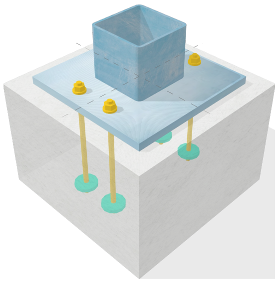
REFERENCES	CALCULATIONS	RESULTS

SkyCiv Base Plate and Anchor Rod Design

Shear and Compression - CSA

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

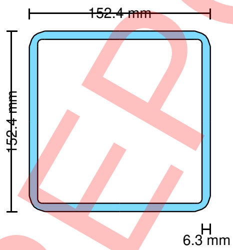


Load Combinations:

Load Combination	Axial Load, Nx (kN)	Strong-axis Shear, Vy (kN)	Weak-axis Shear, Vz (kN)
1	25.00	5.00	5.00

Note(s):
1. Positive Nx (+) indicates compression; negative Nx (-) indicates tension.
3. Engineering methods other than welded plate washers are assumed to be 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.

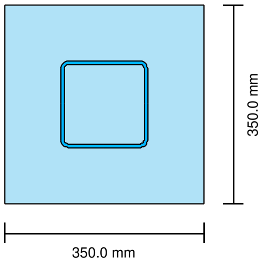
Column Properties:



Symbol	Description	Value
$Section$	Column section	HS152x152x6.4
d_{col}	Column depth	152.4 mm
t_{col}	Column thickness	6.3 mm
b_{col}	Column width	152.4 mm
A_{col}	Column area	3610.0 mm^2
r_{col}	Column root radius	6.3 mm
F_{y_col}	Column yield stress (350W)	350.0 MPa
F_{u_col}	Column tensile stress (350W)	450.0 MPa

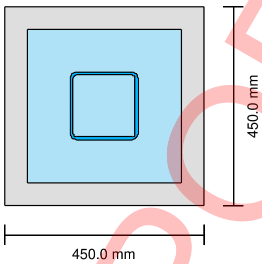
REFERENCES	CALCULATIONS	RESULTS

Base Plate Properties:



Symbol	Description	Value
B_{bp}	Base plate width	350.0 mm
L_{bp}	Base plate length	350.0 mm
t_{bp}	Base plate thickness	20.0 mm
A_{bp}	Base plate plan area	122500.0 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

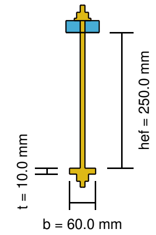
Concrete Properties:



Symbol	Description	Value
B_{conc}	Concrete width	450.0 mm
L_{conc}	Concrete length	450.0 mm
t_{conc}	Concrete thickness	300.0 mm
A_{conc}	Concrete plan area	202500.0 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

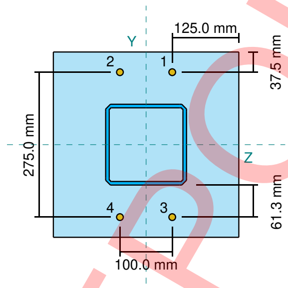
REFERENCES	CALCULATIONS	RESULTS

Anchor Information:



Symbol	Description	Value
d_a	Anchor rod diameter	12.7 mm
h_{ef}	Anchor rod effective embedment length	250.0 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	0.0 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	100.0 mm
s_y	Spacing of anchor rods along Y-axis	275.0 mm
$l_{edge,z}$	Base plate edge distance along Z-axis	125.0 mm
$l_{edge,y}$	Base plate edge distance along Y-axis	37.5 mm

REFERENCES	CALCULATIONS	RESULTS

Anchor Data Summary:

ID	Z (mm)	Y (mm)
1	50.000	137.500
2	-50.000	137.500
3	50.000	-137.500
4	-50.000	-137.500

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	+Vz +Vy	BO Vy Group 1	BO Vz Group 1	PO Vy Group 1	PO Vz Group 1
2	-Vz +Vy	BO Vy Group 1	BO Vz Group 2	PO Vy Group 1	PO Vz Group 2
3	+Vz -Vy	BO Vy Group 2	BO Vz Group 1	PO Vy Group 2	PO Vz Group 1
4	-Vz -Vy	BO Vy Group 2	BO Vz Group 2	PO Vy Group 2	PO Vz Group 2

Weld Properties:

Symbol	Description	Value
$Type$	Weld Type	CJP
X_u	Filler metal classification strength (E43XX-X)	430.0 MPa

REFERENCES	CALCULATIONS	RESULTS

Summary of Detailing Checks

Check Name	Dimensions (Min/Max/Actual)	Status	Reference
Anchor Clearance	Min: 30.16 mm, Actual: 53.30 mm	PASS	SkyCiv Recommendation
Base Plate Edge Distance	Min: 20.00 mm, Actual: 37.50 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: 100.00 mm	PASS	CSA A23.3.19 Clause D.9.2
Min. Concrete Cover to Prevent Concrete Splitting	Min: 75.00 mm, Actual: 87.50 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	0.01	1.23	0.01	PASS
Column Bearing Capacity	1	25.00	1705.73	0.01	PASS
Base Plate Yield Capacity (Compression Load)	1	1.07	27.00	0.04	PASS
Concrete Bearing Capacity	1	25.00	1799.55	0.01	PASS
Concrete Breakout Capacity (Vy Shear)	1	5.00	10.47	0.48	PASS
Concrete Breakout Capacity (Vz Shear)	1	5.00	14.70	0.34	PASS
Concrete Pryout Capacity (Vy Shear)	1	5.00	66.09	0.08	PASS
Concrete Pryout Capacity (Vz Shear)	1	5.00	78.14	0.06	PASS
Anchor Rod Shear Capacity	1	3.54	14.07	0.25	PASS

✔ All Design Checks Passed

The design is adequate.

REFERENCES	CALCULATIONS	RESULTS

Load Combination No. 1: Compression Load and Shear Load

Check No. 1: Weld Capacity

$A_{col} = 3610 \text{ mm}^2$ - Column area

$t_{col} = 6.35 \text{ mm}$ - Column thickness

L_w - Total length on HSS section (CJP)

$$L_w = \frac{A_{col}}{t_{col}} = \frac{3610 \text{ mm}^2}{6.35 \text{ mm}} = 568.5 \text{ mm}$$

Calculate load per unit length of weld

Ensure column is FIT-TO-BEAR on the base plate. Refer to AISC 360-22 Chapter M4.4.

No stress from the compression load is applied to the weld, since the compression load is transferred through bearing.

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

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

v_{fy} - Required weld strength per unit length

$$v_{fy} = \frac{V_y}{L_w} = \frac{5 \text{ kN}}{568.5 \text{ mm}} = 0.008795 \text{ kN/mm}$$

v_{fz} - Required weld strength per unit length

$$v_{fz} = \frac{V_z}{L_w} = \frac{5 \text{ kN}}{568.5 \text{ mm}} = 0.008795 \text{ kN/mm}$$

r_f - Required weld strength per unit length

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

$$r_f = \sqrt{\left((0.008795 \text{ kN/mm})^2\right) + \left((0.008795 \text{ kN/mm})^2\right)} = 0.012438 \text{ kN/mm}$$

Calculate base metal capacities

$F_{u\_col} = 450 \text{ MPa}$ - Column tensile stress (350W)

$t_{col} = 6.35 \text{ mm}$ - Column thickness

$F_{u\_bp} = 450 \text{ MPa}$ - Base plate tensile stress (300W)

$t_{bp} = 20 \text{ mm}$ - Base plate thickness

$\phi = 0.67$ - Weld resistance factor

CSA S16:18 Clause 13.13.2.1(a)

