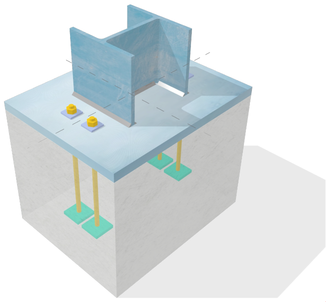
REFERENCES	CALCULATIONS	RESULTS

SkyCiv Base Plate and Anchor Rod Design

Shear and Tension - CSA

Project Information:
Design Code: CSA S16:19 and CSA A23.3:19

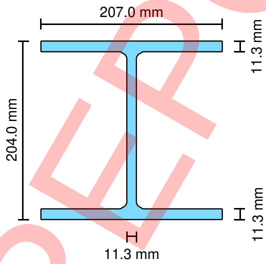


Load Combinations:

Load Combination	Axial Load, Nx (kN)	Strong-axis Shear, Vy (kN)	Weak-axis Shear, Vz (kN)
1	-15.00	-5.00	-5.00

Note(s):
1. Positive Nx (+) indicates compression; negative Nx (-) indicates tension.
2. Shear forces are assumed to be distributed to all anchors in the base plate.
3. Welded plate washers are used to distribute shear forces.
4. Ductile steel is assumed for resistance modification factor for steel failure.
5. Condition B is used for resistance modification factor for concrete failure.

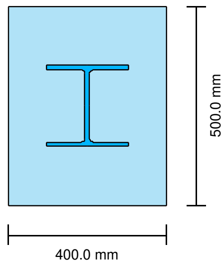
Column Properties:



Symbol	Description	Value
$Section$	Column section	HP200x54
d_{col}	Column depth	204.0 mm
t_w	Column web thickness	11.3 mm
b_f	Column flange width	207.0 mm
t_f	Column flange thickness	11.3 mm
A_{col}	Column area	6840.0 mm^2
r_{col}	Column root radius	9.7 mm
F_{y_col}	Column yield stress (350W)	350.0 MPa
F_{u_col}	Column tensile stress (350W)	450.0 MPa

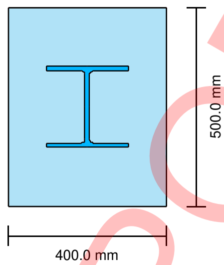
REFERENCES	CALCULATIONS	RESULTS

Base Plate Properties:



Symbol	Description	Value
B_{bp}	Base plate width	400.0 mm
L_{bp}	Base plate length	500.0 mm
t_{bp}	Base plate thickness	25.0 mm
A_{bp}	Base plate plan area	200000.0 mm^2
F_{y_bp}	Base plate yield stress (300W)	300.0 MPa
F_{u_bp}	Base plate tensile stress (300W)	450.0 MPa
t_{grout}	Grout thickness	0.0 mm

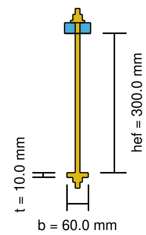
Concrete Properties:



Symbol	Description	Value
B_{conc}	Concrete width	400.0 mm
L_{conc}	Concrete length	500.0 mm
t_{conc}	Concrete thickness	380.0 mm
A_{conc}	Concrete plan area	200000.0 mm^2
f_c'	Concrete compressive strength (20.68)	20.7 MPa
λ	Factor for normal-weight concrete	1.0
—	Concrete assumption: cracked or uncracked	Cracked

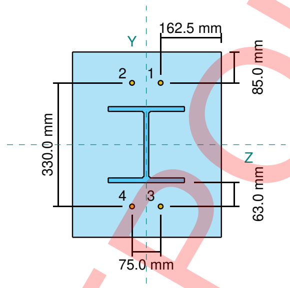
REFERENCES	CALCULATIONS	RESULTS

Anchor Information:



Symbol	Description	Value
d_a	Anchor rod diameter	12.7 mm
h_{ef}	Anchor rod effective embedment length	300.0 mm
b_{embed_plate}	Anchor embed plate dimension	60.0 mm
t_{embed_plate}	Thickness of embed plate	10.0 mm
F_{y_anc}	Anchor rod yield stress (ASTM F1554 G36)	248.2 MPa
F_{u_anc}	Anchor rod tensile stress (ASTM F1554 G36)	399.9 MPa
F_{y_ep}	Embed plate yield stress (300W)	300.0 MPa
t_{pw}	Plate washer thickness	5.0 mm
$Threads$	Threads in shear plane	Included

Anchor Layout:



Symbol	Description	Value
n_a	Total number of anchor rods	4.0
s_z	Spacing of anchor rods along Z-axis	75.0 mm
s_y	Spacing of anchor rods along Y-axis	330.0 mm
$l_{edge,z}$	Base plate edge distance along Z-axis	162.5 mm
$l_{edge,y}$	Base plate edge distance along Y-axis	85.0 mm

REFERENCES	CALCULATIONS	RESULTS

Anchor Data Summary:

ID	Z (mm)	Y (mm)
1	37.500	165.000
2	-37.500	165.000
3	37.500	-165.000
4	-37.500	-165.000

ID	Anchor in Tension Zone	Breakout (Tension)	Side-Face Blowout (Y-direction)	Side-Face Blowout (Z-direction)
1	✓	BO Group 1	N/A	SFz Group 1
2	✓	BO Group 1	N/A	SFz Group 1
3	✓	BO Group 1	N/A	SFz Group 2
4	✓	BO Group 1	N/A	SFz Group 2

ID	Shear Direction Resisted	Breakout (Vy Shear)	Breakout (Vz Shear)	Pryout (Vy Shear)	Pryout (Vz Shear)
1	All Load Directions	BO Vy Group 1	BO Vz Group 1	PO Group 1	PO Group 1
2	All Load Directions	BO Vy Group 1	BO Vz Group 2	PO Group 1	PO Group 1
3	All Load Directions	BO Vy Group 2	BO Vz Group 1	PO Group 1	PO Group 1
4	All Load Directions	BO Vy Group 2	BO Vz Group 2	PO Group 1	PO Group 1

Weld Properties:

Symbol	Description	Value
$Type$	Weld Type	Fillet
D_{top_flange}	Fillet weld size at Top Flange	8.000 mm
D_{bottom_flange}	Fillet weld size at Bottom Flange	8.000 mm
D_{web}	Fillet weld size at Web	8.000 mm
$t_{w\_top\_flange}$	Weld throat at Top Flange	5.657 mm
$t_{w\_bottom\_flange}$	Weld throat at Bottom Flange	5.657 mm
t_{w_web}	Weld throat at Web	5.657 mm
X_u	Filler metal classification strength (E43XX-X)	430.000 MPa

REFERENCES	CALCULATIONS	RESULTS

Summary of Detailing Checks

Check Name	Dimensions (Min/Max/Actual)	Status	Reference
Weld Size Requirement (Flange)	Min: 8.00 mm, Max: 19.00 mm, Actual: 8.00 mm	PASS	CSA W59-13 Table 4.4
Weld Size Requirement (Web)	Min: 8.00 mm, Max: 19.00 mm, Actual: 8.00 mm	PASS	CSA W59-13 Table 4.4
Anchor Clearance	Min: 30.16 mm, Actual: 55.00 mm	PASS	SkyCiv Recommendation
Base Plate Edge Distance	Min: 20.00 mm, Actual: 85.00 mm	PASS	CSA S16:19 Table 5
Minimum Number of Anchors	Min: 4.00, Actual: 4.00	PASS	CSA S16:19 Clause 25.2
Embedded Plate Dimension	Min: 50.80 mm, Actual: 60.00 mm	PASS	SkyCiv Recommendation
Min. Anchor Spacing to Prevent Concrete Splitting	Min: 50.80 mm, Actual: 75.00 mm	PASS	CSA A23.3.19 Clause D.9.2
Min. Concrete Cover to Prevent Concrete Splitting	Min: 75.00 mm, Actual: 85.00 mm	PASS	CSA A23.3.19 Clause D.9.3

✔ All Detailing Checks Passed

The design geometry meets requirements.

Summary of Design Checks

Design Check	Governing LC	Demand	Capacity	DCR	Result
Weld Capacity	1	0.04	1.09	0.03	PASS
Base Plate Yield Capacity (Tension Load)	1	236.25	4239.84	0.06	PASS
Anchor Rod Tensile Capacity	1	3.75	25.02	0.15	PASS
Concrete Breakout Capacity (Tension Load)	1	15.00	53.52	0.28	PASS
Anchor Pullout Capacity	1	3.75	373.51	0.01	PASS
Embed Plate Flexural Capacity	1	2.11	10.00	0.21	PASS
Concrete Side-Face Blowout Capacity (Y-Direction)	1	0.00	0.00	0.00	N/A
Concrete Side-Face Blowout Capacity (Z-Direction)	1	7.50	172.32	0.04	PASS
Concrete Breakout Capacity (Vy Shear)	1	5.00	16.28	0.31	PASS
Concrete Breakout Capacity (Vz Shear)	1	5.00	18.35	0.27	PASS
Concrete Pryout Capacity	1	7.07	107.04	0.07	PASS
Anchor Rod Shear Capacity	1	0.45	1.00	0.45	PASS
Anchor Rod Shear and Tension Capacity (CSA S16)	1	0.63	1.00	0.63	PASS
Interaction Check (CSA A23.3)	1	0.59	1.20	0.49	PASS

✔ All Design Checks Passed

The design is adequate.

REFERENCES	CALCULATIONS	RESULTS

Load Combination No. 1: Tension Load and Shear Load

Check No. 1: Weld Capacity

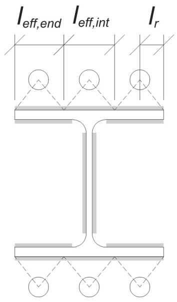


Fig. Effective welds on column to base plate.

Calculate effective weld length on column flange

$b_f = 207\ \mathrm{mm}$ - Column flange width

$s_z = 75\ \mathrm{mm}$ - Spacing of anchor rods along Z-axis

$n_{a,side} = 2$ - Number of anchor rods in tension per side

l_r - Remaining weld length near weld tip

$$l_r = \frac{b_f - s_z\left(n_{a,side} - 1\right)}{2} = \frac{207\ \mathrm{mm} - 75\ \mathrm{mm} \times (2-1)}{2} = 66\ \mathrm{mm}$$

$d_o = 63\ \mathrm{mm}$ - Flange offset distance

$s_z = 75\ \mathrm{mm}$ - Spacing of anchor rods along Z-axis

$l_{eff,end}$ - Effective weld length on end anchors

$$l_{eff,end} = \min\left(\mathrm{d_o},\ 0.5\mathrm{s_z}\right) + \min\left(\mathrm{d_o},\ \mathrm{l_r}\right) = \min\left(63\ \mathrm{mm},\ 0.5 \times 75\ \mathrm{mm}\right) + \min\left(63\ \mathrm{mm},\ 66\ \mathrm{mm}\right) = 100.5\ \mathrm{mm}$$

l_{eff} - Design effective weld length

$$l_{eff} = l_{eff,end} = 100.5\ \mathrm{mm}$$

Calculate load per unit length of weld

$N_x = 15\ \mathrm{kN}$ - Tension load

$n_{a,t} = 4$ - Number of anchors in tension

$l_{eff} = 100.5\ \mathrm{mm}$

$T_{u,anchor}$ - Tension load per anchor

$$T_{u,anchor} = \frac{N_x}{n_{a,t}} = \frac{15\ \mathrm{kN}}{4} = 3.75\ \mathrm{kN}$$

$r_{f,flg}$ - Required weld strength per unit length

$$r_{f,flg} = \frac{T_{u,anchor}}{l_{eff}} = \frac{3.75\ \mathrm{kN}}{100.5\ \mathrm{mm}} = 0.037313\ \mathrm{kN/mm}$$

Calculate total weld length on column flange and web

$d_{col} = 204\ \mathrm{mm}$ - Column depth

$b_f = 207\ \mathrm{mm}$ - Column flange width

$t_f = 11.3\ \mathrm{mm}$ - Column flange thickness

$t_w = 11.3\ \mathrm{mm}$ - Column web thickness

$r_{col} = 9.7\ \mathrm{mm}$ - Column root radius

L_{weld} - Total length of weld

$$L_{weld} = 2b_f + 2\left(d_{col} - 2t_f - 2r_{col}\right) + 2\left(b_f - t_w - 2r_{col}\right)$$

$$L_{weld} = 2 \times 207\ \mathrm{mm} + 2 \times (204\ \mathrm{mm} - 2 \times 11.3\ \mathrm{mm} - 2 \times 9.7\ \mathrm{mm}) + 2 \times (207\ \mathrm{mm} - 11.3\ \mathrm{mm} - 2 \times 9.7\ \mathrm{mm}) = 1090.6\ \mathrm{mm}$$

Calculate shear load per unit length of weld

$V_y = 5\ \mathrm{kN}$ - Vy shear load

$V_z = 5\ \mathrm{kN}$ - Vz shear load

v_{fy} - Required weld strength per unit length

$$v_{fy} = \frac{V_y}{L_{weld}} = \frac{5\ \mathrm{kN}}{1090.6\ \mathrm{mm}} = 0.0045846\ \mathrm{kN/mm}$$

v_{fz} - Required weld strength per unit length

$$v_{fz} = \frac{V_z}{L_{weld}} = \frac{5\ \mathrm{kN}}{1090.6\ \mathrm{mm}} = 0.0045846\ \mathrm{kN/mm}$$

