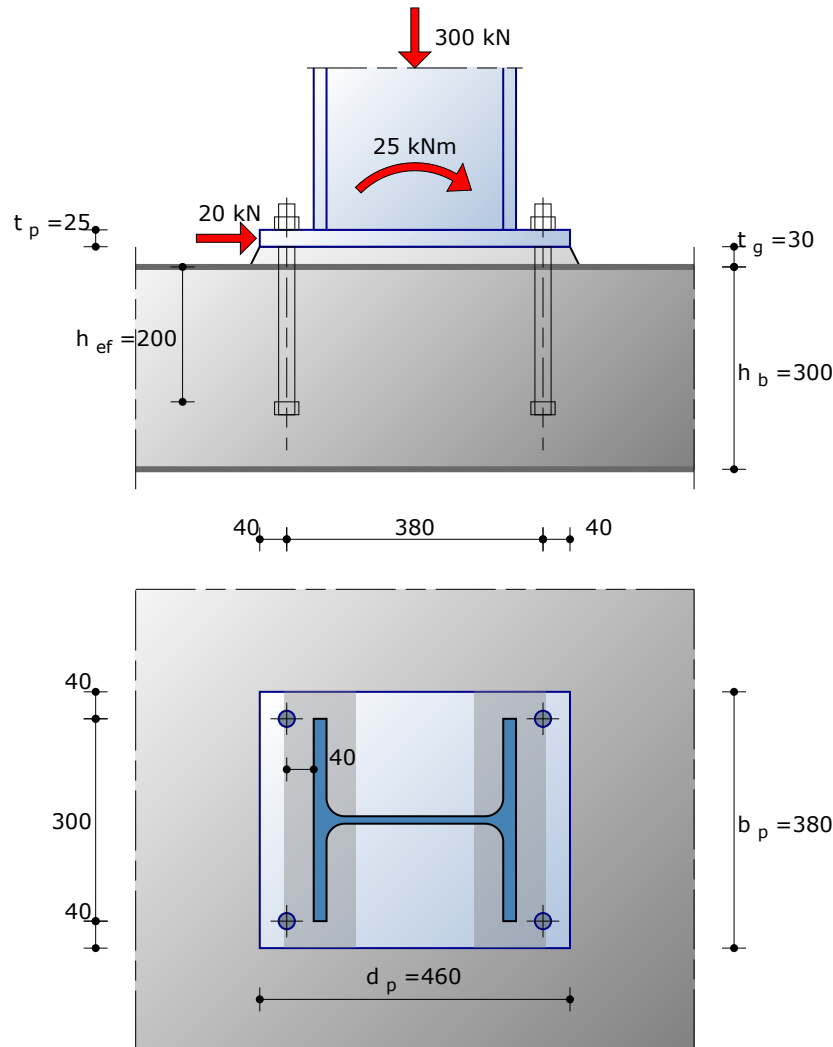


GENERAL

File :Struct4U\website\voorbeeld uitdraai\XConstruct\ Voorbeelden\Dutch.xcst

Consequence class : CC2

COLUMN BASE JOINTS: Columnbase

Profile Name:

HEB300, Steel grade S235

Anchors:

M 24, anchor bolt, 8.8 coiled wire
normal hole clearance $h_{ef} = 200$ mm

Grout:

sand-cement mortar, $t_g = 30$ mm

Foundation:

Concrete grade C25/30, gescheurd

Steel grade B500A

 $h_b = 300$ mm, $c_{min} = 30$ mm

Base plate dimensions:

 $b_p = 380$ mm, $d_p = 460$ mm, $t_p = 25$ mm

Weld:

Double filled weld $a = 6$ mm

Distances of the anchors:

 $b_a = 300$ mm, $d_a = 380$ mm

Edge distances of the anchors:

 $r_2 = 40$ mm, $r_1 = 40$ mm

Loads:

 $N_{Ed} = 300$ kN, $V_{Ed} = 20$ kN, $M_{Ed} = 25$ kNm

CALCULATION according to Eurocode

Applied standards: : NEN-EN 1992-1-1+C1:2011/NB:2016+A1:2020 nl
 NEN-EN 1993-1-1+C2+A1/NB:2016 nl
 NEN-EN 1993-1-8 + C2:2011/NB:2011 (nl)
 CEN/TS 1992-4-1
 CEN/TS 1992-4-2

Joint subjected to compression, bending and shear

Edge conditions

$h = 300 \text{ mm} < 2 d_p = 920 \text{ mm} \rightarrow$ For pressure edge effect

$h = 300 \text{ mm} < 2 b_p = 760 \text{ mm} \rightarrow$ For pressure edge effect

