



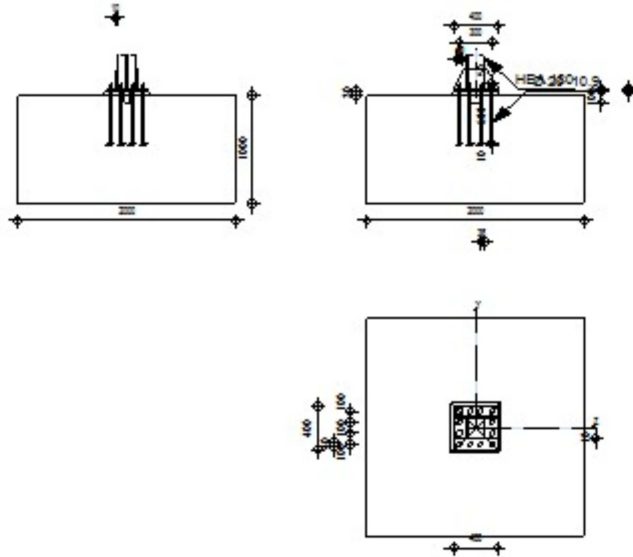
Autodesk Robot Structural Analysis Professional 2015

Fixed column base design

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

OK

Ratio
1.00



GENERAL

Connection no.: 2
Connection name: Montantes

GEOMETRY

COLUMN

Section: HEA 180
 $L_c = 14.30$ [m] Column length
Material: S 235

COLUMN BASE

$l_{pd} = 400$ [mm] Length
 $b_{pd} = 400$ [mm] Width
 $t_{pd} = 25$ [mm] Thickness
Material: S 235
 $f_{ypd} = 235.00$ [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 = 10.9 Anchor class
 $f_{yb} = 900.00$ [MPa] Yield strength of the anchor material
 $f_{ub} = 1000.00$ [MPa] Tensile strength of the anchor material
 $d = 20$ [mm] Bolt diameter
 $n_H = 4$ Number of bolt columns
 $n_V = 4$ Number of bolt rows
Horizontal spacing $e_{Hi} = 100;100$ [mm]
Vertical spacing $e_{Vi} = 100;100$ [mm]

WEDGE

Section: IPE 100
 $l_w = 100$ [mm] Length
Material: S 235
 $f_{yw} = 235.00$ [MPa] Resistance

STIFFENER

$l_s = 400$ [mm] Length
 $h_s = 171$ [mm] Height
 $t_s = 10$ [mm] Thickness
 $d_1 = 20$ [mm] Cut
 $d_2 = 20$ [mm] Cut

MATERIAL FACTORS

$\gamma_{M0} = 1.00$ Partial safety factor
 $\gamma_{M2} = 1.25$ Partial safety factor
 $\gamma_C = 1.50$ Partial safety factor

SPREAD FOOTING

$L = 2000$ [mm] Spread footing length
 $B = 2000$ [mm] Spread footing width
 $H = 1000$ [mm] Spread footing height

Concrete

Class C25/30
 $f_{ck} = 25.00$ [MPa] Characteristic resistance for compression

Grout layer

$t_g = 30$ [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
 $a_w = 4$ [mm] Wedge
 $a_s = 4$ [mm] Stiffeners

LOADS

Case: Manual calculations.

$N_{j,Ed} = 316.00$ [kN] Axial force
 $V_{j,Ed,y} = 92.00$ [kN] Shear force
 $V_{j,Ed,z} = 12.00$ [kN] Shear force
 $M_{j,Ed,y} = 17.50$ [kN*m] Bending moment
 $M_{j,Ed,z} = 21.00$ [kN*m] Bending moment