Calculate resultant loads per unit length of weld at flanges

r_f - Required weld strength per unit length

$$r_f = \sqrt{\left(\left(r_{f,flg}\right)^2\right) + \left(\left(v_{fy}\right)^2\right) + \left(\left(v_{fz}\right)^2\right)}$$

$$r_f = \sqrt{\left((0.037313 \text{ kN/mm})^2\right) + \left((0.0045846 \text{ kN/mm})^2\right) + \left((0.0045846 \text{ kN/mm})^2\right)}$$

$$r_f = 0.037873 \text{ kN/mm}$$

Calculate resultant loads per unit length of weld at web

r_f - Required weld strength per unit length

$$r_f = \sqrt{\left((v_{fy})^2\right) + \left((v_{fz})^2\right)}$$

$$r_f = \sqrt{\left((0.0045846 \text{ kN/mm})^2\right) + \left((0.0045846 \text{ kN/mm})^2\right)} = 0.0064836 \text{ kN/mm}$$

Calculate fillet weld capacity on flange

$X_u = 430 \text{ MPa}$ - Filler metal classification strength (E43XX-X)

$t_w = 5.657 \text{ mm}$ - Design weld throat

$\phi = 0.67$ - Weld resistance factor

$\theta = 0$ - Angle of load in radians

CSA S16:19 Clause 13.13.2.2 k_{ds} - Directional strength increase factor

$$k_{ds} = 1.0 + 0.5(\sin(\theta))^{1.5} = 1 + 0.5 \times (\sin(0))^{1.5} = 1$$

CSA S16:19 Clause 13.13.2.2 $v_{r,flg}$ - Factored weld resistance per unit length

$$v_{r,flg} = 0.67\phi t_w X_u = 0.67 \times 0.67 \times 5.657 \text{ mm} \times 430 \text{ MPa} = 1.092 \text{ kN/mm}$$

Calculate fillet weld capacity on web

$X_u = 430 \text{ MPa}$ - Filler metal classification strength (E43XX-X)

$t_w = 5.657 \text{ mm}$ - Design weld throat

$\phi = 0.67$ - Weld resistance factor

$\theta = 0$ - Angle of load in radians

CSA S16:19 Clause 13.13.2.2 k_{ds} - Directional strength increase factor

$$k_{ds} = 1.0 + 0.5(\sin(\theta))^{1.5} = 1 + 0.5 \times (\sin(0))^{1.5} = 1$$

CSA S16:19 Clause 13.13.2.2 $v_{r,web}$ - Factored weld resistance per unit length

$$v_{r,web} = 0.67\phi t_w X_u = 0.67 \times 0.67 \times 5.657 \text{ mm} \times 430 \text{ MPa} = 1.092 \text{ kN/mm}$$

Result:

PASS = 0.03

DCR - Demand over capacity ratio, comparing two conditions:

$$DCR = \max\left(\frac{r_f}{v_{r,web}}, \frac{r_f}{v_{r,flg}}\right)$$

$$DCR = \max\left(\frac{0.0064836 \text{ kN/mm}}{1.092 \text{ kN/mm}}, \frac{0.037873 \text{ kN/mm}}{1.092 \text{ kN/mm}}\right) = 0.034683$$

Go back to summary results table.

Check No. 2: Base Plate Yield Capacity (Tension Load)

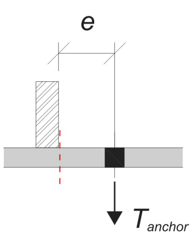


Fig. Bending of base plate from eccentric anchor load.

Calculate applied moment load on effective width of base plate

$T_{u,anchor} = 3.75 \text{ kN}$

$e = 63 \text{ mm}$ - Tensile load eccentricity equal to offset distance

M_f - Factored bending load on base plate

$$M_f = T_{u,anchor} e = 3.75 \text{ kN} \times 63 \text{ mm} = 236.25 \text{ kN·mm}$$

Calculate flexural yielding capacity of base plate

$l_{eff} = 100.5 \text{ mm}$

$t_{bp} = 25 \text{ mm}$ - Base plate thickness

CSA S16:19 Clause 13.5 Z_{eff} - Plastic modulus of the effective section

$$Z_{eff} = \frac{l_{eff}(t_{bp})^2}{4} = \frac{100.5 \text{ mm} \times (25 \text{ mm})^2}{4} = 15703 \text{ mm}^3$$

$F_{y\_bp} = 300 \text{ MPa}$ - Base plate yield stress (300W)

$\phi = 0.9$ - Structural steel resistance factor

CSA S16:19 Clause 13.5 M_r - Factored bending resistance of base plate

$$M_r = \phi F_{y\_bp} Z_{eff} = 0.9 \times 300\ \mathrm{MPa} \times 15703\ \mathrm{mm}^3 = 4239.8\ \mathrm{kN{\cdot}mm}$$

Result:

PASS = 0.06

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{M_f}{M_r} = \frac{236.25\ \mathrm{kN{\cdot}mm}}{4239.8\ \mathrm{kN{\cdot}mm}} = 0.055721$$

Go back to summary results table.

Check No. 3: Anchor Rod Tensile Capacity

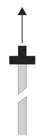


Fig. Anchor steel tension failure.

Calculate load per tension anchor

$N_x = 15\ \mathrm{kN}$ - Tension load

$n_{a,t} = 4$ - Number of anchors in tension

N_{fa} - Factored tensile load on anchor rod

$$N_{fa} = \frac{N_x}{n_{a,t}} = \frac{15\ \mathrm{kN}}{4} = 3.75\ \mathrm{kN}$$

Calculate specified tensile strength of anchor

$F_{u\_anc} = 400\ \mathrm{MPa}$ - Anchor rod tensile stress (ASTM F1554 G36)

$F_{y\_anc} = 248.2\ \mathrm{MPa}$ - Anchor rod yield stress (ASTM F1554 G36)

CSA A23.3:19 Clause D.6.1.2

f_{uta} - Specified tensile strength of anchor steel

$$f_{uta} = \min\left(\mathrm{F_{u\_anc}},\ 1.9\mathrm{F_{y\_anc}},\ 860\right) = \min\left(400\ \mathrm{MPa},\ 1.9 \times 248.2\ \mathrm{MPa},\ 860.00\ \mathrm{MPa}\right) = 400\ \mathrm{MPa}$$

Calculate anchor steel tensile capacity from CSA A23.3:19

CSA A23.3:19 Clause D.6.1.2 and CAC Concrete Design Handbook 3rd Ed. Table 12.3

$A_{se,N} = 92\ \mathrm{mm}^2$ - Effective cross-sectional area of anchor rod in tension

$\phi_s = 0.85$ - Anchor rod resistance factor

$R = 0.8$ - Resistance modification factor of anchor rod in steel failure (Tension Loads)

CSA A23.3:19 Eq. D.2

N_{sar} - Factored resistance of anchor rod in tension

$$N_{sar} = A_{se,N} \phi_s f_{uta} R = 92\ \mathrm{mm}^2 \times 0.85 \times 400\ \mathrm{MPa} \times 0.8 = 25.018\ \mathrm{kN}$$

Calculate anchor steel tensile capacity from CSA S16:19

$F_{u\_anc} = 400\ \mathrm{MPa}$ - Anchor rod tensile stress (ASTM F1554 G36)

CSA S16:19 pg. 31

$A_{ar} = 126.68\ \mathrm{mm}^2$ - Nominal cross-sectional area of anchor rod

CSA S16:19 Clause 25.3.2.1

$\phi_{ar} = 0.67$ - Anchor rod resistance factor

CSA S16:19 Clause 25.3.2.1

T_r - Factored resistance of anchor rod in tension

$$T_r = \phi_{ar} 0.85 A_{ar} F_{u\_anc} = 0.67 \times 0.85 \times 126.68\ \mathrm{mm}^2 \times 400\ \mathrm{MPa} = 28.85\ \mathrm{kN}$$

Result:

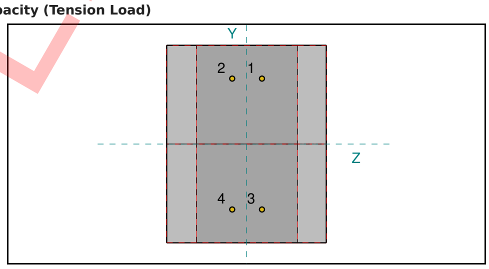
PASS = 0.15

DCR - Demand-to-Capacity Ratio

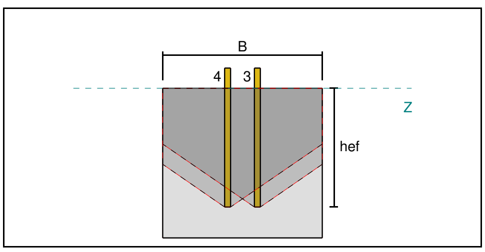
$$DCR = \frac{N_{fa}}{N_{ra}} = \frac{3.75\ \mathrm{kN}}{25.018\ \mathrm{kN}} = 0.14989$$

Go back to summary results table.

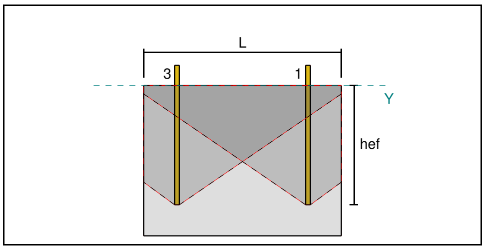
Check No. 4: Concrete Breakout Capacity (Tension Load)



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total tension load on anchor group

$N_x = 15\ \mathrm{kN}$ - Tension load

$n_{a,t} = 4$ - Number of anchors in tension

$n_{a,g1} = 4$ - Number of anchors in anchor group BO 1

N_{fa} - Factored tensile load on anchor group

$$N_{fa} = \left(\frac{N_x}{n_{a,t}}\right) n_{a,g1} = \left(\frac{15\ \mathrm{kN}}{4}\right) \times 4 = 15\ \mathrm{kN}$$

Determine if the support is a narrow concrete member

CSA A23.3:19 Clause D.6.2.3

The support is classified as a narrow member. The modified values below will be used throughout the calculations.

Symbol	Description	Value
$c_{left,g1}$	Anchor group BO 1 concrete edge distance (left)	162.5 mm
$c_{right,g1}$	Anchor group BO 1 concrete edge distance (right)	162.5 mm
$c_{top,g1}$	Anchor group BO 1 concrete edge distance (top)	85.0 mm
$c_{bottom,g1}$	Anchor group BO 1 concrete edge distance (bottom)	85.0 mm
h_{ef}	Anchor rod effective embedment length	300.0 mm
	Narrow Member	TRUE
$h'_{ef,g1}$	Anchor group BO 1 modified effective embedment length	110.0 mm

Sample calculation for worst case: Anchor Group 1.

Calculate maximum projected area for a single anchor

CSA A23.3:19 Clause D.6.2.3

$h'_{ef,g1} = 110\ \mathrm{mm}$ - Anchor group BO 1 modified effective embedment length

CSA A23.3:19 Eq. D.5

A_{Nco} - Maximum projected area for a single anchor

$$A_{Nco} = 9\left(h'_{ef,g1}\right)^2 = 9 \times (110\ \mathrm{mm})^2 = 108900\ \mathrm{mm}^2$$

Calculate length of actual projected cone area (along Z-direction)

$r_{embed\_plate} = 16.35\ \mathrm{mm}$ - Half side length of effective perimeter of embed plate

Equivalent to half anchor diameter plus thickness of embed plate

$s_{sum,z,g1} = 75\ \mathrm{mm}$ - Anchor group BO 1 sum of spacing along Z-axis

$n_{z,g1} = 2$ - Number of anchors along Z-axis for anchor group BO 1

CSA A23.3:19 Clause D.6.2.1

L_{Nc} - Actual length of concrete cone for an anchor group

$$L_{Nc} = \left(\min\left(\mathrm{c_{left,g1}},\ 1.5\mathrm{h'_{ef,g1}} + \mathrm{r_{embed\_plate}}\right)\right) + \left(\min\left(\mathrm{s_{sum,z,g1}},\ 3\mathrm{h'_{ef,g1}}\left(\mathrm{n_{z,g1}} - 1\right)\right)\right) + \left(\min\left(\mathrm{c_{right,g1}},\ 1.5\mathrm{h'_{ef,g1}} + \mathrm{r_{embed\_plate}}\right)\right)$$

$$L_{Nc} = (\min(162.5\ \mathrm{mm},\ 1.5 \times 110\ \mathrm{mm} + 16.35\ \mathrm{mm})) + (\min(75\ \mathrm{mm},\ 3 \times 110\ \mathrm{mm} \times (2-1))) + (\min(162.5\ \mathrm{mm},\ 1.5 \times 110\ \mathrm{mm} + 16.35\ \mathrm{mm}))$$

$$L_{Nc} = 400\ \mathrm{mm}$$

Calculate width of actual projected cone area (along Y-direction)

$r_{embed\_plate} = 16.35\ \mathrm{mm}$ - Half side length of effective perimeter of embed plate

Equivalent to half anchor diameter plus thickness of embed plate

$s_{sum,y,g1} = 330\ \mathrm{mm}$ - Anchor group BO 1 sum of spacing along Y-axis

