [kN] Shear resistance of a bolt - without lever arm [6.2.2.(7)]

CONCRETE PRY-OUT FAILURE

$N_{Rk,c}$ =	156,33	[kN]	Design uplift capacity	CEB [9.2.4]
k_3 =	2,00		Factor related to the anchor length	CEB [9.3.3]
γ_{Mc} =	2,16		Partial safety factor	CEB [3.2.3.1]

$F_{v,Rd,cp} = k_3 * N_{Rk,c} / \gamma_{Mc}$

$F_{v,Rd,cp}$ = 144,75 [kN] Concrete resistance for pry-out failure CEB [9.3.1]

CONCRETE EDGE FAILURE

Shear force $V_{j,Ed,y}$

$V_{Rk,c,y}^{0}$ =	144,96 [kN]	Characteristic resistance of an anchor
$\psi_{A,V,y}$ =	0,73	Factor related to anchor spacing and edge distance
$\psi_{h,V,y}$ =	1,00	Factor related to the foundation thickness
$\psi_{s,V,y}$ =	0,92	Factor related to the influence of edges parallel to the shear load direction
$\psi_{ec,V,y}$ =	1,00	Factor taking account a group effect when different shear loads are acting on the individual anchors in a group
$\psi_{\alpha,V,y}$ =	1,00	Factor related to the angle at which the shear load is applied
$\psi_{ucr,V,y}$ =	1,00	Factor related to the type of edge reinforcement used
γ_{Mc} =	2,16	Partial safety factor

$F_{v,Rd,c,y} = V_{Rk,c,y}^{0} * \psi_{A,V,y} * \psi_{h,V,y} * \psi_{s,V,y} * \psi_{ec,V,y} * \psi_{\alpha,V,y} * \psi_{ucr,V,y} / \gamma_{Mc}$

$F_{v,Rd,c,y}$ = 44,81 [kN] Concrete resistance for edge failure CEB [9.3.1]

Shear force $V_{j,Ed,z}$

$V_{Rk,c,z}^{0}$ =	165,17 [kN]	Characteristic resistance of an anchor
$\psi_{A,V,z}$ =	0,57	Factor related to anchor spacing and edge distance
$\psi_{h,V,z}$ =	1,03	Factor related to the foundation thickness
$\psi_{s,V,z}$ =	0,88	Factor related to the influence of edges parallel to the shear load direction
$\psi_{ec,V,z}$ =	1,00	Factor taking account a group effect when different shear loads are acting on the individual anchors in a group
$\psi_{\alpha,V,z}$ =	1,00	Factor related to the angle at which the shear load is applied
$\psi_{ucr,V,z}$ =	1,00	Factor related to the type of edge reinforcement used
γ_{Mc} =	2,16	Partial safety factor

$F_{v,Rd,c,z} = V_{Rk,c,z}^{0} * \psi_{A,V,z} * \psi_{h,V,z} * \psi_{s,V,z} * \psi_{ec,V,z} * \psi_{\alpha,V,z} * \psi_{ucr,V,z} / \gamma_{Mc}$

$F_{v,Rd,c,z}$ = 39,21 [kN] Concrete resistance for edge failure CEB [9.3.1]

SPLITTING RESISTANCE

$C_{f,d}$ =	0,30	Coeff. of friction between the base plate and concrete	[6.2.2.(6)]
$N_{c,Ed}$ =	685,00 [kN]	Compressive force	[6.2.2.(6)]

$F_{f,Rd} = C_{f,d} * N_{c,Ed}$

$F_{f,Rd}$ = 205,50 [kN] Slip resistance [6.2.2.(6)]

SHEAR CHECK

$V_{j,Rd,y} = n_b * \min(F_{1,vb,Rd,y}, F_{2,vb,Rd}, F_{v,Rd,cp}, F_{v,Rd,c,y}) + F_{f,Rd}$

$V_{j,Rd,y}$ = 474,38 [kN] Connection resistance for shear CEB [9.3.1]

$V_{j,Ed,y} / V_{j,Rd,y} \leq 1,0$	0,27 < 1,00	verified	(0,27)

$V_{j,Rd,z} = n_b * \min(F_{1,vb,Rd,z}, F_{2,vb,Rd}, F_{v,Rd,cp}, F_{v,Rd,c,z}) + F_{f,Rd}$

$V_{j,Rd,z}$ = 440,78 [kN] Connection resistance for shear CEB [9.3.1]

$V_{j,Ed,z} / V_{j,Rd,z} \leq 1,0$	0,21 < 1,00	verified	(0,21)
$V_{j,Ed,y} / V_{j,Rd,y} + V_{j,Ed,z} / V_{j,Rd,z} \leq 1,0$	0,48 < 1,00	verified	(0,48)

WELDS BETWEEN THE COLUMN AND THE BASE PLATE

$\sigma_{\perp}$ =	40,38	[MPa]	Normal stress in a weld	[4.5.3.(7)]
$\tau_{\perp}$ =	40,38	[MPa]	Perpendicular tangent stress	[4.5.3.(7)]
τ_{yII} =	27,37	[MPa]	Tangent stress parallel to $V_{j,Ed,y}$	[4.5.3.(7)]

$\sigma_{\perp}$ =	40,38	[MPa]	Normal stress in a weld	[4.5.3.(7)]
τ_{zII} =	21,06	[MPa]	Tangent stress parallel to $V_{j,Ed,z}$	[4.5.3.(7)]
β_W =	0,80		Resistance-dependent coefficient	[4.5.3.(7)]

$\sigma_{\perp} / (0.9 \cdot f_u/\gamma_{M2}) \leq 1.0$ (4.1)	0,16 < 1,00	verified	(0,16)
$\sqrt{(\sigma_{\perp}^2 + 3.0 (\tau_{yII}^2 + \tau_{\perp}^2))} / (f_u/(\beta_W \cdot \gamma_{M2})) \leq 1.0$ (4.1)	0,26 < 1,00	verified	(0,26)
$\sqrt{(\sigma_{\perp}^2 + 3.0 (\tau_{zII}^2 + \tau_{\perp}^2))} / (f_u/(\beta_W \cdot \gamma_{M2})) \leq 1.0$ (4.1)	0,25 < 1,00	verified	(0,25)

WEAKEST COMPONENT:

FOUNDATION - EDGE FAILURE

Connection conforms to the code Ratio 0,48