$v_{r,col}$ - Factored shear rupture strength of base metal (column)

$$v_{r,col} = 0.67\phi t_{col} F_{u\_col} = 0.67 \times 0.67 \times 6.35 \text{ mm} \times 450 \text{ MPa} = 1.2827 \text{ kN/mm}$$

CSA S16:18 Clause 13.13.2.1(a)

$v_{r,bp}$ - Factored shear rupture strength of base metal (base plate)

$$v_{r,bp} = 0.67\phi t_{bp} F_{u\_bp} = 0.67 \times 0.67 \times 20 \text{ mm} \times 450 \text{ MPa} = 4.0401 \text{ kN/mm}$$

Calculate weld metal capacity

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

$t_{col} = 6.35 \text{ mm}$ - Column thickness

$\phi = 0.67$ - Weld resistance factor

CSA S16:18 Clause 13.13.2.1(b)

$v_{r,weld}$ - Factored shear rupture strength of weld metal (CJP)

$$v_{r,weld} = 0.67\phi t_{col} X_u = 0.67 \times 0.67 \times 6.35 \text{ mm} \times 430 \text{ MPa} = 1.2257 \text{ kN/mm}$$

CSA S16:19 Clause 13.13.2.1

v_r - Governing design shear rupture strength of base metal and weld metal

$$v_r = \min\left(\mathrm{v_{r,bp}},\ \mathrm{v_{r,col}},\ \mathrm{v_{r,weld}}\right) = \min\left(4.0401 \text{ kN/mm},\ 1.2827 \text{ kN/mm},\ 1.2257 \text{ kN/mm}\right) = 1.2257 \text{ kN/mm}$$

Result:

PASS = 0.01

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{r_f}{v_r} = \frac{0.012438 \text{ kN/mm}}{1.2257 \text{ kN/mm}} = 0.010148$$

Go back to summary results table.

Check No. 2: Column Bearing Capacity

Calculate bearing load on column member

$N_x = 25 \text{ kN}$ - Compression load

B_f - Factored bearing load on steel

$$B_f = N_x = 25 \text{ kN}$$

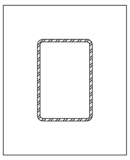


Fig. Bearing area of column.

CSA S16:19 Clause 13.10, Finished bearing plate per CSA S16.19 Clause 28.5

Calculate bearing capacity of column member

$F_{y\_col} = 350\ \mathrm{MPa}$ - Column yield stress (350W)

$A_{col} = 3610\ \mathrm{mm}^2$ - Column area

$\phi = 0.9$ - Structural steel resistance factor

B_r - Factored bearing resistance of steel

$$B_r = 1.50\phi F_{y\_col} A_{col} = 1.5 \times 0.9 \times 350\ \mathrm{MPa} \times 3610\ \mathrm{mm}^2 = 1705.7\ \mathrm{kN}$$

Result:

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{B_f}{B_r} = \frac{25\ \mathrm{kN}}{1705.7\ \mathrm{kN}} = 0.014657$$

PASS = 0.01

Go back to summary results table.

Check No. 3: Base Plate Yield Capacity (Compression Load)

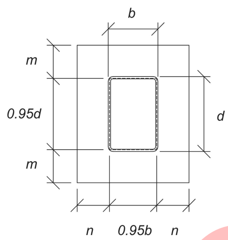


Fig. Cantilever lengths of base plate.

Calculate critical cantilever length for Rect/Square HSS column

$d_{col} = 152.4\ \mathrm{mm}$ - Column depth

$b_{col} = 152.4\ \mathrm{mm}$ - Column width

$L_{bp} = 350\ \mathrm{mm}$ - Base plate length

$B_{bp} = 350\ \mathrm{mm}$ - Base plate width

AISC Design Guide 01 3rd Ed. Section 4.3.1

l - Critical cantilever length of base plate

$$l = \max\left(\frac{\mathrm{L_{bp}} - 0.95\mathrm{d_{col}}}{2}, \frac{\mathrm{B_{bp}} - 0.95\mathrm{b_{col}}}{2}\right)$$

$$l = \max\left(\frac{350\ \mathrm{mm} - 0.95 \times 152.4\ \mathrm{mm}}{2}, \frac{350\ \mathrm{mm} - 0.95 \times 152.4\ \mathrm{mm}}{2}\right) = 102.61\ \mathrm{mm}$$

Calculate applied moment load per unit length on critical section of base plate due to compression from concrete

$N_x = 25\ \mathrm{kN}$ - Compression load

$B_{bp} = 350\ \mathrm{mm}$ - Base plate width

$L_{bp} = 350\ \mathrm{mm}$ - Base plate length

AISC Design Guide 01 3rd Ed. Section 4.3.1

$l = 102.61\ \mathrm{mm}$

AISC Design Guide 01 3rd Ed. Section 4.3.1

m_f - Factored bending load per unit length of base plate

$$m_f = \left(\frac{N_x}{B_{bp} L_{bp}}\right)\left(\frac{l^2}{2}\right)$$

$$m_f = \left(\frac{25\ \mathrm{kN}}{350\ \mathrm{mm} \times 350\ \mathrm{mm}}\right) \times \left(\frac{102.61\ \mathrm{mm}^2}{2}\right) = 1.0744\ \mathrm{kN{\cdot}mm/mm}$$

Calculate flexural yielding capacity of base plate per unit length due to compression from concrete

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

$t_{bp} = 20\ \mathrm{mm}$ - Base plate thickness

$\phi = 0.9$ - Structural steel resistance factor

CSA S16:19 Clause 13.5

m_r - Factored bending resistance of base plate per unit length

$$m_r = \phi\left(\frac{(t_{bp})^2}{4}\right) F_{y\_bp} = 0.9 \times \left(\frac{(20\ \mathrm{mm})^2}{4}\right) \times 300\ \mathrm{MPa} = 27\ \mathrm{kN{\cdot}mm/mm}$$

Result:

DCR - Demand-to-Capacity Ratio

$$DCR = \frac{m_f}{m_r} = \frac{1.0744\ \mathrm{kN{\cdot}mm/mm}}{27\ \mathrm{kN{\cdot}mm/mm}} = 0.039791$$

PASS = 0.04

Go back to summary results table.

Check No. 4: Concrete Bearing Capacity

Calculate bearing load on concrete

$N_x = 25\ \mathrm{kN}$ - Compression load

P_f - Factored bearing load on concrete

$$P_f = N_x = 25\ \mathrm{kN}$$

The restraining side is equal along the concrete width and concrete length.

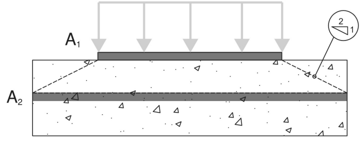


Fig. Bearing area on base plate (A1) and maximum support area on concrete (A2).