$n_{y,g1} = 2$ - Number of anchors along Y-axis for anchor group BO 1

CSA A23.3:19 Clause D.6.2.1

B_{Nc} - Actual width of concrete cone for an anchor group

$$B_{Nc} = \left(\min\left(\mathrm{c_{top,g1}},\ 1.5\mathrm{h'_{ef,g1}} + \mathrm{r_{embed\_plate}}\right)\right) + \left(\min\left(\mathrm{s_{sum,y,g1}},\ 3\mathrm{h'_{ef,g1}}\left(\mathrm{n_{y,g1}} - 1\right)\right)\right) + \left(\min\left(\mathrm{c_{bottom,g1}},\ 1.5\mathrm{h'_{ef,g1}} + \mathrm{r_{embed\_plate}}\right)\right)$$

$$B_{Nc} = (\min(85\ \mathrm{mm},\ 1.5 \times 110\ \mathrm{mm} + 16.35\ \mathrm{mm})) + (\min(330\ \mathrm{mm},\ 3 \times 110\ \mathrm{mm} \times (2-1))) + (\min(85\ \mathrm{mm},\ 1.5 \times 110\ \mathrm{mm} + 16.35\ \mathrm{mm}))$$

$$B_{Nc} = 500\ \mathrm{mm}$$

Calculate actual projected area of the anchor group

$n_{a,g1} = 4$ - Number of anchors in anchor group BO 1

CSA A23.3:19 Clause D.6.2.1

A_{Nc} - Actual projected area for an anchor group

$$A_{Nc} = \min\left(\mathrm{n_{a,g1}A_{Nco}},\ \mathrm{L_{Nc}B_{Nc}}\right) = \min\left(4 \times 108900\ \mathrm{mm}^2,\ 400\ \mathrm{mm} \times 500\ \mathrm{mm}\right) = 200000\ \mathrm{mm}^2$$

Calculate modification factor for lightweight concrete

$\lambda = 1$ - Factor for normal-weight concrete

CSA A23.3:19 Clause D.4.6

λ_a - Modification factor for lightweight concrete

$$\lambda_a = 1.0\lambda = 1 \times 1 = 1$$

Calculate basic single anchor breakout strength

CSA A23.3:19 Clause D.6.2.1

$k_c = 10$ - Factor for cast-in anchors breakout strength

$\phi = 0.65$ - Concrete resistance factor

$f_c^{'} = 20.68\ \mathrm{MPa}$ - Concrete compressive strength (20.68)

CSA A23.3:19 Clause D.6.2.3

$h'_{ef,g1} = 110\ \mathrm{mm}$ - Anchor group BO 1 modified effective embedment length

$R = 1$ - Resistance modification factor of cast-in anchor rod in concrete failure (Tension Loads)

CSA A23.3:19 Eq. D.6

N_{br} - Factored concrete breakout resistance of a single anchor in tension

$$N_{br} = k_c \phi \lambda_a \sqrt{\frac{f_c^{'}}{MPa}} \left(\frac{h'_{ef,g1}}{mm}\right)^{1.5} R(N)$$

$$N_{br} = 10 \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{110\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 34.102\ \mathrm{kN}$$

Calculate minimum edge distance of anchor

$c_{a,min}$ - Shortest edge distance

$$c_{a,min} = \min\left(\mathrm{c_{left,g1}},\ \mathrm{c_{right,g1}},\ \mathrm{c_{top,g1}},\ \mathrm{c_{bottom,g1}}\right) = \min\left(162.5\ \mathrm{mm},\ 162.5\ \mathrm{mm},\ 85\ \mathrm{mm},\ 85\ \mathrm{mm}\right) = 85\ \mathrm{mm}$$

Calculate edge effect factor

CSA A23.3:19 Eq. D.10 and D.11

$\Psi_{ed,N}$ - Modification factor for edge effects of anchors

$$\Psi_{ed,N} = \min\left(1.0,\ 0.7 + 0.3\left(\frac{\mathrm{c_{a,min}}}{1.5\mathrm{h'_{ef,g1}}}\right)\right) = \min\left(1,\ 0.7 + 0.3 \times \left(\frac{85\ \mathrm{mm}}{1.5 \times 110\ \mathrm{mm}}\right)\right) = 0.85455$$

Calculate eccentricity factor

$e'_N = 0$ - Eccentricity of the resultant tensile force (assumed 0 for tension)

CSA A23.3:19 Eq. D.8

$\Psi_{ec,N}$ - Modification factor for anchor groups loaded eccentrically in tension

$$\Psi_{ec,N} = \min\left(1.0,\ \frac{1}{1 + \frac{2e'_N}{3h'_{ef,g1}}}\right) = \min\left(1,\ \frac{1}{1 + \frac{2 \times 0}{3 \times 110\ \mathrm{mm}}}\right) = 1$$

Calculate concrete breakout capacity of the anchor group

CSA A23.3:19 Eq. D.8

$\Psi_{ec,N} = 1$

CSA A23.3:19 Eq. D.10 and D.11

$\Psi_{ed,N} = 0.85455$

CSA A23.3:19 Clause D.6.2.6

$\Psi_{c,N} = 1$ - Modification factor for cracking

CSA A23.3:19 Clause D.6.2.7

$\Psi_{cp,N} = 1$ - Modification factor for concrete splitting

CSA A23.3:19 Eq. D.4

N_{cbr} - Factored concrete breakout resistance

$$N_{cbr} = \left(\frac{A_{Nc}}{A_{Nco}}\right) \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_{br}$$

$$N_{cbr} = \left(\frac{200000\ \mathrm{mm}^2}{108900\ \mathrm{mm}^2}\right) \times 1 \times 0.85455 \times 1 \times 1 \times 34.102\ \mathrm{kN} = 53.52\ \mathrm{kN}$$

Result:

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{N_{fa}}{N_{cbr}} = \frac{15\ \mathrm{kN}}{53.52\ \mathrm{kN}} = 0.28027$$

PASS = 0.28

Go back to summary results table.

Check No. 5: Anchor Pullout Capacity

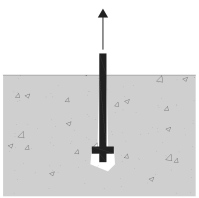


Fig. Headed anchor concrete pullout failure.

Calculate load per tension anchor

$N_x = 15\ \mathrm{kN}$ - Tension load

$n_{a,t} = 4$ - Number of anchors in tension

N_{fa} - Factored load on cast-in anchor

$$N_{fa} = \frac{N_x}{n_{a,t}} = \frac{15\ \text{kN}}{4} = 3.75\ \text{kN}$$

Calculate area of bearing on embedded head

$d_a = 12.7\ \text{mm}$ - Anchor rod diameter

A_{rod} - Area of anchor rod

$$A_{rod} = \frac{\pi}{4}(d_a)^2 = \frac{\pi}{4} \times (12.7\ \text{mm})^2 = 126.68\ \text{mm}^2$$

$b_{embed\_plate} = 60\ \text{mm}$ - Anchor embed plate dimension

A_{brg} - Net area of bearing for rectangular end

$$A_{brg} = \left((b_{embed\_plate})^2\right) - A_{rod} = \left((60\ \text{mm})^2\right) - 126.68\ \text{mm}^2 = 3473.3\ \text{mm}^2$$

Calculate basic anchor pullout strength

CSA A23.3:19 Clause D.6.3.6

$\Psi_{c,P} = 1$ - Modification factor for pullout

$\phi = 0.65$ - Concrete resistance factor

$f_c' = 20.68\ \text{MPa}$ - Concrete compressive strength (20.68)

$R = 1$ - Resistance modification factor of cast-in anchor rod in concrete failure (Tension Loads)

CSA A23.3:19 Eq. D.16

N_{pr} - Factored pullout resistance of a single headed stud or headed bolt

$$N_{pr} = \Psi_{c,P} 8 A_{brg} \phi (f_c') R = 1 \times 8 \times 3473.3\ \text{mm}^2 \times 0.65 \times (20.68\ \text{MPa}) \times 1 = 373.51\ \text{kN}$$

Result:

PASS = 0.01

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{N_{fa}}{N_{pr}} = \frac{3.75\ \text{kN}}{373.51\ \text{kN}} = 0.01004$$

[Go back to summary results table.]

Check No. 6: Embed Plate Flexural Capacity

This additional check is to confirm the embed plate has enough thickness to resist flexural yielding.

Calculate load per tension anchor

T_a - Load per anchor

$$T_a = \frac{N_x}{n_{a,t}} = \frac{15\ \text{kN}}{4} = 3.75\ \text{kN}$$

Calculate one side width of embed plate

$b_{embed\_plate} = 60\ \text{mm}$ - Anchor embed plate dimension

$d_a = 12.7\ \text{mm}$ - Anchor rod diameter

b' - Remaining embed plate dimension

$$b' = \frac{b_{embed\_plate} - d_a}{2} = \frac{60\ \text{mm} - 12.7\ \text{mm}}{2} = 23.65\ \text{mm}$$

Calculate flexural demand on embed plate (taken as moment per unit length)

$A_{brg} = 3473.3\ \text{mm}^2$

m_f - Moment force from uniform pressure

$$m_f = \frac{\left(\frac{T_a}{A_{brg}}\right)(b')^2}{2} = \frac{\left(\frac{3.75\ \text{kN}}{3473.3\ \text{mm}^2}\right) \times (23.65\ \text{mm})^2}{2} = 0.30194\ \text{kN}$$

Calculate the minimum embed plate thickness for flexural yielding

The embed plate yield grade is assumed to match the base plate grade.

$F_{y\_ep} = 300\ \text{MPa}$ - Embed plate yield stress (300W)

$\phi = 0.9$ - Structural steel resistance factor

t_{min} - Required thickness of embed plate

$$t_{min} = \sqrt{\frac{4 m_f}{\phi F_{y\_ep}}} = \sqrt{\frac{4 \times 0.30194\ \text{kN}}{0.9 \times 300\ \text{MPa}}} = 2.115\ \text{mm}$$

Check actual embed plate thickness

t_{actual} - Provided embed plate thickness

$$t_{actual} = t_{embed\_plate} = 10\ \text{mm}$$

Result:

PASS = 0.21

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{t_{min}}{t_{actual}} = \frac{2.115\ \text{mm}}{10\ \text{mm}} = 0.2115$$

[Go back to summary results table.]

Check No. 7: Concrete Side-Face Blowout Capacity (Y-Direction)

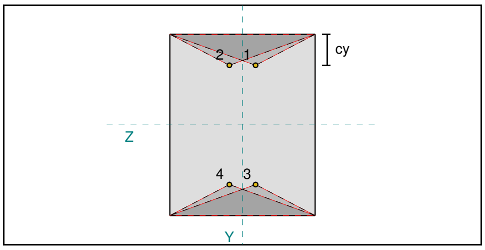
Calculation Note:

Check is not applicable because the effective embedment length (300 mm) is less than or equal to 2.5 times the edge distance (406.25 mm).

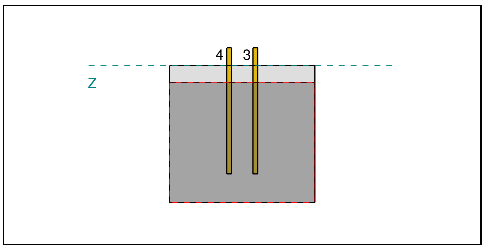
N/A = 0.00

[Go back to summary results table.]

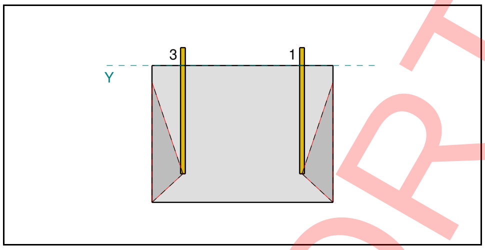
Check No. 8: Concrete Side-Face Blowout Capacity (Z-Direction)



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total tension load on anchor group in Z-direction

$N_x = 15\ \mathrm{kN}$ - Tension load

$n_{a,t} = 4$ - Number of anchors in tension

$n_{z,g1} = 2$ - Number of anchors along Z-axis for anchor group SFz 1

N_{fa} - Factored load on anchors along Z-axis of anchor group

$$N_{fa} = \left(\frac{N_x}{n_{a,t}}\right) n_{z,g1} = \left(\frac{15\ \mathrm{kN}}{4}\right) \times 2 = 7.5\ \mathrm{kN}$$

Symbol	Description	Value
$c_{left,g1}$	Anchor group SFz 1 concrete edge distance (left)	162.5 mm
$c_{right,g1}$	Anchor group SFz 1 concrete edge distance (right)	162.5 mm
$c_{top,g1}$	Anchor group SFz 1 concrete edge distance (top)	85.0 mm
$c_{bottom,g1}$	Anchor group SFz 1 concrete edge distance (bottom)	415.0 mm
$s_{sum,z,g1}$	Anchor group SFz 1 sum of spacing along Z-axis	75.0 mm

Calculation for critical anchor group: Anchor Group SFz 1.