RESULTS

TENSION ZONE

STEEL FAILURE

$F_{t,Rd,s1} = 149.94$ [kN] Anchor resistance to steel failure [Table 3.4]
 $F_{t,Rd,s2} = 183.75$ [kN] Anchor resistance to steel failure CEB [9.2.2]

$$F_{t,Rd,s} = \min(F_{t,Rd,s1}, F_{t,Rd,s2})$$

$F_{t,Rd,s} = 149.94$ [kN] Anchor resistance to steel failure

PULL-OUT FAILURE

$F_{t,Rd,p} = 398.08$ [kN] Design uplift capacity CEB [9.2.3]

CONCRETE CONE FAILURE

$N_{Rk,c}^0 = 419.26$ [kN] Design uplift capacity CEB [9.2.4]

$F_{t,Rd,c} = 194.10$ [kN] Design anchor resistance to concrete cone failure EN 1992-1:[8.4.2.(2)]

SPLITTING FAILURE

$N_{Rk,c}^0 = 419.26$ [kN] Design uplift capacity CEB [9.2.5]

$F_{t,Rd,sp} = 194.10$ [kN] Design anchor resistance to splitting of concrete CEB [9.2.5]

TENSILE RESISTANCE OF AN ANCHOR

$F_{t,Rd} = \min(F_{t,Rd,s}, F_{t,Rd,p}, F_{t,Rd,c}, F_{t,Rd,sp})$

$F_{t,Rd} = 149.94$ [kN] Tensile resistance of an anchor

BENDING OF THE BASE PLATE

$F_{t,pl,Rd,y} = 446.55$ [kN] Tension resistance of a plate [6.2.4]

$F_{t,pl,Rd,z} = 446.55$ [kN] Tension resistance of a plate [6.2.4]

RESISTANCES OF SPREAD FOOTING IN THE TENSION ZONE

$N_{j,Rd} = 1339.64$ [kN] Resistance of a spread footing for axial tension [6.2.8.3]

$F_{T,Rd,y} = F_{t,pl,Rd,y}$

$F_{T,Rd,y} = 446.55$ [kN] Resistance of a column base in the tension zone [6.2.8.3]

$F_{T,Rd,z} = F_{t,pl,Rd,z}$

$F_{T,Rd,z} = 446.55$ [kN] Resistance of a column base in the tension zone [6.2.8.3]

CONNECTION CAPACITY CHECK

$N_{j,Ed} / N_{j,Rd} \leq 1,0$ (6.24) $0.24 < 1.00$ **verified** (0.24)

$M_{j,Rd,y} = 36.12$ [kN*m] Connection resistance for bending [6.2.8.3]

$M_{j,Ed,y} / M_{j,Rd,y} \leq 1,0$ (6.23) $0.48 < 1.00$ **verified** (0.48)

$M_{j,Rd,z} = 41.13$ [kN*m] Connection resistance for bending [6.2.8.3]

$M_{j,Ed,z} / M_{j,Rd,z} \leq 1,0$ (6.23) $0.51 < 1.00$ **verified** (0.51)

$M_{j,Ed,y} / M_{j,Rd,y} + M_{j,Ed,z} / M_{j,Rd,z} \leq 1,0$ $1.00 < 1.00$ **verified** (1.00)

SHEAR

BEARING PRESSURE OF AN ANCHOR BOLT ONTO THE BASE PLATE

$F_{1,vb,Rd,y} = 272.73$ [kN] Resistance of an anchor bolt for bearing pressure onto the base plate [6.2.2.(7)]

$F_{1,vb,Rd,z} = 272.73$ [kN] Resistance of an anchor bolt for bearing pressure onto the base plate [6.2.2.(7)]

SHEAR OF AN ANCHOR BOLT

$F_{2,vb,Rd} = 62.33$ [kN] Shear resistance of a bolt - without lever arm [6.2.2.(7)]

$F_{v,Rd,sm} = 18.14$ [kN] Shear resistance of a bolt - with lever arm CEB [9.3.1]

CONCRETE PRY-OUT FAILURE

$F_{v,Rd,cp} = 388.21$ [kN] Concrete resistance for pry-out failure CEB [9.3.1]

CONCRETE EDGE FAILURE

$F_{v,Rd,c,y} = 473.28$ [kN] Concrete resistance for edge failure CEB [9.3.1]