Calculate bearing area on base plate

$L_{bp} = 350\ \mathrm{mm}$ - Base plate length

$B_{bp} = 350\ \mathrm{mm}$ - Base plate width

CSA A23.3:19 Clause 10.8.1 A_1 - Area of bearing on base plate (assume full area)

$$A_1 = L_{bp}B_{bp} = 350\ \mathrm{mm} \times 350\ \mathrm{mm} = 122500\ \mathrm{mm}^2$$

Calculate maximum bearing area on concrete foundation

$N_{A2} = 450\ \mathrm{mm}$ - Length of max bearing area on support (A2)

$B_{A2} = 450\ \mathrm{mm}$ - Width of max bearing area on support (A2)

CSA A23.3:19 Clause 10.8.1 A_2 - Maximum area of bearing on concrete (assume 1:2 slope)

$$A_2 = N_{A2}B_{A2} = 450\ \mathrm{mm} \times 450\ \mathrm{mm} = 202500\ \mathrm{mm}^2$$

Calculate bearing capacity of concrete

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

CSA A23.3:19 Clause 10.8.1 $A_1 = 122500\ \mathrm{mm}^2$

CSA A23.3:19 Clause 10.8.1 $A_2 = 202500\ \mathrm{mm}^2$

$\phi = 0.65$ - Concrete resistance factor

CSA A23.3:19 Clause 28.5 P_r - Factored bearing resistance of concrete

$$P_r = 0.85\phi\left(f_c^{'}\right)A_1\left(\min\left(\sqrt{\frac{A_2}{A_1}},\ 2\right)\right)$$

$$P_r = 0.85 \times 0.65 \times (20.68\ \mathrm{MPa}) \times 122500\ \mathrm{mm}^2 \times \left(\min\left(\sqrt{\frac{202500\ \mathrm{mm}^2}{122500\ \mathrm{mm}^2}},\ 2\right)\right) = 1799.5\ \mathrm{kN}$$

Result:

PASS = 0.01

DCR - Demand-to-Capacity Ratio

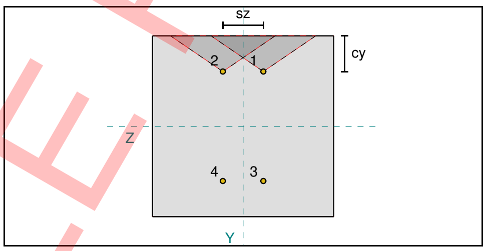
$$DCR = \frac{P_f}{P_r} = \frac{25\ \mathrm{kN}}{1799.5\ \mathrm{kN}} = 0.013892$$

Go back to summary results table.

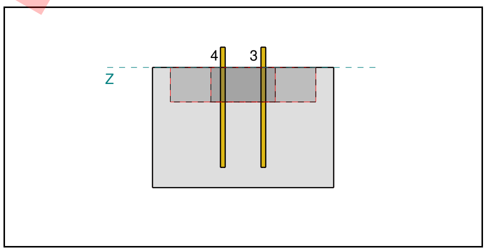
Check No. 5: Concrete Breakout Capacity (Vy Shear)

Only the anchors nearest to the failure edge are assumed to resist the shear load.

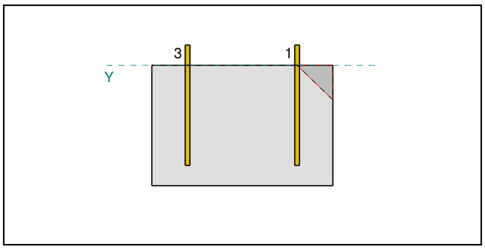
For breakout capacity on failure edge perpendicular to load:



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group. Consider one side only.

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

$n_{a,vy} = 2$ - Number of anchors resisting +Vy shear

$n_{a,g1} = 2$ - Number of anchors in anchor group BO Vy 1

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

$$V_{fa\perp} = V_y\left(\frac{n_{a,g1}}{n_{a,vy}}\right) = 5\ \mathrm{kN} \times \left(\frac{2}{2}\right) = 5\ \mathrm{kN}$$

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 Vy 1 concrete edge distance (left)	175.0 mm
$c_{right,g1}$	Anchor group BO Vy 1 concrete edge distance (right)	175.0 mm
$c_{top,g1}$	Anchor group BO Vy 1 concrete edge distance (top)	87.5 mm
$c_{bottom,g1}$	Anchor group BO Vy 1 concrete edge distance (bottom)	362.5 mm
t_{conc}	Concrete thickness	300.0 mm
s_z	Spacing of anchor rods along Z-axis	100.0 mm
$c_{a1,g1}$	Anchor group distance to failure edge (+Vy shear)	87.5 mm
	Narrow Member	FALSE

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

$c_{a1,g1} = 87.5\ \mathrm{mm}$ - Anchor group distance to failure edge (+Vy shear)

CSA A23.3:19 Equation D.34

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

$$A_{Vco} = 4.5(c_{a1,g1})^2 = 4.5 \times (87.5\ \mathrm{mm})^2 = 34453\ \mathrm{mm}^2$$

Calculate width of actual projected area on failure surface

$s_{sum,z,g1} = 100\ \mathrm{mm}$ - 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

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

$$B_{Vc} = \min\left(175\ \mathrm{mm},\ 1.5 \times 87.5\ \mathrm{mm}\right) + \left(\min\left(100\ \mathrm{mm},\ 3 \times 87.5\ \mathrm{mm} \times (2-1)\right)\right) + \min\left(175\ \mathrm{mm},\ 1.5 \times 87.5\ \mathrm{mm}\right)$$

$$B_{Vc} = 362.5\ \mathrm{mm}$$

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

$$H_{Vc} = \min\left(1.5\mathrm{c_{a1,g1}},\ \mathrm{t_{conc}}\right) = \min\left(1.5 \times 87.5\ \mathrm{mm},\ 300\ \mathrm{mm}\right) = 131.25\ \mathrm{mm}$$

Calculate actual projected area

CSA A23.3:19 Clause D.7.2.1

A_{Vc} - Actual projected area

$$A_{Vc} = B_{Vc}H_{Vc} = 362.5\ \mathrm{mm} \times 131.25\ \mathrm{mm} = 47578\ \mathrm{mm}^2$$

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

$h_{ef} = 250\ \mathrm{mm}$ - Anchor rod effective embedment length

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

l_e - Load bearing length (equal to embedment height)

$$l_e = h_{ef} = 250\ \mathrm{mm}$$

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

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

$$V_{br1} = 0.58 \times \left(\frac{\min\left(250\ \mathrm{mm},\ 8 \times 12.7\ \mathrm{mm}\right)}{12.7\ \mathrm{mm}}\right)^{0.2} \times \sqrt{\frac{12.7\ \mathrm{mm}}{1\ \mathrm{mm}}} \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{87.5\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN}$$

$$V_{br1} = 7.5796\ \mathrm{kN}$$

CSA A23.3:19 Equation D.36

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

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

$$V_{br2} = 3.75 \times 1 \times 0.65 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{87.5\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 9.0726\ \mathrm{kN}$$

CSA A23.3:19 Clause D.7.2.2

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

$$V_{br} = \min\left(\mathrm{V_{br1}},\ \mathrm{V_{br2}}\right) = \min\left(7.5796\ \mathrm{kN},\ 9.0726\ \mathrm{kN}\right) = 7.5796\ \mathrm{kN}$$

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

$$\Psi_{ec,V} = \min\left(1.0,\ \frac{1}{1+\frac{2\mathrm{e_N'}}{3\mathrm{c_{a1,g1}}}}\right) = \min\left(1,\ \frac{1}{1+\frac{2\times 0}{3\times 87.5\ \mathrm{mm}}}\right) = 1$$

Calculate edge effect factor

$c_{a2,g1} = 175\ \mathrm{mm}$ - Anchor group distance to failure edge (+Vy shear)

CSA A23.3:19 Clause D.7.2.6

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

$$\Psi_{ed,V} = \min\left(1.0,\ 0.7 + 0.3\left(\frac{\mathrm{c_{a2,g1}}}{1.5\mathrm{c_{a1,g1}}}\right)\right) = \min\left(1,\ 0.7 + 0.3 \times \left(\frac{175\ \mathrm{mm}}{1.5 \times 87.5\ \mathrm{mm}}\right)\right) = 1$$