Calculate minimum edge distance to the failure edge

$c_{top,g1} = 85\ \mathrm{mm}$ - Anchor group SFz 1 concrete edge distance (top)

$c_{bottom,g1} = 415\ \mathrm{mm}$ - Anchor group SFz 1 concrete edge distance (bottom)

$c_{y,min}$ - Minimum edge distance along Y-axis

$$c_{y,min} = \min\left(\mathrm{c_{top,g1}},\ \mathrm{c_{bottom,g1}}\right) = \min\left(85\ \mathrm{mm},\ 415\ \mathrm{mm}\right) = 85\ \mathrm{mm}$$

Calculate minimum edge distance to the orthogonal edge

$c_{left,g1} = 162.5\ \mathrm{mm}$ - Anchor group SFz 1 concrete edge distance (left)

$c_{right,g1} = 162.5\ \mathrm{mm}$ - Anchor group SFz 1 concrete edge distance (right)

$c_{z,min}$ - Minimum edge distance along Z-axis

$$c_{z,min} = \min\left(\mathrm{c_{left,g1}},\ \mathrm{c_{right,g1}}\right) = \min\left(162.5\ \mathrm{mm},\ 162.5\ \mathrm{mm}\right) = 162.5\ \mathrm{mm}$$

Calculate modification factor for lightweight concrete

$\lambda = 1$ - Factor for normal-weight concrete

CSA A23.3:19 Clause D.4.6

λ_a - Modification factor for lightweight concrete

$$\lambda_a = 1.0\lambda = 1 \times 1 = 1$$

Calculate nominal side-face blowout of the group anchor along Z-direction

$s_{sum,z,g1} = 75\ \mathrm{mm}$ - Anchor group SFz 1 sum of spacing along Z-axis

$A_{brg} = 3473.3\ \mathrm{mm}^2$

$\phi = 0.65$ - Concrete resistance factor

$f_c^{'} = 20.68\ \mathrm{MPa}$ - Concrete compressive strength (20.68)

$R = 1$ - Resistance modification factor of cast-in anchor rod in concrete failure (Tension Loads)

CSA A23.3:19 Clause D.6.4

N_{sbgr} - Factored side-face blowout resistance of multiple-headed anchors in tension (close to perpendicular edge)

$$N_{sbgr} = \left(\frac{1 + \frac{c_{z,min}}{c_{y,min}}}{4} + \frac{s_{sum,z,g1}}{6c_{y,min}}\right) 13.3 \left(\frac{c_{y,min}}{mm}\right) \sqrt{\frac{A_{brg}}{mm^2}} \phi \lambda_a \sqrt{\frac{f_c'}{MPa}} R(N)$$

$$N_{sbgr} = \left(\frac{1 + \frac{162.5 \text{ mm}}{85 \text{ mm}}}{4} + \frac{75 \text{ mm}}{6 \times 85 \text{ mm}}\right) \times 13.3 \times \left(\frac{85 \text{ mm}}{1 \text{ mm}}\right) \times \sqrt{\frac{3473.3 \text{ mm}^2}{1 \text{ mm}^2}} \times 0.65 \times 1 \times \sqrt{\frac{20.68 \text{ MPa}}{1 \text{ MPa}}} \times 1 \times 0.001 \text{ kN}$$

$$N_{sbgr} = 172.32 \text{ kN}$$

Result:

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{N_{fa}}{N_{sbgr}} = \frac{7.5 \text{ kN}}{172.32 \text{ kN}} = 0.043523$$

PASS = 0.04

Go back to summary results table.

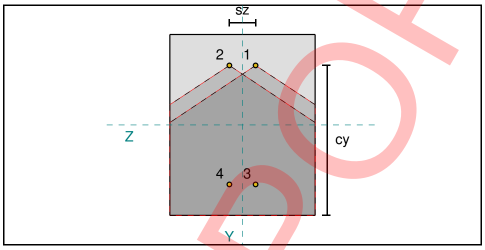
Check No. 9: Concrete Breakout Capacity (Vy Shear)

For breakout capacity on failure edge perpendicular to load:

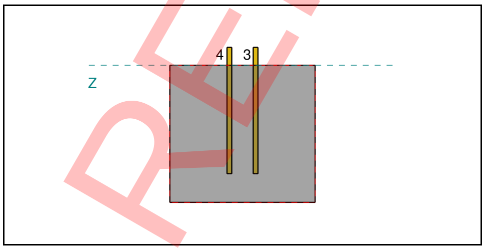
Determine cases:

Symbol	Description	Value
$s_{y,outer}$	Spacing of outer anchor rods along Y-axis	330.0 mm
$c_{a1,g1}$	Anchor group distance to failure edge (-Vy shear)	415.0 mm
	Are welded plate washers used?	Yes
	Applicable Cases	Case 2

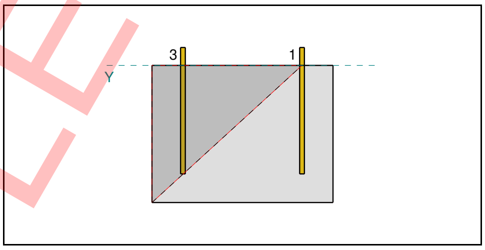
Calculations for Case 2



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group.

$V_y = 5$ kN - Vy shear load

$V_{fa\perp,case2}$ - Required concrete breakout shear strength of anchor group with failure edge perpendicular to load

$$V_{fa\perp,case2} = V_y = 5 \text{ kN}$$

Determine if the support is a narrow concrete member

CSA A23.3:19 Clause D.7.2.4

The support is classified as a narrow member. The modified values below will be used throughout the calculations.

Symbol	Description	Value
$c_{left,g1}$	Anchor group BO Vy 1 concrete edge distance (left)	162.5 mm
$c_{right,g1}$	Anchor group BO Vy 1 concrete edge distance (right)	162.5 mm
$c_{top,g1}$	Anchor group BO Vy 1 concrete edge distance (top)	85.0 mm
$c_{bottom,g1}$	Anchor group BO Vy 1 concrete edge distance (bottom)	415.0 mm
t_{conc}	Concrete thickness	380.0 mm
s_z	Spacing of anchor rods along Z-axis	75.0 mm
$c_{a1,g1}$	Rear anchor group distance to failure edge (-Vy shear)	415.0 mm
	Narrow Member	TRUE
$c'_{a1,g1}$	Rear anchor group modified distance to failure edge (-Vy shear)	253.3 mm

Calculation for critical anchor group: Anchor Group BO Vy 1.

Calculate maximum projected area for a single anchor

CSA A23.3:19 Clause D.7.2.4

$c'_{a1,g1} = 253.33\ \text{mm}$ - Rear anchor group modified distance to failure edge (-Vy shear)

CSA A23.3:19 Equation D.34

A_{Vco} - Maximum projected area for a single anchor

$$A_{Vco} = 4.5\left(c'_{a1,g1}\right)^2 = 4.5 \times (253.33\ \text{mm})^2 = 288800\ \text{mm}^2$$

Calculate width of actual projected area on failure surface

$s_{sum,z,g1} = 75\ \text{mm}$ - Anchor group BO Vy 1 sum of spacing along Z-axis

$n_{z,g1} = 2$ - Number of anchors along Z-axis for anchor group BO Vy 1

CSA A23.3:19 Clause D.7.2.1

B_{Vc} - Actual width of failure surface for an anchor group

$$B_{Vc} = \min\left(\mathrm{c_{left,g1}},\ 1.5\mathrm{c'_{a1,g1}}\right) + \left(\min\left(\mathrm{s_{sum,z,g1}},\ 3\mathrm{c'_{a1,g1}}\left(\mathrm{n_{z,g1}} - 1\right)\right)\right) + \min\left(\mathrm{c_{right,g1}},\ 1.5\mathrm{c'_{a1,g1}}\right)$$

$$B_{Vc} = \min(162.5\ \text{mm},\ 1.5 \times 253.33\ \text{mm}) + (\min(75\ \text{mm},\ 3 \times 253.33\ \text{mm} \times (2-1))) + \min(162.5\ \text{mm},\ 1.5 \times 253.33\ \text{mm})$$

$$B_{Vc} = 400\ \text{mm}$$

Calculate height of actual projected area on failure surface

CSA A23.3:19 Clause D.7.2.1

H_{Vc} - Actual height of projected area

$$H_{Vc} = \min\left(1.5\mathrm{c'_{a1,g1}},\ \mathrm{t_{conc}}\right) = \min(1.5 \times 253.33\ \text{mm},\ 380\ \text{mm}) = 380\ \text{mm}$$

Calculate actual projected area

CSA A23.3:19 Clause D.7.2.1

A_{Vc} - Actual projected area

$$A_{Vc} = B_{Vc}H_{Vc} = 400\ \text{mm} \times 380\ \text{mm} = 152000\ \text{mm}^2$$

Calculate modification factor for lightweight concrete

$\lambda = 1$ - Factor for normal-weight concrete

CSA A23.3:19 Clause D.4.6

λ_a - Modification factor for lightweight concrete

$$\lambda_a = 1.0\lambda = 1 \times 1 = 1$$

Calculate load bearing length of the anchor

$h_{ef} = 300\ \text{mm}$ - Anchor rod effective embedment length

CSA A23.3:19 Clause D.7.2.2(a)

l_e - Load bearing length (equal to embedment height)

$$l_e = h_{ef} = 300\ \text{mm}$$

Calculate basic single anchor breakout strength

$f'_c = 20.68\ \text{MPa}$ - Concrete compressive strength (20.68)

$d_a = 12.7\ \text{mm}$ - Anchor rod diameter

$\phi = 0.65$ - Concrete resistance factor

$R = 1$ - Resistance modification factor of concrete failure (Shear Loads)

CSA A23.3:19 Equation D.35

V_{br1} - Basic single anchor breakout strength condition 1

$$V_{br1} = 0.58\left(\frac{\min\left(\mathrm{l_e},\ 8\mathrm{d_a}\right)}{d_a}\right)^{0.2}\sqrt{\frac{d_a}{mm}}\phi\lambda_a\sqrt{\frac{f'_c}{MPa}}\left(\frac{c'_{a1,g1}}{mm}\right)^{1.5}R(N)$$

$$V_{br1} = 0.58 \times \left(\frac{\min(300\ \text{mm},\ 8 \times 12.7\ \text{mm})}{12.7\ \text{mm}}\right)^{0.2} \times \sqrt{\frac{12.7\ \text{mm}}{1\ \text{mm}}} \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \text{MPa}}{1\ \text{MPa}}} \times \left(\frac{253.33\ \text{mm}}{1\ \text{mm}}\right)^{1.5} \times 1 \times 0.001\ \text{kN}$$

$$V_{br1} = 37.34\ \text{kN}$$

CSA A23.3:19 Equation D.36

V_{br2} - Basic single anchor breakout strength condition 2

$$V_{br2} = 3.75\lambda_a\phi\sqrt{\frac{f'_c}{MPa}}\left(\frac{c'_{a1,g1}}{mm}\right)^{1.5}R(N)$$

$$V_{br2} = 3.75 \times 1 \times 0.65 \times \sqrt{\frac{20.68\ \text{MPa}}{1\ \text{MPa}}} \times \left(\frac{253.33\ \text{mm}}{1\ \text{mm}}\right)^{1.5} \times 1 \times 0.001\ \text{kN} = 44.695\ \text{kN}$$

CSA A23.3:19 Clause D.7.2.2

V_{br} - Factored concrete breakout resistance in shear of a single anchor

$$V_{br} = \min\left(\mathrm{V_{br1}},\ \mathrm{V_{br2}}\right) = \min\left(37.34\ \mathrm{kN},\ 44.695\ \mathrm{kN}\right) = 37.34\ \mathrm{kN}$$

Calculate eccentricity factor

$e'_N = 0$ - Eccentricity of the resultant tensile force (assumed 0 for shear)

CSA A23.3:19 Clause D.7.2.5

$\Psi_{ec,V}$ - Breakout eccentricity factor

$$\Psi_{ec,V} = \min\left(1.0,\ \frac{1}{1+\frac{2e'_{\mathrm{N}}}{3c'_{\mathrm{a1,g1}}}}\right) = \min\left(1,\ \frac{1}{1+\frac{2\times0}{3\times253.33\ \mathrm{mm}}}\right) = 1$$

Calculate edge effect factor

$c_{a2,g1} = 162.5\ \mathrm{mm}$ - Anchor group distance to failure edge (-Vy shear)

CSA A23.3:19 Clause D.7.2.6

$\Psi_{ed,V}$ - Breakout edge effect factor

$$\Psi_{ed,V} = \min\left(1.0,\ 0.7+0.3\left(\frac{\mathrm{c_{a2,g1}}}{1.5\mathrm{c'_{a1,g1}}}\right)\right) = \min\left(1,\ 0.7+0.3\times\left(\frac{162.5\ \mathrm{mm}}{1.5\times253.33\ \mathrm{mm}}\right)\right) = 0.82829$$

Calculate thickness factor

CSA A23.3:19 Clause D.7.2.8

$\Psi_{h,V}$ - Breakout thickness factor

$$\Psi_{h,V} = \max\left(\sqrt{\frac{1.5\mathrm{c'_{a1,g1}}}{\mathrm{t_{conc}}}},\ 1.0\right) = \max\left(\sqrt{\frac{1.5\times253.33\ \mathrm{mm}}{380\ \mathrm{mm}}},\ 1\right) = 1$$

Calculate concrete breakout capacity at the perpendicular edge

CSA A23.3:19 Clause D.7.2.7

$\Psi_{c,V} = 1$ - Breakout cracking factor (shear)

CSA A23.3:19 Clause D.7.2.1

$V_{cbg\perp}$ - Factored concrete breakout strength in shear of an anchor group (perpendicular edge)

$$V_{cbg\perp} = \left(\frac{A_{Vc}}{A_{Vco}}\right)\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{br}$$

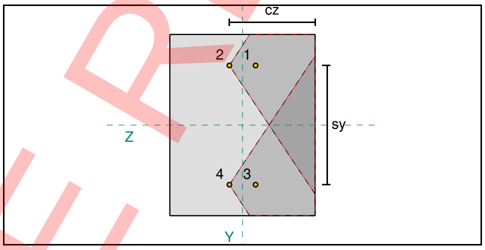
$$V_{cbg\perp} = \left(\frac{152000\ \mathrm{mm}^2}{288800\ \mathrm{mm}^2}\right)\times1\times0.82829\times1\times1\times37.34\ \mathrm{kN} = 16.278\ \mathrm{kN}$$

For breakout capacity on failure edge parallel to load:

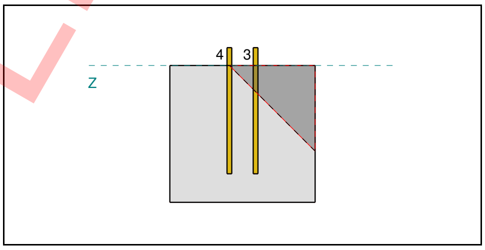
Determine cases:

Symbol	Description	Value
$s_{z,outer}$	Spacing of outer anchor rods along Z-axis	75.0 mm
$c_{a1,g1}$	Anchor group distance to failure edge (+Vz shear)	162.5 mm
	Are welded plate washers used?	Yes
	Applicable Cases	Case 2

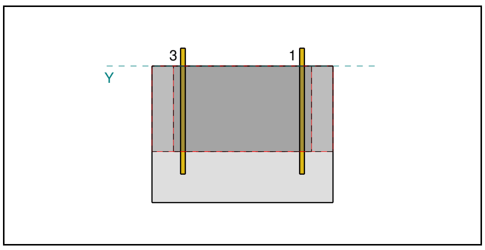
Calculations for Case 2



PLAN VIEW



FRONT VIEW



SIDE VIEW

SkyCiv

Calculate total shear load on anchor group.