Type of stress distribution

$e = M_{Ed} / N_{Ed} = 25 / 300 = 0,083 \text{ m}$

$z_I = h_a - t_f = 300 - 19 = 281 \text{ mm}$

$e = 83,3 \text{ mm} < 0,5 z_I = 140,5 \text{ mm} \rightarrow$ Type of stress distribution I

Drukkracht F_c

$$F_{C,max} = \frac{N_{Ed}}{2} + \frac{M_{Ed}}{z_I} = \frac{300}{2} + \frac{25 \times 10^3}{281} = 239 \text{ kN}$$

Compressive strength concrete

$b_1 = t_f + 2 c = 19 + 2 \times 43,6 = 106,2 \text{ mm}$

$d_1 = b_p = 380 \text{ mm}$

$b_2 = 3 b_1 = 3 \times 106,2 = 318,7 \text{ mm}$

$d_2 = d_1 + h = 380 + 300 = 680 \text{ mm}$

$A_{c0} = b_1 d_1 = 106,2 \times 380 = 40374 \text{ mm}^2$

$A_{c1} = b_2 d_2 = 318,7 \times 680 = 216747 \text{ mm}^2$

$$k_d = \sqrt{\frac{A_{c1}}{A_{c0}}} = \sqrt{\frac{216747}{40374}} = 2,32$$

C25/30: $f_{cd} = \alpha_{cc} f_{ck} / \gamma_c = 1,0 \times 25 / 1,5 = 16,67 \text{ N/mm}^2$...EN 1992-1-1 (3.15)

$F_{Rdu} = A_{c0} f_{cd} k_d = 40374 \times 16,67 \times 2,32 \times 10^{-3} = 1559,1 \text{ kN}$...EN 1992-1-1 (6.63)

$$f_{jd} = \frac{\beta_j F_{Rdu}}{A_{c0}} = \frac{2/3 \times 1559,1 \times 10^3}{40374} = 25,74 \text{ N/mm}^2 \quad \dots\text{EN 1993-1-8 (6.6)}$$

Condition grout:

$t_g \leq 0,2 \min[b_p ; d_p] = 0,2 \times \min[380 ; 460] = 76 \text{ mm} \rightarrow \text{OK}$...EN 1993-1-8; 6.2.5(7)

The characteristic strength of the grout must be at least equal to:

$f_{gr,k} \geq 0,2 f_{ck} = 0,20 \times 25 = 5 \text{ N/mm}^2$...EN 1993-1-8; 6.2.5(7)

Additional butt width

$$c = t \sqrt{\frac{f_{yd}}{3 f_{jd}}} = 25 \times \sqrt{\frac{235}{3 \times 25,74}} = 43,6 \text{ mm}$$

...EN 1993-1-8 (6.5)

Short projection:

$$b_{\text{eff}} = t_f + 2c = 19 + 2 \times 43,6 = 106,2 \text{ mm}$$

$$l_{\text{eff}} = b_p = 380 \text{ mm}$$

$$A_{\text{pr,fl}} = b_{\text{eff}} l_{\text{eff}} = 106,2 \times 380 = 40363 \text{ mm}^2$$

Testing pressure side

$$F_{\text{C,Rd}} = f_{jd} A_{\text{pr,fl}} = 25,74 \times 40363 \times 10^{-3} = 1039,1 \text{ kN}$$

$$\frac{F_C}{F_{\text{C,Rd}}} = \frac{239}{1039,1} = 0,23 \rightarrow \text{complies}$$

Splicing reinforcement pressure side

$$\frac{F_C}{A_{\text{pr,fl}}} = \frac{239 \times 10^3}{40363} = 5,92 \text{ N/mm}^2 < f_{\text{c,d}} = 16,67 \text{ N/mm}^2$$

$$\frac{F_C}{A_{\text{c1}}} = \frac{239 \times 10^3}{216747} = 1,1 \text{ N/mm}^2 < 5 \text{ N/mm}^2$$

→ No splicing reinforcement required.

Shear

By friction:

$$\text{Frictional resistance (sand-cement mortar)} \quad C_{\text{f,d}} = 0,20$$

$$F_{\text{f,Rd}} = C_{\text{f,d}} F_C = 0,20 \times 239 = 47,8 \text{ kN}$$

...EN 1993-1-8; 6.2.2(6)

Door anchors:

$$k_1 = \min\left[2,8 \frac{e_2}{d_0} - 1,7; 2,5\right] = \min\left[2,8 \times \frac{40}{26} - 1,7; 2,5\right] = 2,5$$

$$\alpha_d = \frac{e_1}{3d_0} = \frac{40}{3 \times 26} = 0,513$$

$$\alpha_b = \min\left[\alpha_d; \frac{f_{\text{ub}}}{f_u}; 1,0\right] = \min\left[0,513; \frac{800}{360}; 1,0\right] = 0,513$$

$$F_{1,\text{vb,Rd}} = \frac{k_1 \alpha_b f_u d t}{\gamma_{\text{M2}}} = \frac{2,5 \times 0,513 \times 360 \times 24 \times 25}{1,25 \times 10^3} = 221,5 \text{ kN}$$