Calculate thickness factor

CSA A23.3:19 Clause D.7.2.8

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

$$\Psi_{h,V} = \max\left(\sqrt{\frac{1.5\mathrm{c_{a1,g1}}}{\mathrm{t_{conc}}}},\ 1.0\right) = \max\left(\sqrt{\frac{1.5 \times 87.5\ \mathrm{mm}}{300\ \mathrm{mm}}},\ 1\right) = 1$$

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)

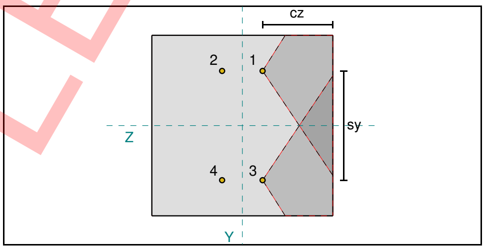
CSA A23.3:19 Clause D.7.2.1

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

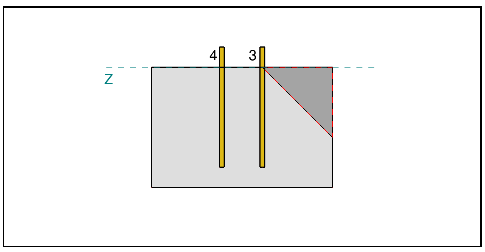
$$V_{cbg\perp} = \left(\frac{A_{Vc}}{A_{Vco}}\right)\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{br}$$

$$V_{cbg\perp} = \left(\frac{47578\ \mathrm{mm}^2}{34453\ \mathrm{mm}^2}\right) \times 1 \times 1 \times 1 \times 1 \times 7.5796\ \mathrm{kN} = 10.467\ \mathrm{kN}$$

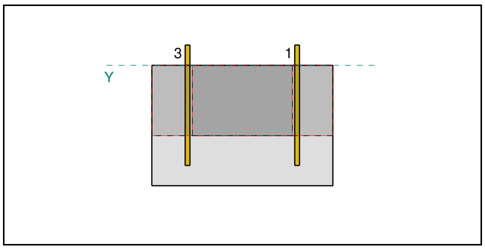
For breakout capacity on failure edge parallel to load:



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group. Consider one side only.

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

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

$n_{a,vz} = 2$ - Number of anchors resisting +Vz shear

$n_{a,g1} = 2$ - Number of anchors in anchor group BO Vz 1

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

$$V_{f\parallel} = V_y \left(\frac{n_{a,g1}}{n_{a,vz}}\right) = 5\ \mathrm{kN} \times \left(\frac{2}{2}\right) = 5\ \mathrm{kN}$$

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)	275.0 mm
$c_{right,g1}$	Anchor group BO Vz 1 concrete edge distance (right)	175.0 mm
$c_{top,g1}$	Anchor group BO Vz 1 concrete edge distance (top)	87.5 mm
$c_{bottom,g1}$	Anchor group BO Vz 1 concrete edge distance (bottom)	87.5 mm
t_{conc}	Concrete thickness	300.0 mm
s_y	Spacing of anchor rods along Y-axis	275.0 mm
$c_{a1,g1}$	Anchor group distance to failure edge (+Vz shear)	175.0 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

$c_{a1,g1} = 175\ \mathrm{mm}$ - Anchor group distance to failure edge (+Vz shear)

CSA A23.3:19 Equation D.34

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

$$A_{Vco} = 4.5(c_{a1,g1})^2 = 4.5 \times (175\ \mathrm{mm})^2 = 137810\ \mathrm{mm}^2$$

Calculate width of actual projected area on failure surface

$s_{sum,y,g1} = 275\ \mathrm{mm}$ - 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

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

$$B_{Vc} = \min(87.5\ \mathrm{mm},\ 1.5 \times 175\ \mathrm{mm}) + (\min(275\ \mathrm{mm},\ 3 \times 175\ \mathrm{mm} \times (2-1))) + \min(87.5\ \mathrm{mm},\ 1.5 \times 175\ \mathrm{mm})$$

$$B_{Vc} = 450\ \mathrm{mm}$$

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

$$H_{Vc} = \min\left(1.5\mathrm{c_{a1,g1}},\ \mathrm{t_{conc}}\right) = \min(1.5 \times 175\ \mathrm{mm},\ 300\ \mathrm{mm}) = 262.5\ \mathrm{mm}$$

Calculate actual projected area

CSA A23.3:19 Clause D.7.2.1

A_{Vc} - Actual projected area

$$A_{Vc} = B_{Vc}H_{Vc} = 450\ \mathrm{mm} \times 262.5\ \mathrm{mm} = 118130\ \mathrm{mm}^2$$

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

$h_{ef} = 250\ \mathrm{mm}$ - Anchor rod effective embedment length

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

l_e - Load bearing length (equal to embedment height)

$$l_e = h_{ef} = 250\ \mathrm{mm}$$

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

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

$$V_{br1} = 0.58 \times \left(\frac{\min\left(250\ \mathrm{mm},\ 8\times 12.7\ \mathrm{mm}\right)}{12.7\ \mathrm{mm}}\right)^{0.2} \times \sqrt{\frac{12.7\ \mathrm{mm}}{1\ \mathrm{mm}}} \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{175\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN}$$

$$V_{br1} = 21.438\ \mathrm{kN}$$

CSA A23.3:19 Equation D.36

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

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

$$V_{br2} = 3.75 \times 1 \times 0.65 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{175\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 25.661\ \mathrm{kN}$$

CSA A23.3:19 Clause D.7.2.2

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

$$V_{br} = \min\left(\mathrm{V_{br1}},\ \mathrm{V_{br2}}\right) = \min\left(21.438\ \mathrm{kN},\ 25.661\ \mathrm{kN}\right) = 21.438\ \mathrm{kN}$$

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

$$\Psi_{ec,V} = \min\left(1.0,\ \frac{1}{1+\frac{2e_N'}{3c_{a1,g1}}}\right) = \min\left(1,\ \frac{1}{1+\frac{2\times 0}{3\times 175\ \mathrm{mm}}}\right) = 1$$

Calculate thickness factor

CSA A23.3:19 Clause D.7.2.8

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

$$\Psi_{h,V} = \max\left(\sqrt{\frac{1.5\mathrm{c_{a1,g1}}}{\mathrm{t_{conc}}}},\ 1.0\right) = \max\left(\sqrt{\frac{1.5\times 175\ \mathrm{mm}}{300\ \mathrm{mm}}},\ 1\right) = 1$$

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)

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

$$V_{cbgr\parallel} = 2 \times \left(\frac{118130\ \mathrm{mm}^2}{137810\ \mathrm{mm}^2}\right) \times 1 \times 1 \times 1 \times 1 \times 21.438\ \mathrm{kN} = 36.752\ \mathrm{kN}$$

Result:

DCR - Demand over capacity ratio, comparing two conditions:

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

$$DCR = \max\left(\frac{5\ \mathrm{kN}}{10.467\ \mathrm{kN}},\ \frac{5\ \mathrm{kN}}{36.752\ \mathrm{kN}}\right) = 0.47769$$

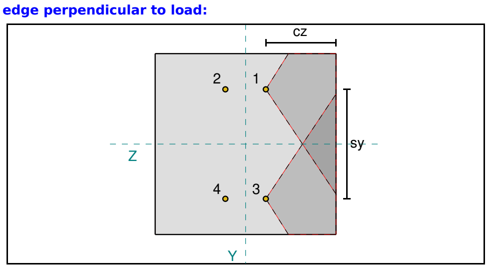
PASS = 0.48

Go back to summary results table.