$V_y = 5\ \mathrm{kN}$ - Vy shear load

Assume Vy load is acting perpendicular to the anchors along the failure edge.

$V_{fa\|,case2}$ - Required concrete breakout shear strength of anchor group with failure edge parallel to load

$$V_{fa\|,case2} = V_y = 5\ \mathrm{kN}$$

CSA A23.3:19 Clause D.7.2.4

Determine if the support is a narrow concrete member

The support is not a narrow member.

Symbol	Description	Value
$c_{left,g2}$	Anchor group BO Vz 2 concrete edge distance (left)	162.5 mm
$c_{right,g2}$	Anchor group BO Vz 2 concrete edge distance (right)	237.5 mm
$c_{top,g2}$	Anchor group BO Vz 2 concrete edge distance (top)	85.0 mm
$c_{bottom,g2}$	Anchor group BO Vz 2 concrete edge distance (bottom)	85.0 mm
t_{conc}	Concrete thickness	380.0 mm
s_y	Spacing of anchor rods along Y-axis	330.0 mm
$c_{a1,g2}$	Rear anchor group distance to failure edge (+Vz shear)	237.5 mm
	Narrow Member	FALSE

Calculation for critical anchor group: Anchor Group BO Vz 2.

Calculate maximum projected area for a single anchor

CSA A23.3:19 Clause D.7.2.4

$c_{a1,g2} = 237.5\ \mathrm{mm}$ - Rear anchor group distance to failure edge (+Vz shear)

CSA A23.3:19 Equation D.34

A_{Vco} - Maximum projected area for a single anchor

$$A_{Vco} = 4.5(c_{a1,g2})^2 = 4.5 \times (237.5\ \mathrm{mm})^2 = 253830\ \mathrm{mm}^2$$

Calculate width of actual projected area on failure surface

$s_{sum,y,g2} = 330\ \mathrm{mm}$ - Anchor group BO Vz 2 sum of spacing along Y-axis

$n_{y,g2} = 2$ - Number of anchors along Y-axis for anchor group BO Vz 2

CSA A23.3:19 Clause D.7.2.1

B_{Vc} - Actual width of failure surface for an anchor group

$$B_{Vc} = \min\left(\mathrm{c_{bottom,g2}},\ 1.5\mathrm{c_{a1,g2}}\right) + \left(\min\left(\mathrm{s_{sum,y,g2}},\ 3\mathrm{c_{a1,g2}}\left(\mathrm{n_{y,g2}} - 1\right)\right)\right) + \min\left(\mathrm{c_{top,g2}},\ 1.5\mathrm{c_{a1,g2}}\right)$$

$$B_{Vc} = \min\left(85\ \mathrm{mm},\ 1.5 \times 237.5\ \mathrm{mm}\right) + \left(\min\left(330\ \mathrm{mm},\ 3 \times 237.5\ \mathrm{mm} \times (2-1)\right)\right) + \min\left(85\ \mathrm{mm},\ 1.5 \times 237.5\ \mathrm{mm}\right)$$

$$B_{Vc} = 500\ \mathrm{mm}$$

Calculate height of actual projected area on failure surface

CSA A23.3:19 Clause D.7.2.1

H_{Vc} - Actual height of projected area

$$H_{Vc} = \min\left(1.5\mathrm{c_{a1,g2}},\ \mathrm{t_{conc}}\right) = \min\left(1.5 \times 237.5\ \mathrm{mm},\ 380\ \mathrm{mm}\right) = 356.25\ \mathrm{mm}$$

Calculate actual projected area

CSA A23.3:19 Clause D.7.2.1

A_{Vc} - Actual projected area

$$A_{Vc} = B_{Vc}H_{Vc} = 500\ \mathrm{mm} \times 356.25\ \mathrm{mm} = 178130\ \mathrm{mm}^2$$

Calculate modification factor for lightweight concrete

$\lambda = 1$ - Factor for normal-weight concrete

CSA A23.3:19 Clause D.4.6

λ_a - Modification factor for lightweight concrete

$$\lambda_a = 1.0\lambda = 1 \times 1 = 1$$

Calculate load bearing length of the anchor

$h_{ef} = 300\ \mathrm{mm}$ - Anchor rod effective embedment length

CSA A23.3:19 Clause D.7.2.2(a)

l_e - Load bearing length (equal to embedment height)

$$l_e = h_{ef} = 300\ \mathrm{mm}$$

Calculate basic single anchor breakout strength

$f_c' = 20.68\ \mathrm{MPa}$ - Concrete compressive strength (20.68)

$d_a = 12.7\ \mathrm{mm}$ - Anchor rod diameter

$\phi = 0.65$ - Concrete resistance factor

$R = 1$ - Resistance modification factor of concrete failure (Shear Loads)

CSA A23.3:19 Equation D.35

V_{br1} - Basic single anchor breakout strength condition 1

$$V_{br1} = 0.58\left(\frac{\min\left(\mathrm{l_e},\ 8\mathrm{d_a}\right)}{d_a}\right)^{0.2}\sqrt{\frac{d_a}{mm}}\phi\lambda_a\sqrt{\frac{f_c'}{MPa}}\left(\frac{c_{a1,g2}}{mm}\right)^{1.5}R(N)$$

$$V_{br1} = 0.58 \times \left(\frac{\min\left(300\ \mathrm{mm},\ 8 \times 12.7\ \mathrm{mm}\right)}{12.7\ \mathrm{mm}}\right)^{0.2} \times \sqrt{\frac{12.7\ \mathrm{mm}}{1\ \mathrm{mm}}} \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{237.5\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN}$$

$$V_{br1} = 33.895\ \mathrm{kN}$$

CSA A23.3:19 Equation D.36

V_{br2} - Basic single anchor breakout strength condition 2

$$V_{br2} = 3.75\lambda_a\phi\sqrt{\frac{f_c'}{MPa}}\left(\frac{c_{a1,g2}}{mm}\right)^{1.5}R(N)$$

$$V_{br2} = 3.75 \times 1 \times 0.65 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{237.5\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 40.571\ \mathrm{kN}$$

CSA A23.3:19 Clause D.7.2.2

V_{br} - Factored concrete breakout resistance in shear of a single anchor

$$V_{br} = \min\left(\mathrm{V_{br1}},\ \mathrm{V_{br2}}\right) = \min\left(33.895\ \mathrm{kN},\ 40.571\ \mathrm{kN}\right) = 33.895\ \mathrm{kN}$$

Calculate eccentricity factor

$e_N' = 0$ - Eccentricity of the resultant tensile force (assumed 0 for shear)

CSA A23.3:19 Clause D.7.2.5

$\Psi_{ec,V}$ - Breakout eccentricity factor

$$\Psi_{ec,V} = \min\left(1.0,\ \frac{1}{1+\frac{2e_N'}{3c_{a1,g2}}}\right) = \min\left(1,\ \frac{1}{1+\frac{2\times 0}{3\times 237.5\ \mathrm{mm}}}\right) = 1$$

Calculate thickness factor

CSA A23.3:19 Clause D.7.2.8

$\Psi_{h,V}$ - Breakout thickness factor

$$\Psi_{h,V} = \max\left(\sqrt{\frac{1.5c_{a1,g2}}{t_{conc}}},\ 1.0\right) = \max\left(\sqrt{\frac{1.5 \times 237.5\ \mathrm{mm}}{380\ \mathrm{mm}}},\ 1\right) = 1$$

Calculate concrete breakout capacity at the parallel edge

CSA A23.3:19 Clause D.7.2.7

$\Psi_{c,V} = 1$ - Breakout cracking factor (shear)

CSA A23.3:19 Clause D.7.2.1(c)

$\Psi_{ed,V} = 1$ - Breakout edge effect factor for parallel failure edge

CSA A23.3:19 Clause D.7.2.1

$V_{cbgr\parallel}$ - Factored concrete breakout strength in shear of an anchor group (parallel edge)

$$V_{cbgr\parallel} = 2\left(\frac{A_{Vc}}{A_{Vco}}\right)\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{br}$$

$$V_{cbgr\parallel} = 2 \times \left(\frac{178130\ \mathrm{mm}^2}{253830\ \mathrm{mm}^2}\right) \times 1 \times 1 \times 1 \times 1 \times 33.895\ \mathrm{kN} = 47.572\ \mathrm{kN}$$

Result:

PASS = 0.31

DCR - Demand over capacity ratio, comparing two conditions:

$$DCR = \max\left(\frac{\mathrm{V_{fa\perp,case2}}}{\mathrm{V_{cbg\perp}}},\ \frac{\mathrm{V_{fa\parallel,case2}}}{\mathrm{V_{cbgr\parallel}}}\right)$$

$$DCR = \max\left(\frac{5\ \mathrm{kN}}{16.278\ \mathrm{kN}},\ \frac{5\ \mathrm{kN}}{47.572\ \mathrm{kN}}\right) = 0.30716$$

Go back to summary results table.

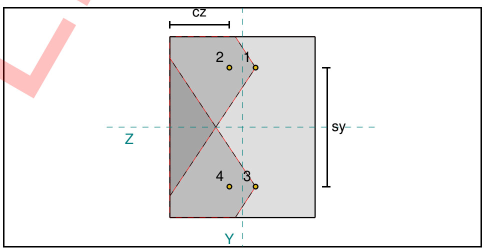
Check No. 10: Concrete Breakout Capacity (Vz Shear)

For breakout capacity on failure edge perpendicular to load:

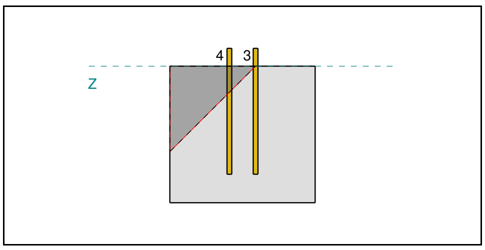
Determine cases:

Symbol	Description	Value
$s_{z,outer}$	Spacing of outer anchor rods along Z-axis	75.0 mm
$c_{a1,g1}$	Anchor group distance to failure edge (-Vz shear)	237.5 mm
	Are welded plate washers used?	Yes
	Applicable Cases	Case 2

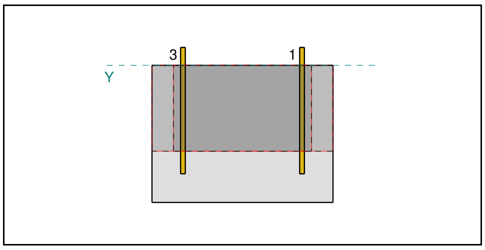
Calculations for Case 2



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group.

$V_z = 5\ \mathrm{kN}$ - Vz shear load

$V_{fa\perp,case2}$ - Required concrete breakout shear strength of anchor group with failure edge perpendicular to load

$$V_{fa\perp,case2} = V_z = 5\ \mathrm{kN}$$

Determine if the support is a narrow concrete member

CSA A23.3:19 Clause D.7.2.4

The support is not a narrow member.

Symbol	Description	Value
$c_{left,g1}$	Anchor group BO Vz 1 concrete edge distance (left)	237.5 mm
$c_{right,g1}$	Anchor group BO Vz 1 concrete edge distance (right)	162.5 mm
$c_{top,g1}$	Anchor group BO Vz 1 concrete edge distance (top)	85.0 mm
$c_{bottom,g1}$	Anchor group BO Vz 1 concrete edge distance (bottom)	85.0 mm
t_{conc}	Concrete thickness	380.0 mm
s_y	Spacing of anchor rods along Y-axis	330.0 mm
$c_{a1,g1}$	Rear anchor group distance to failure edge (-Vz shear)	237.5 mm
	Narrow Member	FALSE

Calculation for critical anchor group: Anchor Group BO Vz 1.

