Holding-down Bolt Design - SANS 10162 - 2005

Material Strength Properties

fcu : 25 MPa
fu Bolt : 800 MPa
Bolt Grade : 8.8
Bolt fy : 640 MPa
Bolt fu : 800 MPa
fy Baseplate : 350 MPa
fu Baseplate : 350 MPa
fy Column : 350 MPa
fu Column : 350 MPa
tu Weld : 500 MPa

Column Section

H2 203x203x86

BasPlate Design Data:

Plate Shape : Rectangular
Height : 400 mm
Breadth : 400 mm
Thickness : 20 mm

Weld Properties

Size :8 mm Fillet Weld

Bolt Properties

Diameter : 20 mm
Achor Length : 400 mm
Compression allowed in bolts
BasePlate not elevated

Bolt End Plate Properties

End Type : Square Plate
Dimension : 250 x 250 mm
Thickness : 10 mm

Bolt Resistance Forces

Bolt Netto Cross Section 25.2.2.1

$$A_n = \frac{0.75 \cdot \pi \, d^2}{4}$$

$$= \frac{0.75 \times \pi \times 20^2}{4}$$

$$= 235.619 \text{ mm}^2$$

Tension Resistance 25.2.2.1

$$T_r = \frac{0.67 \cdot A_n \cdot f_u}{1000}$$

$$= \frac{0.67 \times 235.62 \times 800}{1000}$$

$$= 126.292 \text{ kN}$$

Tension Resistance Concrete 25.2.2.1

$$T_{rc} = \frac{0.28 \cdot \sqrt{f_{cu}} \cdot p_i \cdot d \cdot l_b + 0.6 \cdot f_{cu} \cdot (A_{nchorArea} - B_{oltArea})}{1000}$$

$$= \frac{0.28 \times \sqrt{25} \times 3.1416 \times 20 \times 400 + 0.6 \times 25 \times (62500 - 314.16)}{1000}$$

$$= 967.974 \text{ kN}$$

Shear Resistance 25.2.3.3

$$V_r = \frac{0.6 \cdot 0.67 \cdot 0.7 \cdot A_n \cdot f_u}{1000}$$

$$= \frac{0.6 \times 0.67 \times 0.7 \times 235.62 \times 800}{1000}$$

$$= 53.043 \text{ kN}$$

Compression Resistance 13.3.1

$$C_r = \frac{0.9 \cdot A_n \cdot f_u}{1000}$$

$$= \frac{0.9 \times 235.62 \times 800}{1000}$$

$$= 169.646 \text{ kN}$$

Find Effective Compression Area

Calculate Zpl

$$Z_{pl} = \frac{b \cdot t_p^{\,2}}{4}$$

$$= \frac{1 \times 20^2}{4}$$

$$= 100.000$$

Moment of Resistance equation 13.5

$$M_r = 0.9 \cdot Z_{pl} \cdot f_y$$

$$= 0.9 \times 100 \times 350$$

$$= 31.50 \times 10^3$$

Moment Ultimate equation
Mu = (c*b)*(c/2)*fcu

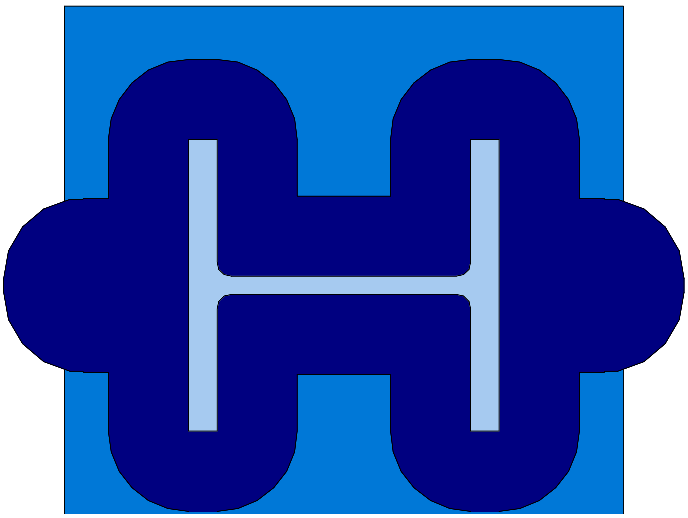
Through substitution cMax can be calculated