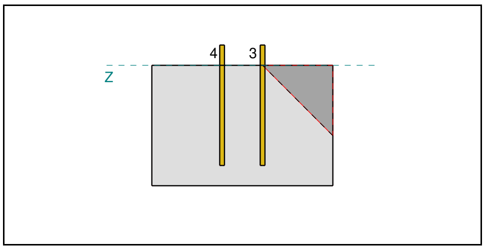
Check No. 6: Concrete Breakout Capacity (Vz Shear)

Only the anchors nearest to the failure edge are assumed to resist the shear load.

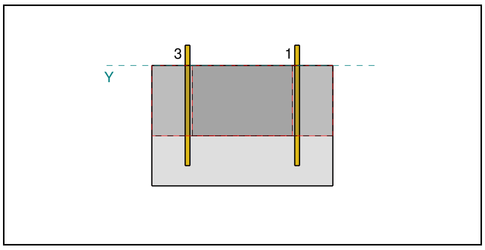
For breakout capacity on failure edge perpendicular to load:



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group. Consider one side only.

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

$n_{a,vz} = 2$ - Number of anchors resisting +Vz shear

$n_{a,g1} = 2$ - Number of anchors in anchor group BO Vz 1

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

$$V_{fa\perp} = V_z\left(\frac{n_{a,g1}}{n_{a,vz}}\right) = 5\ \text{kN} \times \left(\frac{2}{2}\right) = 5\ \text{kN}$$

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)	275.0 mm
$c_{right,g1}$	Anchor group BO Vz 1 concrete edge distance (right)	175.0 mm
$c_{top,g1}$	Anchor group BO Vz 1 concrete edge distance (top)	87.5 mm
$c_{bottom,g1}$	Anchor group BO Vz 1 concrete edge distance (bottom)	87.5 mm
t_{conc}	Concrete thickness	300.0 mm
s_y	Spacing of anchor rods along Y-axis	275.0 mm
$c_{a1,g1}$	Anchor group distance to failure edge (+Vz shear)	175.0 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

$c_{a1,g1} = 175\ \text{mm}$ - Anchor group distance to failure edge (+Vz shear)

CSA A23.3:19 Equation D.34

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

$$A_{Vco} = 4.5(c_{a1,g1})^2 = 4.5 \times (175\ \text{mm})^2 = 137810\ \text{mm}^2$$

Calculate width of actual projected area on failure surface

$s_{sum,y,g1} = 275\ \text{mm}$ - 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

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

$$B_{Vc} = \min(87.5\ \text{mm},\ 1.5 \times 175\ \text{mm}) + (\min(275\ \text{mm},\ 3 \times 175\ \text{mm} \times (2-1))) + \min(87.5\ \text{mm},\ 1.5 \times 175\ \text{mm})$$

$$B_{Vc} = 450\ \text{mm}$$

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

$$H_{Vc} = \min(1.5\mathrm{c_{a1,g1}},\ \mathrm{t_{conc}}) = \min(1.5 \times 175\ \text{mm},\ 300\ \text{mm}) = 262.5\ \text{mm}$$

Calculate actual projected area

CSA A23.3:19 Clause D.7.2.1

A_{Vc} - Actual projected area

$$A_{Vc} = B_{Vc}H_{Vc} = 450\ \text{mm} \times 262.5\ \text{mm} = 118130\ \text{mm}^2$$

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

$h_{ef} = 250\ \mathrm{mm}$ - Anchor rod effective embedment length

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

l_e - Load bearing length (equal to embedment height)

$$l_e = h_{ef} = 250\ \mathrm{mm}$$

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

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

$$V_{br1} = 0.58 \times \left(\frac{\min(250\ \mathrm{mm},\ 8 \times 12.7\ \mathrm{mm})}{12.7\ \mathrm{mm}}\right)^{0.2} \times \sqrt{\frac{12.7\ \mathrm{mm}}{1\ \mathrm{mm}}} \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{175\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN}$$

$$V_{br1} = 21.438\ \mathrm{kN}$$

CSA A23.3:19 Equation D.36

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

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

$$V_{br2} = 3.75 \times 1 \times 0.65 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{175\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 25.661\ \mathrm{kN}$$

CSA A23.3:19 Clause D.7.2.2

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

$$V_{br} = \min(\mathrm{V_{br1}},\ \mathrm{V_{br2}}) = \min(21.438\ \mathrm{kN},\ 25.661\ \mathrm{kN}) = 21.438\ \mathrm{kN}$$

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

$$\Psi_{ec,V} = \min\left(1.0,\ \frac{1}{1 + \frac{2e_N'}{3c_{a1,g1}}}\right) = \min\left(1,\ \frac{1}{1 + \frac{2\times 0}{3\times 175\ \mathrm{mm}}}\right) = 1$$

Calculate edge effect factor

$c_{a2,g1} = 87.5\ \mathrm{mm}$ - Anchor group distance to failure edge (+Vz shear)

CSA A23.3:19 Clause D.7.2.6

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

$$\Psi_{ed,V} = \min\left(1.0,\ 0.7 + 0.3\left(\frac{\mathrm{c_{a2,g1}}}{1.5\mathrm{c_{a1,g1}}}\right)\right) = \min\left(1,\ 0.7 + 0.3 \times \left(\frac{87.5\ \mathrm{mm}}{1.5 \times 175\ \mathrm{mm}}\right)\right) = 0.8$$

Calculate thickness factor

CSA A23.3:19 Clause D.7.2.8

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

$$\Psi_{h,V} = \max\left(\sqrt{\frac{1.5\mathrm{c_{a1,g1}}}{\mathrm{t_{conc}}}},\ 1.0\right) = \max\left(\sqrt{\frac{1.5 \times 175\ \mathrm{mm}}{300\ \mathrm{mm}}},\ 1\right) = 1$$

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)

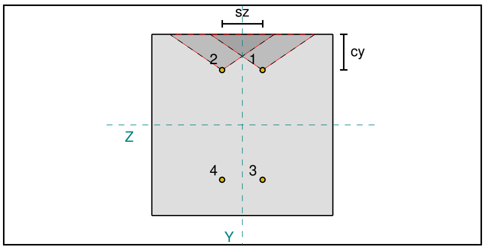
CSA A23.3:19 Clause D.7.2.1

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

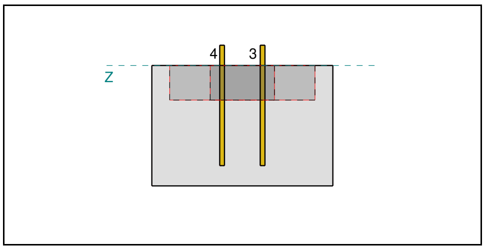
$$V_{cbg\perp} = \left(\frac{A_{Vc}}{A_{Vco}}\right)\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{br}$$

$$V_{cbg\perp} = \left(\frac{118130\ \mathrm{mm}^2}{137810\ \mathrm{mm}^2}\right) \times 1 \times 0.8 \times 1 \times 1 \times 21.438\ \mathrm{kN} = 14.701\ \mathrm{kN}$$

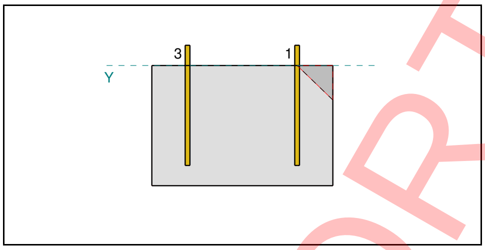
For breakout capacity on failure edge parallel to load:



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group. Consider one side only.