Calculate maximum projected area for a single anchor

CSA A23.3:19 Clause D.7.2.4

$c_{a1,g1} = 237.5\ \mathrm{mm}$ - Rear anchor group distance to failure edge (-Vz shear)

CSA A23.3:19 Equation D.34

A_{Vco} - Maximum projected area for a single anchor

$$A_{Vco} = 4.5(c_{a1,g1})^2 = 4.5 \times (237.5\ \mathrm{mm})^2 = 253830\ \mathrm{mm}^2$$

Calculate width of actual projected area on failure surface

$s_{sum,y,g1} = 330\ \mathrm{mm}$ - Anchor group BO Vz 1 sum of spacing along Y-axis

$n_{y,g1} = 2$ - Number of anchors along Y-axis for anchor group BO Vz 1

CSA A23.3:19 Clause D.7.2.1

B_{Vc} - Actual width of failure surface for an anchor group

$$B_{Vc} = \min\left(\mathrm{c_{bottom,g1}},\ 1.5\mathrm{c_{a1,g1}}\right) + \left(\min\left(\mathrm{s_{sum,y,g1}},\ 3\mathrm{c_{a1,g1}}\left(\mathrm{n_{y,g1}} - 1\right)\right)\right) + \min\left(\mathrm{c_{top,g1}},\ 1.5\mathrm{c_{a1,g1}}\right)$$

$$B_{Vc} = \min\left(85\ \mathrm{mm},\ 1.5 \times 237.5\ \mathrm{mm}\right) + \left(\min\left(330\ \mathrm{mm},\ 3 \times 237.5\ \mathrm{mm} \times (2 - 1)\right)\right) + \min\left(85\ \mathrm{mm},\ 1.5 \times 237.5\ \mathrm{mm}\right)$$

$$B_{Vc} = 500\ \mathrm{mm}$$

Calculate height of actual projected area on failure surface

CSA A23.3:19 Clause D.7.2.1

H_{Vc} - Actual height of projected area

$$H_{Vc} = \min\left(1.5\mathrm{c_{a1,g1}},\ \mathrm{t_{conc}}\right) = \min\left(1.5 \times 237.5\ \mathrm{mm},\ 380\ \mathrm{mm}\right) = 356.25\ \mathrm{mm}$$

Calculate actual projected area

CSA A23.3:19 Clause D.7.2.1

A_{Vc} - Actual projected area

$$A_{Vc} = B_{Vc}H_{Vc} = 500\ \mathrm{mm} \times 356.25\ \mathrm{mm} = 178130\ \mathrm{mm}^2$$

Calculate modification factor for lightweight concrete

$\lambda = 1$ - Factor for normal-weight concrete

CSA A23.3:19 Clause D.4.6

λ_a - Modification factor for lightweight concrete

$$\lambda_a = 1.0\lambda = 1 \times 1 = 1$$

Calculate load bearing length of the anchor

$h_{ef} = 300\ \mathrm{mm}$ - Anchor rod effective embedment length

CSA A23.3:19 Clause D.7.2.2(a)

l_e - Load bearing length (equal to embedment height)

$$l_e = h_{ef} = 300\ \mathrm{mm}$$

Calculate basic single anchor breakout strength

$f_c' = 20.68\ \mathrm{MPa}$ - Concrete compressive strength (20.68)

$d_a = 12.7\ \mathrm{mm}$ - Anchor rod diameter

$\phi = 0.65$ - Concrete resistance factor

$R = 1$ - Resistance modification factor of concrete failure (Shear Loads)

CSA A23.3:19 Equation

V_{br1} - Basic single anchor breakout strength condition 1

D.35

$$V_{br1} = 0.58\left(\frac{\min\left(\mathrm{l_e},\ 8\mathrm{d_a}\right)}{d_a}\right)^{0.2}\sqrt{\frac{d_a}{mm}}\phi\lambda_a\sqrt{\frac{f_c^{'}}{MPa}}\left(\frac{c_{a1,g1}}{mm}\right)^{1.5}R(N)$$

$$V_{br1} = 0.58 \times \left(\frac{\min\left(300\ \mathrm{mm},\ 8 \times 12.7\ \mathrm{mm}\right)}{12.7\ \mathrm{mm}}\right)^{0.2} \times \sqrt{\frac{12.7\ \mathrm{mm}}{1\ \mathrm{mm}}} \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{237.5\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN}$$

$$V_{br1} = 33.895\ \mathrm{kN}$$

CSA A23.3:19 Equation D.36

V_{br2} - Basic single anchor breakout strength condition 2

$$V_{br2} = 3.75\lambda_a\phi\sqrt{\frac{f_c^{'}}{MPa}}\left(\frac{c_{a1,g1}}{mm}\right)^{1.5}R(N)$$

$$V_{br2} = 3.75 \times 1 \times 0.65 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{237.5\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 40.571\ \mathrm{kN}$$

CSA A23.3:19 Clause D.7.2.2

V_{br} - Factored concrete breakout resistance in shear of a single anchor

$$V_{br} = \min\left(\mathrm{V_{br1}},\ \mathrm{V_{br2}}\right) = \min\left(33.895\ \mathrm{kN},\ 40.571\ \mathrm{kN}\right) = 33.895\ \mathrm{kN}$$

Calculate eccentricity factor

$e'_N = 0$ - Eccentricity of the resultant tensile force (assumed 0 for shear)

CSA A23.3:19 Clause D.7.2.5

$\Psi_{ec,V}$ - Breakout eccentricity factor

$$\Psi_{ec,V} = \min\left(1.0,\ \frac{1}{1 + \frac{2e'_N}{3c_{a1,g1}}}\right) = \min\left(1,\ \frac{1}{1 + \frac{2 \times 0}{3 \times 237.5\ \mathrm{mm}}}\right) = 1$$

Calculate edge effect factor

$c_{a2,g1} = 85\ \mathrm{mm}$ - Anchor group distance to failure edge (-Vz shear)

CSA A23.3:19 Clause D.7.2.6

$\Psi_{ed,V}$ - Breakout edge effect factor

$$\Psi_{ed,V} = \min\left(1.0,\ 0.7 + 0.3\left(\frac{\mathrm{c_{a2,g1}}}{1.5\mathrm{c_{a1,g1}}}\right)\right) = \min\left(1,\ 0.7 + 0.3 \times \left(\frac{85\ \mathrm{mm}}{1.5 \times 237.5\ \mathrm{mm}}\right)\right) = 0.77158$$

Calculate thickness factor

CSA A23.3:19 Clause D.7.2.8

$\Psi_{h,V}$ - Breakout thickness factor

$$\Psi_{h,V} = \max\left(\sqrt{\frac{1.5\mathrm{c_{a1,g1}}}{\mathrm{t_{conc}}}},\ 1.0\right) = \max\left(\sqrt{\frac{1.5 \times 237.5\ \mathrm{mm}}{380\ \mathrm{mm}}},\ 1\right) = 1$$

Calculate concrete breakout capacity at the perpendicular edge

CSA A23.3:19 Clause D.7.2.7

$\Psi_{c,V} = 1$ - Breakout cracking factor (shear)

CSA A23.3:19 Clause D.7.2.1

$V_{cbg\perp}$ - Factored concrete breakout strength in shear of an anchor group (perpendicular edge)

$$V_{cbg\perp} = \left(\frac{A_{Vc}}{A_{Vco}}\right)\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{br}$$

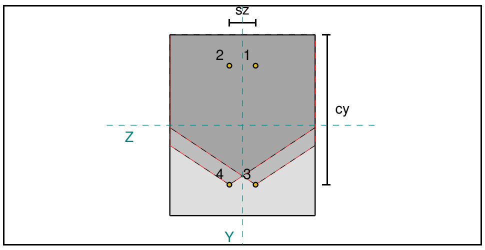
$$V_{cbg\perp} = \left(\frac{178130\ \mathrm{mm}^2}{253830\ \mathrm{mm}^2}\right) \times 1 \times 0.77158 \times 1 \times 1 \times 33.895\ \mathrm{kN} = 18.353\ \mathrm{kN}$$

For breakout capacity on failure edge parallel to load:

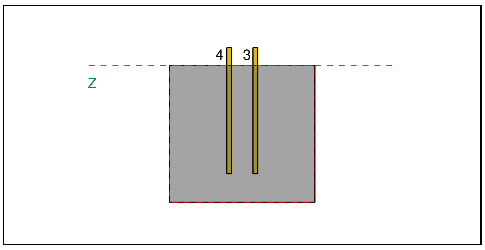
Determine cases:

Symbol	Description	Value
$s_{y,outer}$	Spacing of outer anchor rods along Y-axis	330.0 mm
$c_{a1,g1}$	Anchor group distance to failure edge (+Vy shear)	85.0 mm
	Are welded plate washers used?	Yes
	Applicable Cases	Case 2

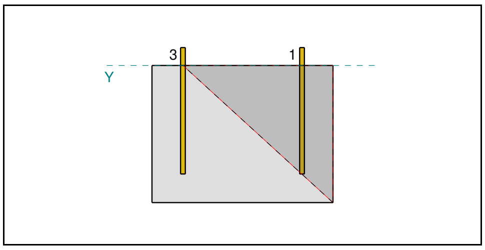
Calculations for Case 2



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group.

$V_z = 5\ \mathrm{kN}$ - Vz shear load

Assume Vz load is acting perpendicular to the anchors along the failure edge.

$V_{fa\|,case2}$ - Required concrete breakout shear strength of anchor group with failure edge parallel to load

$$V_{fa\|,case2} = V_z = 5\ \mathrm{kN}$$

Determine if the support is a narrow concrete member

CSA A23.3:19 Clause D.7.2.4

The support is classified as a narrow member. The modified values below will be used throughout the calculations.

Symbol	Description	Value
$c_{left,g2}$	Anchor group BO Vy 2 concrete edge distance (left)	162.5 mm
$c_{right,g2}$	Anchor group BO Vy 2 concrete edge distance (right)	162.5 mm
$c_{top,g2}$	Anchor group BO Vy 2 concrete edge distance (top)	415.0 mm
$c_{bottom,g2}$	Anchor group BO Vy 2 concrete edge distance (bottom)	85.0 mm
t_{conc}	Concrete thickness	380.0 mm
s_z	Spacing of anchor rods along Z-axis	75.0 mm
$c_{a1,g2}$	Rear anchor group distance to failure edge (+Vy shear)	415.0 mm
	Narrow Member	TRUE
$c'_{a1,g2}$	Rear anchor group modified distance to failure edge (+Vy shear)	253.3 mm

Calculation for critical anchor group: Anchor Group BO Vy 2.

Calculate maximum projected area for a single anchor

CSA A23.3:19 Clause D.7.2.4

$c'_{a1,g2} = 253.33\ \mathrm{mm}$ - Rear anchor group modified distance to failure edge (+Vy shear)

CSA A23.3:19 Equation D.34

A_{Vco} - Maximum projected area for a single anchor

$$A_{Vco} = 4.5\left(c'_{a1,g2}\right)^2 = 4.5 \times (253.33\ \mathrm{mm})^2 = 288800\ \mathrm{mm}^2$$

Calculate width of actual projected area on failure surface

$s_{sum,z,g2} = 75\ \mathrm{mm}$ - Anchor group BO Vy 2 sum of spacing along Z-axis

$n_{z,g2} = 2$ - Number of anchors along Z-axis for anchor group BO Vy 2

CSA A23.3:19 Clause D.7.2.1

B_{Vc} - Actual width of failure surface for an anchor group

$$B_{Vc} = \min\left(\mathrm{c_{left,g2}},\ 1.5\mathrm{c'_{a1,g2}}\right) + \left(\min\left(\mathrm{s_{sum,z,g2}},\ 3\mathrm{c'_{a1,g2}}\left(\mathrm{n_{z,g2}} - 1\right)\right)\right) + \min\left(\mathrm{c_{right,g2}},\ 1.5\mathrm{c'_{a1,g2}}\right)$$

$$B_{Vc} = \min(162.5\ \mathrm{mm},\ 1.5 \times 253.33\ \mathrm{mm}) + (\min(75\ \mathrm{mm},\ 3 \times 253.33\ \mathrm{mm} \times (2-1))) + \min(162.5\ \mathrm{mm},\ 1.5 \times 253.33\ \mathrm{mm})$$

$$B_{Vc} = 400\ \mathrm{mm}$$

Calculate height of actual projected area on failure surface

CSA A23.3:19 Clause D.7.2.1

H_{Vc} - Actual height of projected area

$$H_{Vc} = \min\left(1.5\mathrm{c'_{a1,g2}},\ \mathrm{t_{conc}}\right) = \min(1.5 \times 253.33\ \mathrm{mm},\ 380\ \mathrm{mm}) = 380\ \mathrm{mm}$$

Calculate actual projected area

CSA A23.3:19 Clause D.7.2.1

A_{Vc} - Actual projected area

$$A_{Vc} = B_{Vc}H_{Vc} = 400\ \mathrm{mm} \times 380\ \mathrm{mm} = 152000\ \mathrm{mm}^2$$