$F_{v,Rd,c,z} = 473.28$ [kN] Concrete resistance for edge failure CEB [9.3.1]

SPLITTING RESISTANCE

$F_{f,Rd} = 0.00$ [kN] Slip resistance [6.2.2.(6)]

BEARING PRESSURE OF THE WEDGE ONTO CONCRETE

$F_{v,Rd,wg,y} = 233.33$ [kN] Resistance for bearing pressure of the wedge onto concrete

$F_{v,Rd,wg,z} = 128.33$ [kN] Resistance for bearing pressure of the wedge onto concrete

SHEAR CHECK

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

$V_{j,Rd,y} = 450.96$ [kN] Connection resistance for shear CEB [9.3.1]

$V_{j,Ed,y} / V_{j,Rd,y} \leq 1,0$ 0.20 < 1.00 **verified** (0.20)

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

$V_{j,Rd,z} = 345.96$ [kN] Connection resistance for shear CEB [9.3.1]

$V_{j,Ed,z} / V_{j,Rd,z} \leq 1,0$ 0.03 < 1.00 **verified** (0.03)

$V_{j,Ed,y} / V_{j,Rd,y} + V_{j,Ed,z} / V_{j,Rd,z} \leq 1,0$ 0.24 < 1.00 **verified** (0.24)

STIFFENER CHECK**Trapezoid plate parallel to the column web**

$\sigma_d = 5.48$ [MPa] Normal stress on the contact surface between stiffener and plate EN 1993-1-1:[6.2.1.(5)]

$\sigma_g = 75.46$ [MPa] Normal stress in upper fibers EN 1993-1-1:[6.2.1.(5)]

$\tau = 72.22$ [MPa] Tangent stress in a stiffener EN 1993-1-1:[6.2.1.(5)]

$\sigma_z = 125.21$ [MPa] Equivalent stress on the contact surface between stiffener and plate EN 1993-1-1:[6.2.1.(5)]

$\max(\sigma_g, \tau / (0.58), \sigma_z) / (f_{yp} / \gamma_{M0}) \leq 1.0$ (6.1) 0.53 < 1.00 **verified** (0.53)

WELDS BETWEEN THE COLUMN AND THE BASE PLATE

| | | | | |
|--|-------|-------|---|-----------------|
| $\sigma_{\perp} =$ | 54.32 | [MPa] | Normal stress in a weld | [4.5.3.(7)] |
| $\tau_{\perp} =$ | 54.32 | [MPa] | Perpendicular tangent stress | [4.5.3.(7)] |
| $\tau_{yII} =$ | 32.49 | [MPa] | Tangent stress parallel to $V_{j,Ed,y}$ | [4.5.3.(7)] |
| $\tau_{zII} =$ | 1.58 | [MPa] | Tangent stress parallel to $V_{j,Ed,z}$ | [4.5.3.(7)] |
| $\beta_W =$ | 0.80 | | Resistance-dependent coefficient | [4.5.3.(7)] |
| $\sigma_{\perp} / (0.9 \cdot f_u / \gamma_{M2}) \leq 1.0$ (4.1) | 0.21 | < | 1.00 | verified (0.21) |
| $\sqrt{(\sigma_{\perp}^2 + 3.0 (\tau_{yII}^2 + \tau_{zII}^2))} / (f_u / (\beta_W \cdot \gamma_{M2})) \leq 1.0$ (4.1) | 0.34 | < | 1.00 | verified (0.34) |
| $\sqrt{(\sigma_{\perp}^2 + 3.0 (\tau_{zII}^2 + \tau_{\perp}^2))} / (f_u / (\beta_W \cdot \gamma_{M2})) \leq 1.0$ (4.1) | 0.17 | < | 1.00 | verified (0.17) |