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

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

$n_{a,vy} = 2$ - Number of anchors resisting +Vy shear

$n_{a,g1} = 2$ - Number of anchors in anchor group BO Vy 1

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

$$V_{f a\|} = V_z \left(\frac{n_{a,g1}}{n_{a,vy}}\right) = 5\ \mathrm{kN} \times \left(\frac{2}{2}\right) = 5\ \mathrm{kN}$$

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 Vy 1 concrete edge distance (left)	175.0 mm
$c_{right,g1}$	Anchor group BO Vy 1 concrete edge distance (right)	175.0 mm
$c_{top,g1}$	Anchor group BO Vy 1 concrete edge distance (top)	87.5 mm
$c_{bottom,g1}$	Anchor group BO Vy 1 concrete edge distance (bottom)	362.5 mm
t_{conc}	Concrete thickness	300.0 mm
s_z	Spacing of anchor rods along Z-axis	100.0 mm
$c_{a1,g1}$	Anchor group distance to failure edge (+Vy shear)	87.5 mm
	Narrow Member	FALSE

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

$c_{a1,g1} = 87.5\ \mathrm{mm}$ - Anchor group distance to failure edge (+Vy shear)

CSA A23.3:19 Equation D.34

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

$$A_{Vco} = 4.5(c_{a1,g1})^2 = 4.5 \times (87.5\ \mathrm{mm})^2 = 34453\ \mathrm{mm}^2$$

Calculate width of actual projected area on failure surface

$s_{sum,z,g1} = 100\ \mathrm{mm}$ - 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

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

$$B_{Vc} = \min\left(175\ \mathrm{mm},\ 1.5 \times 87.5\ \mathrm{mm}\right) + \left(\min\left(100\ \mathrm{mm},\ 3 \times 87.5\ \mathrm{mm} \times (2 - 1)\right)\right) + \min\left(175\ \mathrm{mm},\ 1.5 \times 87.5\ \mathrm{mm}\right)$$

$$B_{Vc} = 362.5\ \mathrm{mm}$$

CSA A23.3:19 Clause D.7.2.1

Calculate height of actual projected area on failure surface

H_{Vc} - Actual height of projected area

$$H_{Vc} = \min\left(1.5\mathrm{c_{a1,g1}},\ \mathrm{t_{conc}}\right) = \min\left(1.5 \times 87.5\ \mathrm{mm},\ 300\ \mathrm{mm}\right) = 131.25\ \mathrm{mm}$$

CSA A23.3:19 Clause D.7.2.1

Calculate actual projected area

A_{Vc} - Actual projected area

$$A_{Vc} = B_{Vc}H_{Vc} = 362.5\ \mathrm{mm} \times 131.25\ \mathrm{mm} = 47578\ \mathrm{mm}^2$$

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

$h_{ef} = 250\ \mathrm{mm}$ - Anchor rod effective embedment length

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

l_e - Load bearing length (equal to embedment height)

$$l_e = h_{ef} = 250\ \mathrm{mm}$$

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

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

$$V_{br1} = 0.58 \times \left(\frac{\min\left(250\ \mathrm{mm},\ 8 \times 12.7\ \mathrm{mm}\right)}{12.7\ \mathrm{mm}}\right)^{0.2} \times \sqrt{\frac{12.7\ \mathrm{mm}}{1\ \mathrm{mm}}} \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{87.5\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN}$$

$$V_{br1} = 7.5796\ \mathrm{kN}$$

CSA A23.3:19 Equation D.36

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

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

$$V_{br2} = 3.75 \times 1 \times 0.65 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{87.5\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 9.0726\ \mathrm{kN}$$

CSA A23.3:19 Clause D.7.2.2

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

$$V_{br} = \min\left(\mathrm{V_{br1}},\ \mathrm{V_{br2}}\right) = \min\left(7.5796\ \mathrm{kN},\ 9.0726\ \mathrm{kN}\right) = 7.5796\ \mathrm{kN}$$

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

$$\Psi_{ec,V} = \min\left(1.0,\ \frac{1}{1 + \frac{2e_N'}{3c_{a1,g1}}}\right) = \min\left(1,\ \frac{1}{1 + \frac{2\times0}{3\times87.5\ \mathrm{mm}}}\right) = 1$$

Calculate thickness factor

CSA A23.3:19 Clause D.7.2.8

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

$$\Psi_{h,V} = \max\left(\sqrt{\frac{1.5\mathrm{c_{a1,g1}}}{\mathrm{t_{conc}}}},\ 1.0\right) = \max\left(\sqrt{\frac{1.5 \times 87.5\ \mathrm{mm}}{300\ \mathrm{mm}}},\ 1\right) = 1$$

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)

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

$$V_{cbgr\parallel} = 2 \times \left(\frac{47578\ \mathrm{mm}^2}{34453\ \mathrm{mm}^2}\right) \times 1 \times 1 \times 1 \times 1 \times 7.5796\ \mathrm{kN} = 20.934\ \mathrm{kN}$$

Result:

PASS = 0.34

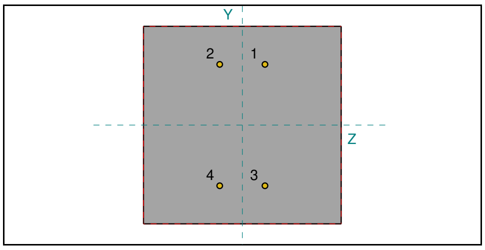
DCR - Demand over capacity ratio, comparing two conditions:

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

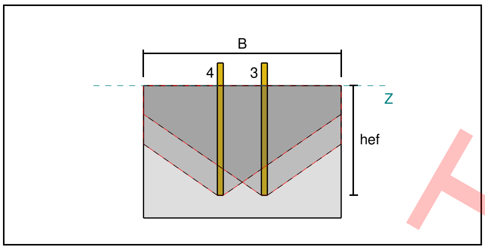
$$DCR = \max\left(\frac{5\ \text{kN}}{14.701\ \text{kN}}, \frac{5\ \text{kN}}{20.934\ \text{kN}}\right) = 0.34012$$

Go back to summary results table.

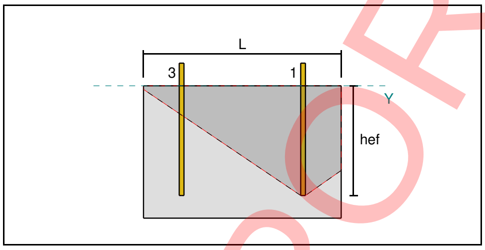
Check No. 7: Concrete Pryout Capacity (Vy Shear)



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group due to Vy shear

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

$n_{a,vy} = 2$ - Number of anchors resisting +Vy shear

$n_{a,g1} = 2$ - Number of anchors in anchor group PO Vy 1

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

$$V_{fa} = \left(\frac{V_y}{n_{a,vy}}\right) n_{a,g1} = \left(\frac{5\ \text{kN}}{2}\right) \times 2 = 5\ \text{kN}$$

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 Vy 1 concrete edge distance (left)	175.0 mm
$c_{right,g1}$	Anchor group PO Vy 1 concrete edge distance (right)	175.0 mm
$c_{top,g1}$	Anchor group PO Vy 1 concrete edge distance (top)	87.5 mm
$c_{bottom,g1}$	Anchor group PO Vy 1 concrete edge distance (bottom)	362.5 mm
h_{ef}	Anchor rod effective embedment length	250.0 mm
$s_{sum,y,g1}$	Anchor group PO Vy 1 sum of spacing along Y-axis	0.0 mm
$s_{sum,z,g1}$	Anchor group PO Vy 1 sum of spacing along Z-axis	100.0 mm
$n_{y,g1}$	Number of anchors along Y-axis for anchor group PO Vy 1	1.0
$n_{z,g1}$	Number of anchors along Z-axis for anchor group PO Vy 1	2.0
	Narrow Member	TRUE
$h'_{ef,g1}$	Anchor group PO Vy 1 modified effective embedment length	241.7 mm