Calculate modification factor for lightweight concrete

$\lambda = 1$ - Factor for normal-weight concrete

CSA A23.3:19 Clause D.4.6

λ_a - Modification factor for lightweight concrete

$$\lambda_a = 1.0\lambda = 1 \times 1 = 1$$

Calculate load bearing length of the anchor

$h_{ef} = 300\ \text{mm}$ - Anchor rod effective embedment length

CSA A23.3:19 Clause D.7.2.2(a)

l_e - Load bearing length (equal to embedment height)

$$l_e = h_{ef} = 300\ \text{mm}$$

Calculate basic single anchor breakout strength

$f_c' = 20.68\ \text{MPa}$ - Concrete compressive strength (20.68)

$d_a = 12.7\ \text{mm}$ - Anchor rod diameter

$\phi = 0.65$ - Concrete resistance factor

$R = 1$ - Resistance modification factor of concrete failure (Shear Loads)

CSA A23.3:19 Equation D.35

V_{br1} - Basic single anchor breakout strength condition 1

$$V_{br1} = 0.58\left(\frac{\min(\mathrm{l_e},\ 8\mathrm{d_a})}{d_a}\right)^{0.2}\sqrt{\frac{d_a}{mm}}\phi\lambda_a\sqrt{\frac{f_c'}{MPa}}\left(\frac{c'_{a1,g2}}{mm}\right)^{1.5}R(N)$$

$$V_{br1} = 0.58 \times \left(\frac{\min(300\ \text{mm},\ 8 \times 12.7\ \text{mm})}{12.7\ \text{mm}}\right)^{0.2} \times \sqrt{\frac{12.7\ \text{mm}}{1\ \text{mm}}} \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \text{MPa}}{1\ \text{MPa}}} \times \left(\frac{253.33\ \text{mm}}{1\ \text{mm}}\right)^{1.5} \times 1 \times 0.001\ \text{kN}$$

$$V_{br1} = 37.34\ \text{kN}$$

CSA A23.3:19 Equation D.36

V_{br2} - Basic single anchor breakout strength condition 2

$$V_{br2} = 3.75\lambda_a\phi\sqrt{\frac{f_c'}{MPa}}\left(\frac{c'_{a1,g2}}{mm}\right)^{1.5}R(N)$$

$$V_{br2} = 3.75 \times 1 \times 0.65 \times \sqrt{\frac{20.68\ \text{MPa}}{1\ \text{MPa}}} \times \left(\frac{253.33\ \text{mm}}{1\ \text{mm}}\right)^{1.5} \times 1 \times 0.001\ \text{kN} = 44.695\ \text{kN}$$

CSA A23.3:19 Clause D.7.2.2

V_{br} - Factored concrete breakout resistance in shear of a single anchor

$$V_{br} = \min(\mathrm{V_{br1}},\ \mathrm{V_{br2}}) = \min(37.34\ \text{kN},\ 44.695\ \text{kN}) = 37.34\ \text{kN}$$

Calculate eccentricity factor

$e'_N = 0$ - Eccentricity of the resultant tensile force (assumed 0 for shear)

CSA A23.3:19 Clause D.7.2.5

$\Psi_{ec,V}$ - Breakout eccentricity factor

$$\Psi_{ec,V} = \min\left(1.0,\ \frac{1}{1+\frac{2e'_N}{3c'_{a1,g2}}}\right) = \min\left(1,\ \frac{1}{1+\frac{2\times0}{3\times253.33\ \text{mm}}}\right) = 1$$

Calculate thickness factor

CSA A23.3:19 Clause D.7.2.8

$\Psi_{h,V}$ - Breakout thickness factor

$$\Psi_{h,V} = \max\left(\sqrt{\frac{1.5c'_{a1,g2}}{\mathrm{t_{conc}}}},\ 1.0\right) = \max\left(\sqrt{\frac{1.5 \times 253.33\ \text{mm}}{380\ \text{mm}}},\ 1\right) = 1$$

Calculate concrete breakout capacity at the parallel edge

CSA A23.3:19 Clause D.7.2.7

$\Psi_{c,V} = 1$ - Breakout cracking factor (shear)

CSA A23.3:19 Clause D.7.2.1(c)

$\Psi_{ed,V} = 1$ - Breakout edge effect factor for parallel failure edge

CSA A23.3:19 Clause D.7.2.1

$V_{cbgr\parallel}$ - Factored concrete breakout strength in shear of an anchor group (parallel edge)

$$V_{cbgr\parallel} = 2\left(\frac{A_{Vc}}{A_{Vco}}\right)\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{br}$$

$$V_{cbgr\parallel} = 2 \times \left(\frac{152000\ \text{mm}^2}{288800\ \text{mm}^2}\right) \times 1 \times 1 \times 1 \times 1 \times 37.34\ \text{kN} = 39.305\ \text{kN}$$

Result:

DCR - Demand over capacity ratio, comparing two conditions:

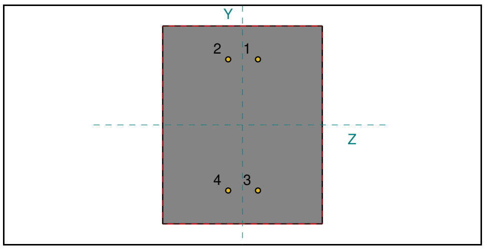
$$DCR = \max\left(\frac{\mathrm{V_{fa\perp,case2}}}{\mathrm{V_{cbg\perp}}},\ \frac{\mathrm{V_{fa\parallel,case2}}}{\mathrm{V_{cbgr\parallel}}}\right)$$

$$DCR = \max\left(\frac{5\ \text{kN}}{18.353\ \text{kN}},\ \frac{5\ \text{kN}}{39.305\ \text{kN}}\right) = 0.27244$$

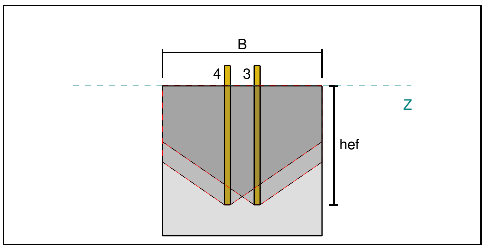
PASS = 0.27

Go back to summary results table.

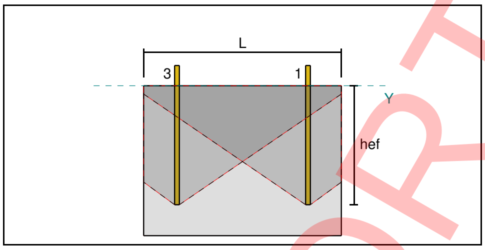
Check No. 11: Concrete Pryout Capacity



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group

$V_y = 5 \text{ kN}$ - Vy shear load

$V_z = 5 \text{ kN}$ - Vz shear load

V_{fa} - Resultant shear load

$$V_{fa} = \sqrt{\left((V_y)^2\right) + \left((V_z)^2\right)} = \sqrt{\left((5 \text{ kN})^2\right) + \left((5 \text{ kN})^2\right)} = 7.0711 \text{ kN}$$

$n_a = 4$ - Total number of anchor rods

$n_{a,g1} = 4$ - Number of anchors in anchor group PO 1

V_{fa} - Required concrete pryout strength of an anchor group

$$V_{fa} = \left(\frac{V_{fa}}{n_a}\right) n_{a,g1} = \left(\frac{7.0711 \text{ kN}}{4}\right) \times 4 = 7.0711 \text{ kN}$$

Determine if the support is a narrow concrete member

CSA A23.3:19 Clause D.6.2.3

The support is classified as a narrow member. The modified values below will be used throughout the calculations.

Symbol	Description	Value
$c_{left,g1}$	Anchor group PO 1 concrete edge distance (left)	162.5 mm
$c_{right,g1}$	Anchor group PO 1 concrete edge distance (right)	162.5 mm
$c_{top,g1}$	Anchor group PO 1 concrete edge distance (top)	85.0 mm
$c_{bottom,g1}$	Anchor group PO 1 concrete edge distance (bottom)	85.0 mm
h_{ef}	Anchor rod effective embedment length	300.0 mm
$s_{sum,y,g1}$	Anchor group PO 1 sum of spacing along Y-axis	330.0 mm
$s_{sum,z,g1}$	Anchor group PO 1 sum of spacing along Z-axis	75.0 mm
$n_{y,g1}$	Number of anchors along Y-axis for anchor group PO 1	2.0
$n_{z,g1}$	Number of anchors along Z-axis for anchor group PO 1	2.0
	Narrow Member	TRUE
$h'_{ef,g1}$	Anchor group PO 1 modified effective embedment length	110.0 mm

Calculation for critical anchor group: Anchor Group PO 1.

Calculate maximum projected area for a single anchor

CSA A23.3:19 Eq. D.5

A_{Nco} - Maximum projected area for a single anchor

$$A_{Nco} = 9\left(h'_{ef,g1}\right)^2 = 9 \times (110 \text{ mm})^2 = 108900 \text{ mm}^2$$

Calculate length of actual projected cone area (along Z-direction)

$r_{embed\_plate} = 16.35 \text{ mm}$ - Half side length of effective perimeter of embed plate

Equivalent to half anchor diameter plus thickness of embed plate

$r_{embed\_plate} = 16.35 \text{ mm}$ - Half side length of effective perimeter of embed plate

Equivalent to half anchor diameter plus thickness of embed plate

$s_{sum,z,g1} = 75 \text{ mm}$ - Anchor group PO 1 sum of spacing along Z-axis

SkyCiv

$n_{z,g1} = 2$ - Number of anchors along Z-axis for anchor group PO 1

CSA A23.3:19 Clause D.6.2.1

L_{Nc} - Actual length of concrete cone for an anchor group

$$L_{Nc} = \left(\min\left(\mathrm{c_{left,g1}},\ 1.5\mathrm{h'_{ef,g1}} + \mathrm{r_{embed\_plate}}\right)\right) + \left(\min\left(\mathrm{s_{sum,z,g1}},\ 3\mathrm{h'_{ef,g1}}\left(\mathrm{n_{z,g1}} - 1\right)\right)\right) + \left(\min\left(\mathrm{c_{right,g1}},\ 1.5\mathrm{h'_{ef,g1}} + \mathrm{r_{embed\_plate}}\right)\right)$$

$$L_{Nc} = (\min(162.5\ \mathrm{mm},\ 1.5 \times 110\ \mathrm{mm} + 16.35\ \mathrm{mm})) + (\min(75\ \mathrm{mm},\ 3 \times 110\ \mathrm{mm} \times (2-1))) + (\min(162.5\ \mathrm{mm},\ 1.5 \times 110\ \mathrm{mm} + 16.35\ \mathrm{mm}))$$

$$L_{Nc} = 400\ \mathrm{mm}$$

Calculate width of actual projected cone area (along Y-direction)

$r_{embed\_plate} = 16.35\ \mathrm{mm}$ - Half side length of effective perimeter of embed plate

Equivalent to half anchor diameter plus thickness of embed plate

$s_{sum,y,g1} = 330\ \mathrm{mm}$ - Anchor group PO 1 sum of spacing along Y-axis

$n_{y,g1} = 2$ - Number of anchors along Y-axis for anchor group PO 1

CSA A23.3:19 Clause D.6.2.1

B_{Nc} - Actual width of concrete cone for an anchor group

$$B_{Nc} = \left(\min\left(\mathrm{c_{top,g1}},\ 1.5\mathrm{h'_{ef,g1}} + \mathrm{r_{embed\_plate}}\right)\right) + \left(\min\left(\mathrm{s_{sum,y,g1}},\ 3\mathrm{h'_{ef,g1}}\left(\mathrm{n_{y,g1}} - 1\right)\right)\right) + \left(\min\left(\mathrm{c_{bottom,g1}},\ 1.5\mathrm{h'_{ef,g1}} + \mathrm{r_{embed\_plate}}\right)\right)$$

$$B_{Nc} = (\min(85\ \mathrm{mm},\ 1.5 \times 110\ \mathrm{mm} + 16.35\ \mathrm{mm})) + (\min(330\ \mathrm{mm},\ 3 \times 110\ \mathrm{mm} \times (2-1))) + (\min(85\ \mathrm{mm},\ 1.5 \times 110\ \mathrm{mm} + 16.35\ \mathrm{mm}))$$

$$B_{Nc} = 500\ \mathrm{mm}$$

Calculate actual projected area of the anchor group

$n_{a,g1} = 4$ - Number of anchors in anchor group PO 1

CSA A23.3:19 Clause D.6.2.1

A_{Nc} - Actual projected area for an anchor group

$$A_{Nc} = \min\left(\mathrm{n_{a,g1}A_{Nco}},\ \mathrm{L_{Nc}B_{Nc}}\right) = \min\left(4 \times 108900\ \mathrm{mm^2},\ 400\ \mathrm{mm} \times 500\ \mathrm{mm}\right) = 200000\ \mathrm{mm^2}$$

Calculate modification factor for lightweight concrete

$\lambda = 1$ - Factor for normal-weight concrete

CSA A23.3:19 Clause D.4.6

λ_a - Modification factor for lightweight concrete

$$\lambda_a = 1.0\lambda = 1 \times 1 = 1$$

Calculate basic single anchor breakout strength

$f_c^{'} = 20.68\ \mathrm{MPa}$ - Concrete compressive strength (20.68)

$\phi = 0.65$ - Concrete resistance factor

$R = 1$ - Resistance modification factor of cast-in anchor rod in concrete failure (Tension Loads)