...NEN-EN 1993-1-8; tabel 3.4

$$\alpha_b = 0,44 - 0,0003 f_{\text{yb}} = 0,44 - 0,0003 \times 640 = 0,248$$

$$F_{2,\text{vb,Rd}} = \frac{\alpha_b f_{\text{ub}} A_s}{\gamma_{\text{Mb}}} = \frac{0,248 \times 800 \times 353}{1,25 \times 10^3} = 56 \text{ kN}$$

...EN 1993-1-8; 6.2.2(7)

$$F_{\text{v,Rd}} = F_{\text{f,Rd}} + n F_{\text{vb,Rd}} = 47,8 + 2 \times 56 = 159,8 \text{ kN}$$

...EN 1993-1-8 (6.3)

$$\frac{V_{\text{Ed}}}{F_{\text{v,Rd}}} = \frac{20}{159,8} = 0,13 \rightarrow \text{complies}$$

Determination of the fillet welds for flange and web

$$F_{t,max,Ed} = \frac{|N_{Ed}|}{2} + \frac{|M_{Ed}|}{h-t} = \frac{|300|}{2} + \frac{|25 \times 10^3|}{300-19} = 238,97 \text{ kN}$$

$$\text{statisch bepaald} \rightarrow \sigma_{Ed} = \frac{F_{t,max,Ed}}{A_f} = \frac{238,97 \times 10^3}{5700} = 41,9 \text{ N/mm}^2$$

$$\tau_{f,Ed} = \frac{V_{y,Ed}}{2 A_f} = 0 \text{ N/mm}^2 \quad \tau_{w,Ed} = \frac{V_{z,Ed}}{A_w} = \frac{20 \times 10^3}{2882} = 6,9 \text{ N/mm}^2$$

$$a_f \geq \beta_w \gamma_{M2} \frac{\sqrt{2 \sigma_{Ed}^2 + 3 \tau_{f,Ed}^2} t_f}{f_u} = 0,8 \times 1,25 \times \frac{\sqrt{2 \times 41,9^2 + 3 \times 0^2} \cdot 19}{360} = 1,6 \text{ mm}$$

$$\rightarrow a_f = 3 \text{ mm} \quad \dots \text{EN 1993-1-8; 4.5.2(2)}$$

$$a_w \geq \beta_w \gamma_{M2} \frac{\sqrt{2 \sigma_{Ed}^2 + 3 \tau_{w,Ed}^2} t_w}{f_u} = 0,8 \times 1,25 \times \frac{\sqrt{2 \times 41,9^2 + 3 \times 6,9^2} \cdot 11}{360} = 0,9 \text{ mm}$$

$$\rightarrow a_w = 3 \text{ mm} \quad \dots \text{EN 1993-1-8; 4.5.2(2)}$$

Determination of the stiffness

$$k_{13} = 1 \times \frac{E_c \sqrt{b_{eff} I_{eff}}}{1,275 E} = 1 \times \frac{15738 \times \sqrt{106,2 \times 262,8}}{1,275 \times 210000} = 9,82$$

...EN 1993-1-8; tabel 6.11

$$k_c = k_{13} = 9,82$$

$$e = M_{Ed} / N_{Ed} = 25 / -300 = -83,3 \text{ mm}$$

$$z = h_a - t_f = 300 - 19 = 281 \text{ mm}$$

...NEN-EN 1993-1-8 (6.27)

$$S_j = \frac{1}{\mu} \frac{E z^2}{\sum \frac{1}{k}} \frac{e}{e + e_k} = \frac{1}{1} \times \frac{210000 \times 281^2}{0,204} \times \frac{-83,3}{-83,3 + 1} = 82416 \text{ kNm/rad}$$

$$\text{Rotational rigidity} = 82416,04 \text{ kNm/rad}$$

Rotational rigidity

$$S_j = \frac{1}{\mu} \frac{E z^2}{\sum \frac{1}{k}} \frac{e}{e + e_k} = \frac{1}{1} \times \frac{210000 \times 281^2}{0,204} \times \frac{-83,3}{-83,3 + 1} = 82416 \text{ kNm/rad}$$

$$\text{Rotational rigidity} = \frac{S_j}{\eta} = \frac{82416}{3,00} = 27472,01 \text{ kNm/rad}$$

Conclusion: Column base joints complies.