Calculation for critical anchor group: Anchor Group PO Vy 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

$$A_{Nco} = 9\left(h'_{ef,g1}\right)^2 = 9 \times (241.67\ \text{mm})^2 = 525630\ \text{mm}^2$$

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

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

Equivalent to half anchor diameter plus thickness of embed plate

$s_{sum,z,g1} = 100\ \text{mm}$ - Anchor group PO Vy 1 sum of spacing along Z-axis

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

CSA A23.3:19 Clause D.6.2.1

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

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

$$L_{Nc} = \min\left(175\ \mathrm{mm},\ 1.5 \times 241.67\ \mathrm{mm}\right) + \left(\min\left(100\ \mathrm{mm},\ 3 \times 241.67\ \mathrm{mm} \times (2-1)\right)\right) + \min\left(175\ \mathrm{mm},\ 1.5 \times 241.67\ \mathrm{mm}\right)$$

$$L_{Nc} = 450\ \mathrm{mm}$$

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

$s_{sum,y,g1} = 0\ \mathrm{mm}$ - Anchor group PO Vy 1 sum of spacing along Y-axis

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

CSA A23.3:19 Clause D.6.2.1

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

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

$$B_{Nc} = \min\left(87.5\ \mathrm{mm},\ 1.5 \times 241.67\ \mathrm{mm}\right) + \left(\min\left(0\ \mathrm{mm},\ 3 \times 241.67\ \mathrm{mm} \times (1-1)\right)\right) + \min\left(362.5\ \mathrm{mm},\ 1.5 \times 241.67\ \mathrm{mm}\right)$$

$$B_{Nc} = 450\ \mathrm{mm}$$

Calculate actual projected area of the anchor group

$n_{a,g1} = 2$ - Number of anchors in anchor group PO Vy 1

CSA A23.3:19 Clause D.6.2.1

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

$$A_{Nc} = \min\left(\mathrm{n_{a,g1}A_{Nco}},\ \mathrm{L_{Nc}B_{Nc}}\right) = \min\left(2 \times 525630\ \mathrm{mm}^2,\ 450\ \mathrm{mm} \times 450\ \mathrm{mm}\right) = 202500\ \mathrm{mm}^2$$

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

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

$$N_{br} = 10 \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{241.67\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 111.05\ \mathrm{kN}$$

Calculate minimum edge distance of anchor

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

$$c_{a,min} = \min\left(\mathrm{c_{left,g1}},\ \mathrm{c_{right,g1}},\ \mathrm{c_{top,g1}},\ \mathrm{c_{bottom,g1}}\right) = \min\left(175\ \mathrm{mm},\ 175\ \mathrm{mm},\ 87.5\ \mathrm{mm},\ 362.5\ \mathrm{mm}\right) = 87.5\ \mathrm{mm}$$

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

$$\Psi_{ec,N} = \min\left(1.0,\ \frac{1}{1 + \frac{2\mathrm{e'_N}}{3\mathrm{h'_{ef,g1}}}}\right) = \min\left(1,\ \frac{1}{1 + \frac{2 \times 0}{3 \times 241.67\ \mathrm{mm}}}\right) = 1$$

Calculate edge effect factor

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

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

$$\Psi_{ed,N} = \min\left(1.0,\ 0.7 + 0.3\left(\frac{\mathrm{c_{a,min}}}{1.5\mathrm{h'_{ef,g1}}}\right)\right) = \min\left(1,\ 0.7 + 0.3 \times \left(\frac{87.5\ \mathrm{mm}}{1.5 \times 241.67\ \mathrm{mm}}\right)\right) = 0.77241$$

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

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

$$N_{cbr} = \left(\frac{202500\ \mathrm{mm}^2}{525630\ \mathrm{mm}^2}\right) \times 1 \times 0.77241 \times 1 \times 1 \times 111.05\ \mathrm{kN} = 33.046\ \mathrm{kN}$$

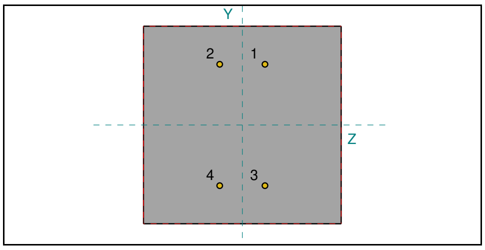
Calculate factored concrete pryout capacity

CSA A23.3:19 Clause D.7.3

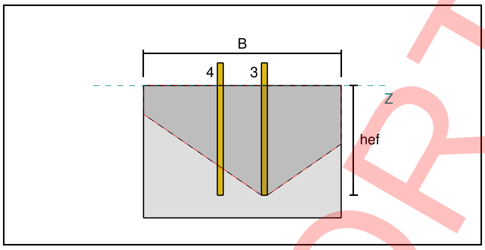
$k_{cp} = 2$ - Factor for pryout strength

CSA A23.3:19 Clause D.7.3	V_{cpgr} - Factored concrete pryout strength of an anchor group $$V_{cpgr} = k_{cp} N_{cbr} = 2 \times 33.046 \text{ kN} = 66.091 \text{ kN}$$ **Result:** DCR - Demand-to-Capacity Ratio $$DCR = \frac{V_{fa}}{V_{cpgr}} = \frac{5 \text{ kN}}{66.091 \text{ kN}} = 0.075653$$	**PASS = 0.08** Go back to summary results table.

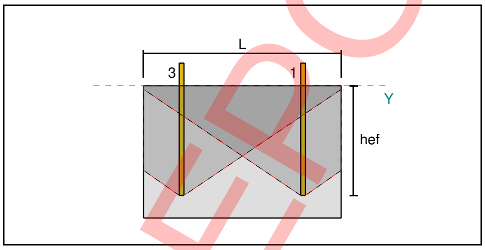
Check No. 8: Concrete Pryout Capacity (Vz Shear)



PLAN VIEW



FRONT VIEW



SIDE VIEW

Calculate total shear load on anchor group due to Vz shear

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

$n_{a,vz} = 2$ - Number of anchors resisting +Vz shear

$n_{a,g1} = 2$ - Number of anchors in anchor group PO Vz 1

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

$$V_{fa} = \left(\frac{V_z}{n_{a,vz}}\right) n_{a,g1} = \left(\frac{5 \text{ kN}}{2}\right) \times 2 = 5 \text{ kN}$$

CSA A23.3:19 Clause D.6.2.3

Determine if the support is a narrow concrete member

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 Vz 1 concrete edge distance (left)	275.0 mm
$c_{right,g1}$	Anchor group PO Vz 1 concrete edge distance (right)	175.0 mm
$c_{top,g1}$	Anchor group PO Vz 1 concrete edge distance (top)	87.5 mm
$c_{bottom,g1}$	Anchor group PO Vz 1 concrete edge distance (bottom)	87.5 mm
h_{ef}	Anchor rod effective embedment length	250.0 mm
$s_{sum,y,g1}$	Anchor group PO Vz 1 sum of spacing along Y-axis	275.0 mm
$s_{sum,z,g1}$	Anchor group PO Vz 1 sum of spacing along Z-axis	0.0 mm
$n_{y,g1}$	Number of anchors along Y-axis for anchor group PO Vz 1	2.0
$n_{z,g1}$	Number of anchors along Z-axis for anchor group PO Vz 1	1.0
	Narrow Member	TRUE
$h'_{ef,g1}$	Anchor group PO Vz 1 modified effective embedment length	183.3 mm

Calculation for critical anchor group: Anchor Group

SkyCiv

BO Vz 1.