CSA A23.3:19 Clause D.6.2.1

$k_c = 10$ - Factor for cast-in anchors breakout strength

CSA A23.3:19 Eq. D.6

N_{br} - Factored concrete breakout resistance of a single anchor in tension

$$N_{br} = k_c \phi \lambda_a \sqrt{\frac{f_c^{'}}{MPa}} \left(\frac{h'_{ef,g1}}{mm}\right)^{1.5} R(N)$$

$$N_{br} = 10 \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{110\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 34.102\ \mathrm{kN}$$

Calculate minimum edge distance of anchor

$c_{a,min}$ - Shortest edge distance

$$c_{a,min} = \min\left(\mathrm{c_{left,g1}},\ \mathrm{c_{right,g1}},\ \mathrm{c_{top,g1}},\ \mathrm{c_{bottom,g1}}\right) = \min(162.5\ \mathrm{mm},\ 162.5\ \mathrm{mm},\ 85\ \mathrm{mm},\ 85\ \mathrm{mm}) = 85\ \mathrm{mm}$$

Calculate eccentricity factor

$e'_N = 0$ - Eccentricity of the resultant tensile force (assumed 0 for shear)

CSA A23.3:19 Eq. D.8

$\Psi_{ec,N}$ - Modification factor for anchor groups loaded eccentrically in tension

$$\Psi_{ec,N} = \min\left(1.0,\ \frac{1}{1 + \frac{2e'_N}{3h'_{ef,g1}}}\right) = \min\left(1,\ \frac{1}{1 + \frac{2 \times 0}{3 \times 110\ \mathrm{mm}}}\right) = 1$$

Calculate edge effect factor

CSA A23.3:19 Eq. D.10 and D.11

$\Psi_{ed,N}$ - Modification factor for edge effects of anchors

$$\Psi_{ed,N} = \min\left(1.0,\ 0.7 + 0.3\left(\frac{\mathrm{c_{a,min}}}{1.5\mathrm{h'_{ef,g1}}}\right)\right) = \min\left(1,\ 0.7 + 0.3 \times \left(\frac{85\ \mathrm{mm}}{1.5 \times 110\ \mathrm{mm}}\right)\right) = 0.85455$$

Calculate factored concrete breakout capacity

CSA A23.3:19 Clause D.6.2.6

$\Psi_{c,N} = 1$ - Modification factor for cracking

CSA A23.3:19 Clause D.6.2.7

$\Psi_{cp,N} = 1$ - Modification factor for concrete splitting

CSA A23.3:19 Eq. D.4

N_{cbr} - Factored concrete breakout resistance

$$N_{cbr} = \left(\frac{A_{Nc}}{A_{Nco}}\right) \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_{br}$$

$$N_{cbr} = \left(\frac{200000\ \text{mm}^2}{108900\ \text{mm}^2}\right) \times 1 \times 0.85455 \times 1 \times 1 \times 34.102\ \text{kN} = 53.52\ \text{kN}$$

Calculate factored concrete pryout capacity

CSA A23.3:19 Clause D.7.3

$k_{cp} = 2$ - Factor for pryout strength

CSA A23.3:19 Clause D.7.3

V_{cpgr} - Factored concrete pryout strength of an anchor group

$$V_{cpgr} = k_{cp} N_{cbr} = 2 \times 53.52\ \text{kN} = 107.04\ \text{kN}$$

Result:

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{V_{fa}}{V_{cpgr}} = \frac{7.0711\ \text{kN}}{107.04\ \text{kN}} = 0.06606$$

PASS = 0.07

Go back to summary results table.

Check No. 12: Anchor Rod Shear Capacity

Calculate portion of Vy shear load on most critical anchor

Governing case from concrete breakout calculation for Vy shear: **Case 2 (perpendicular)**. Therefore, check the perpendicular anchors for a portion of Vy load

$V_y = 5\ \text{kN}$ - Vy shear load

$n_a = 4$ - Total number of anchor rods

$n_{z,g2} = 2$ - Number of anchors along Z-axis for anchor group BO Vy 2

$V_{fa,y}$ - Required shear strength on anchor due to Vy load

$$V_{fa,y} = \frac{V_y}{n_{z,g2}} = \frac{5\ \text{kN}}{2} = 2.5\ \text{kN}$$

Calculate portion of Vz shear load on most critical anchor

Governing case from concrete breakout calculation for Vz shear: **Case 2 (perpendicular)**. Therefore, check the perpendicular anchors for a portion of Vz load

$V_z = 5\ \text{kN}$ - Vz shear load

$n_a = 4$ - Total number of anchor rods

$n_{y,g2} = 2$ - Number of anchors along Y-axis for anchor group BO Vz 2

$V_{fa,z}$ - Required shear strength on anchor due to Vz load

$$V_{fa,z} = \frac{V_z}{n_{y,g2}} = \frac{5\ \text{kN}}{2} = 2.5\ \text{kN}$$

Calculate resultant load on most critical anchor

V_{fa} - Required shear strength on anchor

$$V_{fa} = \sqrt{\left((V_{fa,y})^2\right) + \left((V_{fa,z})^2\right)} = \sqrt{\left((2.5\ \text{kN})^2\right) + \left((2.5\ \text{kN})^2\right)} = 3.5355\ \text{kN}$$

Calculate eccentricity of shear load

$t_{bp} = 25\ \text{mm}$ - Base plate thickness

$t_{pw} = 5\ \text{mm}$ - Plate washer thickness

AISC Design Guide 1 3rd Ed. Section 4.3.3

e - Eccentricity of shear load due to plate washer

$$e = 0.5\left(\frac{t_{pw}}{2} + t_{bp}\right) = 0.5 \times \left(\frac{5\ \text{mm}}{2} + 25\ \text{mm}\right) = 13.75\ \text{mm}$$

Calculate section modulus of the anchor rod

$d_a = 12.7\ \text{mm}$ - Anchor rod diameter

Z_{rod} - Plastic modulus of anchor rod

$$Z_{rod} = \frac{(d_a)^3}{6} = \frac{(12.7\ \text{mm})^3}{6} = 341.4\ \text{mm}^3$$

Calculate tensile stress on anchor due to lever arm

f_t - Tensile stress on anchor due to shear load with lever arm

$$f_t = \frac{V_{fa} e}{Z_{rod}} = \frac{3.5355\ \text{kN} \times 13.75\ \text{mm}}{341.4\ \text{mm}^3} = 142.4\ \text{MPa}$$

Calculate equivalent tensile force

T_f - Equivalent tensile force

$$T_f = f_t A_{rod} = 142.4\ \text{MPa} \times 126.68\ \text{mm}^2 = 18.038\ \text{kN}$$

Calculations according to CSA A23.3:19 provisions:

Calculate specified tensile strength of anchor

$F_{u\_anc} = 400\ \text{MPa}$ - Anchor rod tensile stress (ASTM F1554 G36)

$F_{y\_anc} = 248.2\ \text{MPa}$ - Anchor rod yield stress (ASTM F1554 G36)

CSA A23.3:19 Clause D.7.1.2(b)

f_{uta} - Specified tensile strength of anchor steel

$$f_{uta} = \min\left(\mathrm{F_{u\_anc}},\ 1.9\mathrm{F_{y\_anc}},\ 860\right) = \min\left(400\ \text{MPa},\ 1.9 \times 248.2\ \text{MPa},\ 860.00\ \text{MPa}\right) = 400\ \text{MPa}$$

Calculate factored shear strength of the anchor rod per CSA A23.3:19 provisions

CSA A23.3:19 Clause D.7.1.2 and CAC Concrete Design Handbook 3rd Ed. Table 12.3

$A_{se,V} = 92\ \text{mm}^2$ - Effective cross-sectional area of anchor rod in shear

$\phi_s = 0.85$ - Anchor rod resistance factor

$R = 0.75$ - Resistance modification factor of anchor rod steel failure (Shear Loads)

CSA A23.3:19 Clause D.31

$V_{sar,A23}$ - Factored anchor rod steel shear strength per CSA A23

$$V_{sar,A23} = A_{se,V}\phi_s 0.6 f_{uta} R = 92 \text{ mm}^2 \times 0.85 \times 0.6 \times 400 \text{ MPa} \times 0.75 = 14.072 \text{ kN}$$

Calculations according to CSA S16:19 provisions:

Calculate factored shear strength of the anchor rod per CSA S16:19 provisions

$F_{u\_anc} = 400 \text{ MPa}$ - Anchor rod tensile stress (ASTM F1554 G36)

CSA S16:19 Clause 25.3.2.1

$\phi_{ar} = 0.67$ - Anchor rod resistance factor

$m = 1$ - Number of shear planes

CSA S16:19 Clause 25.3.3.3

$V_{r,s16}$ - Factored anchor rod shear strength per CSA S16

$$V_{r,s16} = 0.7\phi_{ar} 0.6 m A_{ar} F_{u\_anc} = 0.7 \times 0.67 \times 0.6 \times 1 \times 126.68 \text{ mm}^2 \times 400 \text{ MPa} = 14.255 \text{ kN}$$

Calculate factored tensile strength of the anchor rod per CSA S16:19 provisions

$F_{u\_anc} = 400 \text{ MPa}$ - Anchor rod tensile stress (ASTM F1554 G36)

CSA S16:19 pg. 31

$A_{ar} = 126.68 \text{ mm}^2$ - Nominal cross-sectional area of anchor rod

CSA S16:19 Clause 25.3.2.1

$\phi_{ar} = 0.67$ - Anchor rod resistance factor

CSA S16:19 Clause 25.3.2.1

T_r - Factored resistance of anchor rod in tension

$$T_r = \phi_{ar} 0.85 A_{ar} F_{u\_anc} = 0.67 \times 0.85 \times 126.68 \text{ mm}^2 \times 400 \text{ MPa} = 28.85 \text{ kN}$$

Calculate combined shear and tension capacity

CSA S16:19 Clause 13.12.1.4

I - Combined shear and tension capacity

$$I = \left(\left(\frac{V_{fa}}{V_{r,s16}}\right)^2\right) + \left(\left(\frac{T_f}{T_r}\right)^2\right)$$

$$I = \left(\left(\frac{3.5355 \text{ kN}}{14.255 \text{ kN}}\right)^2\right) + \left(\left(\frac{18.038 \text{ kN}}{28.85 \text{ kN}}\right)^2\right) = 0.45245$$

Result:

PASS = 0.45

DCR - Demand over capacity ratio, comparing two conditions:

$$DCR = \max\left(\frac{\mathrm{V_{fa}}}{\mathrm{V_{sar,A23}}}, \frac{\mathrm{I}}{\mathrm{I_{max}}}\right) = \max\left(\frac{3.5355 \text{ kN}}{14.072 \text{ kN}}, \frac{0.45245}{1}\right) = 0.45245$$

Go back to summary results table.

Check No. 13: Anchor Rod Shear and Tension Capacity (CSA S16)

Calculate total tensile load on anchor

Recall equivalent tensile load on anchor from shear with lever arm calculations

$T_f = 18.038 \text{ kN}$

Recall tension load on anchor from direct column tension

$N_{fa} = 3.75 \text{ kN}$

$T_{f,total}$ - Sum of tensile force

$$T_{f,total} = T_f + N_{fa} = 18.038 \text{ kN} + 3.75 \text{ kN} = 21.788 \text{ kN}$$

Calculate shear and tension capacity

CSA S16:19 Clause 13.12.1.4

I - Combined shear and tension capacity

$$I = \left(\left(\frac{V_{fa}}{V_{r,s16}}\right)^2\right) + \left(\left(\frac{T_{f,total}}{T_r}\right)^2\right)$$

$$I = \left(\left(\frac{3.5355 \text{ kN}}{14.255 \text{ kN}}\right)^2\right) + \left(\left(\frac{21.788 \text{ kN}}{28.85 \text{ kN}}\right)^2\right) = 0.63189$$

Result:

PASS = 0.63

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{I}{I_{max}} = \frac{0.63189}{1} = 0.63189$$

Go back to summary results table.

Check No. 14: Interaction Check (CSA A23.3)

Ratios of Anchor Checks for Tension Load:

Check Name	Demand	Capacity	DCR
Concrete Breakout Capacity (Tension Load)	15.00	53.52	0.280
Anchor Pullout Capacity	3.75	373.51	0.010
Embed Plate Flexural Capacity	2.11	10.00	0.211
Concrete Side-Face Blowout Capacity (Z-Direction)	7.50	172.32	0.044
Anchor Rod Tension Capacity (CSA A23.3)	3.75	25.02	0.150

Ratios of Anchor Checks For Shear Load:

Check Name	Demand	Capacity	DCR
Concrete Breakout Capacity (Vy Shear)	5.00	16.28	0.307
Concrete Breakout Capacity (Vy Shear)	5.00	47.57	0.105
Concrete Breakout Capacity (Vz Shear)	5.00	18.35	0.272
Concrete Breakout Capacity (Vz Shear)	5.00	39.31	0.127
Concrete Pryout Capacity	7.07	107.04	0.066
Anchor Rod Shear Capacity (CSA A23.3)	3.54	14.07	0.251

CSA A23.3:19 Equation D.46

Maximum interaction ratio

$I_{max} = 1.2$

CSA A23.3:19 Equation D.46

Calculate shear and axial interaction ratio

I_{int} - Shear and axial interaction check

$$I_{int} = \frac{N_{fa}}{N_{ra}} + \frac{V_{fa}}{V_{ra}} = \frac{15}{53.52} + \frac{5}{16.278} = 0.58743$$

Result:

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{I_{int}}{I_{max}} = \frac{0.58743}{1.2} = 0.48953$$

PASS = 0.49

Go back to summary results table.