Effective Distance from Edge of Section

$$c_{Max} = \sqrt{\frac{Z_{pl} \cdot 2 \cdot 0.9 \cdot \frac{f_y}{1.15}}{b \cdot \frac{f_{cu}}{1.5}}}$$

$$= \sqrt{\frac{100 \times 2 \times 0.9 \times \frac{350}{1.15}}{1 \times \frac{25}{1.5}}}$$

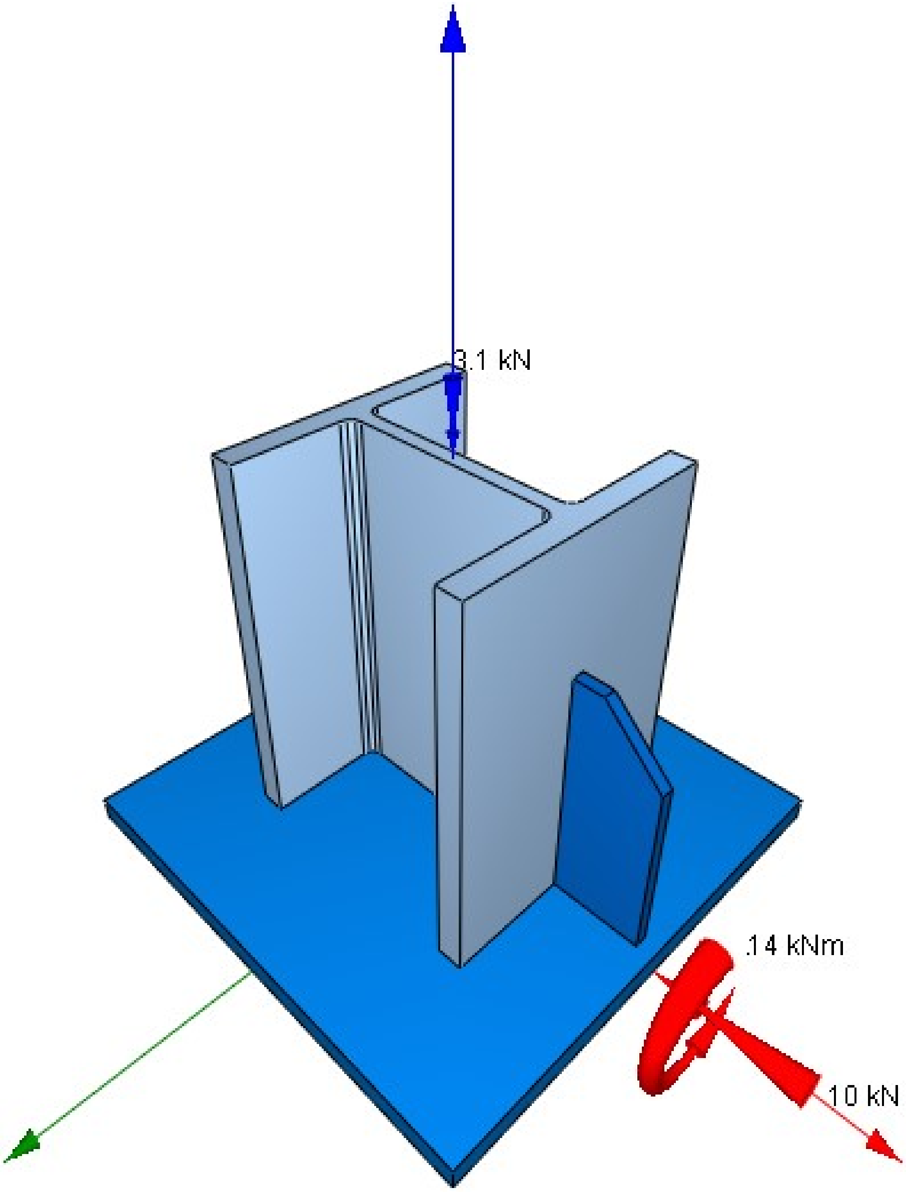
$$= 57.332 \text{ mm}$$



Calculation Sheet for Load Case : 1

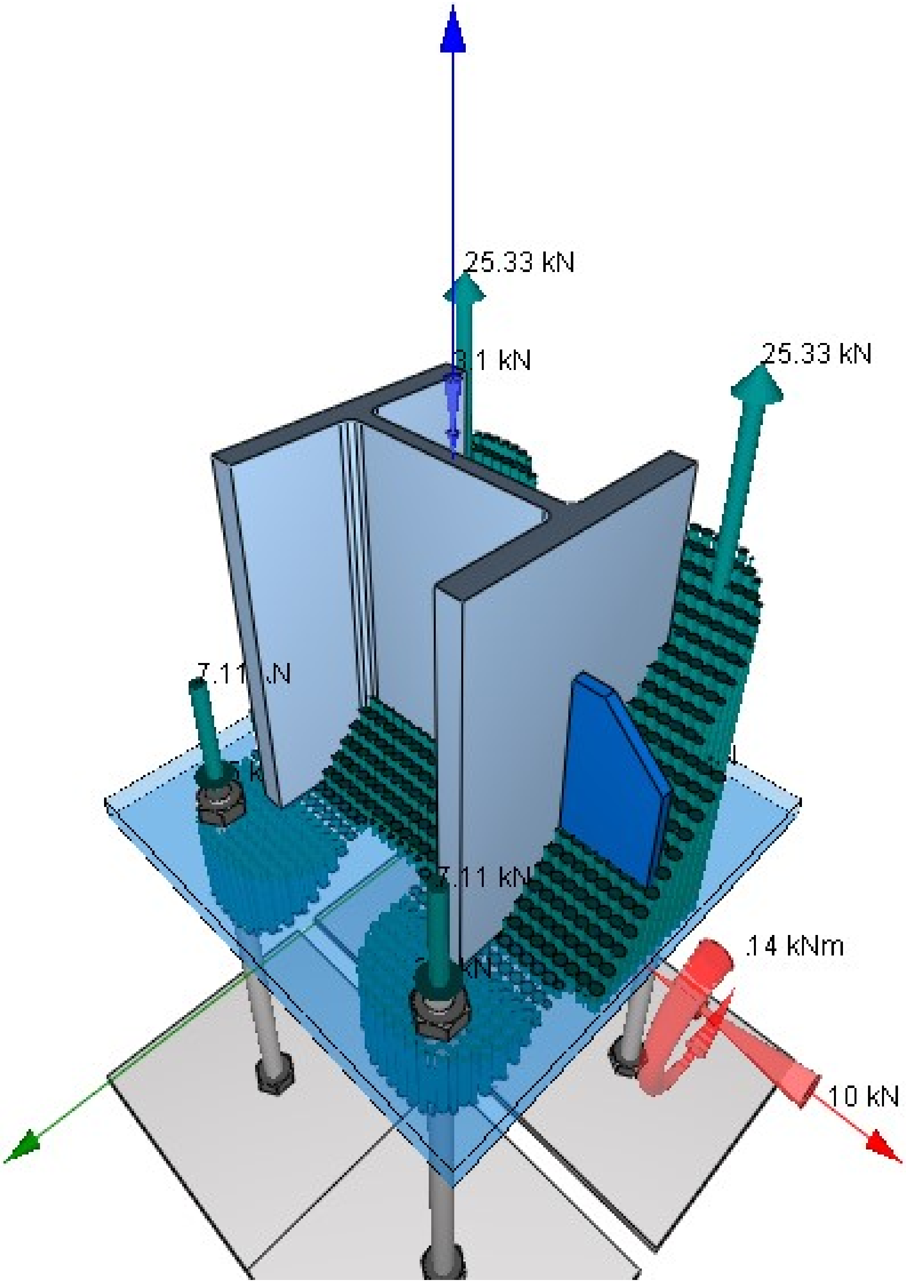
Factored loads

P :	3.1 kN
Vx :	10 kN
Mx :	14 kNm



Find Equilibruim

The actual number of Grid Point used for calculation is 1096



Moment balancing

Sum Of Moments around X-axis = 0.0 kNm
Sum Of Moments around Y-axis = 0.0 kNm

Axial Force balancing

Sum Of Forces in Y-direction = 0.0 kN

The Shear Resistance in the Bolts Resists the Following Forces:

Forces in X-direction
Moments around Y-axis

Forces in Z-direction

Calculating Factors of Concrete

$$F_{OS} = \frac{S_{trainMax}}{S_{train}}$$

$$= \frac{.0035}{.0002}$$

$$= 17.500$$