CSA A23.3:19 Eq. D.5

Calculate maximum projected area for a single anchor

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

$$A_{Nco} = 9\left(h'_{ef,g1}\right)^2 = 9 \times (183.33\ \mathrm{mm})^2 = 302500\ \mathrm{mm}^2$$

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

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

Equivalent to half anchor diameter plus thickness of embed plate

$s_{sum,z,g1} = 0\ \mathrm{mm}$ - Anchor group PO Vz 1 sum of spacing along Z-axis

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

CSA A23.3:19 Clause D.6.2.1

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

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

$$L_{Nc} = \min(275\ \mathrm{mm},\ 1.5 \times 183.33\ \mathrm{mm}) + (\min(0\ \mathrm{mm},\ 3 \times 183.33\ \mathrm{mm} \times (1-1))) + \min(175\ \mathrm{mm},\ 1.5 \times 183.33\ \mathrm{mm})$$

$$L_{Nc} = 450\ \mathrm{mm}$$

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

$s_{sum,y,g1} = 275\ \mathrm{mm}$ - Anchor group PO Vz 1 sum of spacing along Y-axis

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

CSA A23.3:19 Clause D.6.2.1

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

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

$$B_{Nc} = \min(87.5\ \mathrm{mm},\ 1.5 \times 183.33\ \mathrm{mm}) + (\min(275\ \mathrm{mm},\ 3 \times 183.33\ \mathrm{mm} \times (2-1))) + \min(87.5\ \mathrm{mm},\ 1.5 \times 183.33\ \mathrm{mm})$$

$$B_{Nc} = 450\ \mathrm{mm}$$

Calculate actual projected area of the anchor group

$n_{a,g1} = 2$ - Number of anchors in anchor group PO Vz 1

CSA A23.3:19 Clause D.6.2.1

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

$$A_{Nc} = \min\left(\mathrm{n_{a,g1}A_{Nco}},\ \mathrm{L_{Nc}B_{Nc}}\right) = \min\left(2 \times 302500\ \mathrm{mm}^2,\ 450\ \mathrm{mm} \times 450\ \mathrm{mm}\right) = 202500\ \mathrm{mm}^2$$

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

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

$$N_{br} = 10 \times 0.65 \times 1 \times \sqrt{\frac{20.68\ \mathrm{MPa}}{1\ \mathrm{MPa}}} \times \left(\frac{183.33\ \mathrm{mm}}{1\ \mathrm{mm}}\right)^{1.5} \times 1 \times 0.001\ \mathrm{kN} = 73.375\ \mathrm{kN}$$

Calculate minimum edge distance of anchor

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

$$c_{a,min} = \min\left(\mathrm{c_{left,g1}},\ \mathrm{c_{right,g1}},\ \mathrm{c_{top,g1}},\ \mathrm{c_{bottom,g1}}\right) = \min(275\ \mathrm{mm},\ 175\ \mathrm{mm},\ 87.5\ \mathrm{mm},\ 87.5\ \mathrm{mm}) = 87.5\ \mathrm{mm}$$

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

$$\Psi_{ec,N} = \min\left(1.0,\ \frac{1}{1 + \frac{2e'_N}{3h'_{ef,g1}}}\right) = \min\left(1,\ \frac{1}{1 + \frac{2 \times 0}{3 \times 183.33\ \mathrm{mm}}}\right) = 1$$

Calculate edge effect factor

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

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

$$\Psi_{ed,N} = \min\left(1.0,\ 0.7 + 0.3\left(\frac{\mathrm{c_{a,min}}}{1.5\mathrm{h'_{ef,g1}}}\right)\right) = \min\left(1,\ 0.7 + 0.3 \times \left(\frac{87.5\ \mathrm{mm}}{1.5 \times 183.33\ \mathrm{mm}}\right)\right) = 0.79545$$

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 $$N_{cbr} = \left(\frac{A_{Nc}}{A_{Nco}}\right)\Psi_{ec,N}\Psi_{ed,N}\Psi_{c,N}\Psi_{cp,N}N_{br}$$ $$N_{cbr} = \left(\frac{202500\ \mathrm{mm}^2}{302500\ \mathrm{mm}^2}\right) \times 1 \times 0.79545 \times 1 \times 1 \times 73.375\ \mathrm{kN} = 39.072\ \mathrm{kN}$$	
	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 $$V_{cpgr} = k_{cp}N_{cbr} = 2 \times 39.072\ \mathrm{kN} = 78.144\ \mathrm{kN}$$	
	Result: DCR - Demand-to-Capacity Ratio $$DCR = \frac{V_{fa}}{V_{cpr}} = \frac{5\ \mathrm{kN}}{78.144\ \mathrm{kN}} = 0.063984$$	**PASS = 0.06** Go back to summary results table.
	Check No. 9: Anchor Rod Shear Capacity **Calculate shear load on most critical anchor (corner anchor)** $V_y = 5\ \mathrm{kN}$ - Vy shear load $n_{a,vy} = 2$ - Number of anchors resisting +Vy shear $V_z = 5\ \mathrm{kN}$ - Vz shear load $n_{a,vz} = 2$ - Number of anchors resisting +Vz shear V_{fa} - Required shear strength on anchor $$V_{fa} = \sqrt{\left(\left(\frac{V_y}{n_{a,vy}}\right)^2\right) + \left(\left(\frac{V_z}{n_{a,vz}}\right)^2\right)}$$ $$V_{fa} = \sqrt{\left(\left(\frac{5\ \mathrm{kN}}{2}\right)^2\right) + \left(\left(\frac{5\ \mathrm{kN}}{2}\right)^2\right)} = 3.5355\ \mathrm{kN}$$	
	Calculations according to CSA A23.3:19 provisions: **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.7.1.2(b)	f_{uta} - Specified tensile strength of anchor steel $$f_{uta} = \min\left(\mathrm{F_{u\_anc}},\ 1.9\mathrm{F_{y\_anc}},\ 860\right) = \min\left(400\ \mathrm{MPa},\ 1.9 \times 248.2\ \mathrm{MPa},\ 860.00\ \mathrm{MPa}\right) = 400\ \mathrm{MPa}$$	
	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	$A_{se,V} = 92\ \mathrm{mm}^2$ - 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 $$V_{sar,A23} = A_{se,V}\phi_s 0.6 f_{uta}R = 92\ \mathrm{mm}^2 \times 0.85 \times 0.6 \times 400\ \mathrm{MPa} \times 0.75 = 14.072\ \mathrm{kN}$$	
	Calculations according to CSA S16:19 provisions: **Calculate factored shear strength of the anchor rod per CSA S16:19 provisions**	
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 $m = 1$ - Number of shear planes	
CSA S16:19 Clause 25.3.3.3	$V_{r,s16}$ - Factored anchor rod shear strength per CSA S16 $$V_{r,s16} = 0.7\phi_{ar}0.6mA_{ar}F_{u\_anc} = 0.7 \times 0.67 \times 0.6 \times 1 \times 126.68\ \mathrm{mm}^2 \times 400\ \mathrm{MPa} = 14.255\ \mathrm{kN}$$	
	Result: DCR - Demand over capacity ratio, comparing two conditions: $$DCR = \max\left(\frac{\mathrm{V_{fa}}}{\mathrm{V_{sar,A23}}}, \frac{\mathrm{V_{fa}}}{\mathrm{V_{r,s16}}}\right) = \max\left(\frac{3.5355\ \mathrm{kN}}{14.072\ \mathrm{kN}}, \frac{3.5355\ \mathrm{kN}}{14.255\ \mathrm{kN}}\right) = 0.25124$$	**PASS = 0.25** Go back to summary results table.