VERTICAL WELDS OF STIFFENERS

Trapezoid plate parallel to the column web

| | | | | |
|---|-------|-------|----------------------------------|-----------------|
| $\sigma_{\perp} =$ | 0.00 | [MPa] | Normal stress in a weld | [4.5.3.(7)] |
| $\tau_{\perp} =$ | 0.00 | [MPa] | Perpendicular tangent stress | [4.5.3.(7)] |
| $\tau_{II} =$ | 90.28 | [MPa] | Parallel tangent stress | [4.5.3.(7)] |
| $\sigma_z =$ | 0.00 | [MPa] | Total equivalent stress | [4.5.3.(7)] |
| $\beta_W =$ | 0.80 | | Resistance-dependent coefficient | [4.5.3.(7)] |
| $\max(\sigma_{\perp}, \tau_{II} \cdot \sqrt{3}, \sigma_z) / (f_u / (\beta_W \cdot \gamma_{M2})) \leq 1.0$ (4.1) | 0.43 | < | 1.00 | verified (0.43) |

TRANSVERSAL WELDS OF STIFFENERS

Trapezoid plate parallel to the column web

| | | | | |
|---|--------|-------|----------------------------------|-----------------|
| $\sigma_{\perp} =$ | 95.34 | [MPa] | Normal stress in a weld | [4.5.3.(7)] |
| $\tau_{\perp} =$ | 95.34 | [MPa] | Perpendicular tangent stress | [4.5.3.(7)] |
| $\tau_{II} =$ | 148.45 | [MPa] | Parallel tangent stress | [4.5.3.(7)] |
| $\sigma_z =$ | 320.10 | [MPa] | Total equivalent stress | [4.5.3.(7)] |
| $\beta_W =$ | 0.80 | | Resistance-dependent coefficient | [4.5.3.(7)] |
| $\max(\sigma_{\perp}, \tau_{II} \cdot \sqrt{3}, \sigma_z) / (f_u / (\beta_W \cdot \gamma_{M2})) \leq 1.0$ (4.1) | 0.89 | < | 1.00 | verified (0.89) |

CONNECTION STIFFNESS

Bending moment $M_{j,Ed,y}$

| | | | | |
|-------------------|----------|--------|---|---------------|
| $k_{13,y} =$ | 17 | [mm] | Stiffness coeff. of compressed concrete | [Table 6.11] |
| $k_{15,y} =$ | 12 | [mm] | Stiffness coeff. of the base plate subjected to tension | [Table 6.11] |
| $k_{16,y} =$ | 2 | [mm] | Stiffness coeff. of an anchor subjected to tension | [Table 6.11] |
| $\lambda_{0,y} =$ | 2.04 | | Column slenderness | [5.2.2.5.(2)] |
| $S_{j,ini,y} =$ | 14126.17 | [kN*m] | Initial rotational stiffness | [Table 6.12] |
| $S_{j,rig,y} =$ | 11059.32 | [kN*m] | Stiffness of a rigid connection | [5.2.2.5] |

$S_{j,ini,y}$ B $S_{j,rig,y}$ RIGID

[5.2.2.5.(2)]

Bending moment $M_{j,Ed,z}$
 $k_{13,z} = 22$ [mm] Stiffness coeff. of compressed concrete

[Table 6.11]

 $k_{15,z} = 12$ [mm] Stiffness coeff. of the base plate subjected to tension

[Table 6.11]

 $k_{16,z} = 2$ [mm] Stiffness coeff. of an anchor subjected to tension

[Table 6.11]

 $\lambda_{0,z} = 3.37$ Column slenderness

[5.2.2.5.(2)]

 $S_{j,ini,z} = 14126.17$ [kN*m] Initial rotational stiffness

[6.3.1.(4)]

 $S_{j,rig,z} = 4073.43$ [kN*m] Stiffness of a rigid connection

[5.2.2.5]

 $S_{j,ini,z}$ B $S_{j,rig,z}$ RIGID

[5.2.2.5.(2)]

WEAKEST COMPONENT:

BASE PLATE - BENDING

Connection conforms to the code

Ratio 1.00