Calculating Factors of Safety in Critical Bolt

Tension in Bolts

Critical Bolt Tension

$$F_{OS} = \frac{T_r}{T_{ension}}$$

$$= \frac{125.66}{25.331}$$

$$= 4.961$$

Critical Bolt Pull-Out

$$F_{OS} = \frac{T_{rc}}{T_{ension}}$$

$$= \frac{967.97}{25.331}$$

$$= 38.213$$

Compression in Bolts

Critical Bolt Compression

$$F_{OS} = \frac{C_r}{C_{ompression}}$$

$$= \frac{169.65}{7.1136}$$

$$= 23.849$$

Shear in Bolts

Critical Bolt Shear

$$FOS = \frac{Vr}{Shear}$$
$$= \frac{52.779}{2.5}$$
$$= 21.112$$

Shear and Tension combined in Bolts

The factor should be less than 1.4 for bolts in shear and tension

The bolt number 4 has the critical shear and tension combination

The tension in the bolt is: 25.33 kN
The shear in the bolt is: 2.50 kN

Tension and Shear Resistance combination 13.11.4

$$combinedfactor = \frac{Shear}{Vr} + \frac{Tension}{Tr}$$
$$= \frac{2.5}{52.779} + \frac{25.331}{125.66}$$
$$= 0.2490$$

0.249 <= 1.4
OK

Converted to Factor of Safety relevant to 1

$$FOS = \frac{1.4}{factor}$$
$$= \frac{1.4}{.24894}$$
$$= 5.624$$

Bolt BasePlate interaction

$$FOS = \frac{Resistance}{Force}$$
$$= \frac{191.22}{25.331}$$
$$= 7.549$$

Welds

Since unit values are used for the length and size of the weld, the capacity of this layout is given in kN/mm

The capacity, Vr is the lesser of Vr1 and Vr2:
Resistance of weld material

$$V_{r1} = \frac{0.67 \cdot \frac{T_u}{1.5} \cdot 0.707 \cdot S_{ize}}{1000}$$

$$= \frac{0.67 \times \frac{500}{1.5} \times 0.707 \times 8}{1000}$$

$$= 1.263 \text{ kN/mm}$$

Resistance of parent material

$$V_{r2} = \frac{0.9 \cdot \frac{f_y}{1.5} \cdot 0.707 \cdot S_{ize}}{1000}$$

$$= \frac{0.9 \times \frac{350}{1.5} \times 0.707 \times 8}{1000}$$

$$= 1.188 \text{ kN/mm}$$

Capacity of 8mm weld is 1.188kN/mm

$$F_{OS} = \frac{R_{esistance}}{F_{orce}}$$

$$= \frac{1.1878}{.36822}$$

$$= 3.226$$