CHECK FOR ANCHOR BOLTS:

1 Strength of Anchor Bolt under tension(Pulling force)

Strength reduction factor (ϕ)	=	0.7	ACI 318-14 – 17.3.3	
Tensile Area of Bolt	=	0.7854*(28-(0.9743/40))^2	489.92 mm^2	
Fu	=	420 N/mm^2		
Pullout strength = ϕ x At x fu	=	0.7 x 489.919 x 420 / 1000	= 144.0362 kN	
Tension Force from structure			= 93.831 kN	Hence Safe

$$At = 0.7854 * [d - (0.9743 / n)]^2,$$

Steel strength of anchor in tension

Steel strength of anchor in tension is determined according to ACI 318-14 – 17.4.1 as

$\phi N_{sa} = \phi A_{se,N} f_{uta}$

where:

- ϕ = 0.7 – strength reduction factor for anchors in tension according to ACI 318-14 – 17.3.3, the factor is editable in Code setup
- $A_{se,N}$ – tensile stress area
- f_{uta} – specified tensile strength of anchor steel and shall not be greater than 1.9 f_{ya} and 125 ksi

Concrete pullout strength of an anchor is defined in ACI 318-14 – 17.4.3 as

$\phi N_{pn} = \phi \Psi_{c,P} N_p$

where:

- ϕ = 0.7 – strength reduction factor for anchors in tension according to ACI 318-14 – 17.3.3, editable in Code setup
- $\Psi_{c,P}$ – modification factor for concrete condition; $\Psi_{c,P}$ = 1.0 for cracked concrete, $\Psi_{c,P}$ = 1.4 for non-cracked concrete
- $N_P = 8 A_{brg} f'_c$ for headed anchor
- A_{brg} – bearing area of the head of stud or anchor bolt
- f'_c – concrete compressive strength

Concrete pullout strength for other types of anchors than headed is not evaluated in the software and has to be specified by the manufacturer.

2 Check for Concrete Pullout Strength

Strength reduction factor (ϕ)	=	0.7	ACI 318-14 – 17.4.3	
Modification Factor (Ψ)	=	1.0		
Pullout strength = 8 x Abr x f'c	=	8*((PI()/4)*25^2)*30	= 147.7805 kN	
Tension Force from structure			= 93.831 kN	Hence Safe

3 Embedment Length

Minimum embedment length for lug	=	$12d\sqrt{\frac{F_u}{58\psi}}$	
Dia of Anchor Bolt provided	=	25 mm	
Required embedment length for lug	=	12*25*SQRT((30*0.9)/58*0.5)	
	=	145 mm	
Provided embedment length for lug	=	500 mm	
		Hence Safe	

4 Check for Concrete Break out test:

Provided embedment depth	=	500 mm		
Embedment Length	=	1.5 x hef =	750 mm	
$A_{Nco} = 9 h_{ef}^2$	=	5062500	mm^2	
A_{Nc} = $A=\pi r l + \pi r^2$	=	1180000	mm^2	
k_c	=	16		
f'_c	=	30 N/mm^2		
λ_a	=	0.65		
h_{ef}	=	500 mm		
$N_b = 16\lambda_a \sqrt{f'_c}\, h_{ef}^{5/3}$	=	1185.6	kN	
	=	93.8	kN	Hence Safe

$N_b = k_c \lambda_a \sqrt{f'_c}\, h_{ef}^{1.5}$

Group Anchor Bolt check for Tension:

Base Plate size = L = 250 mm B = 250 mm

Angle on Base plate = 65 x 65 x 8 mm

Thickness of Base Plate = t = 20 mm

Dia of Achor Bolt = 25 mm

Dia of Bolt Hole = 28 mm

Base plate Edge distance to centre of bolt hole = 50 mm

Distance c/c of Bolt = 150 mm

Diagonal distance c/c of Bolt = 212 mm

CG of Plate for top view = 125 mm

No of Bolts = 4 nos

Max.Tension in the support structure = 93.8 kN

Tension taken per bolt = 23.5 kN

Effective Embedment Depth (h_{ef}) = 300 ~ 350 mm (As per PIP STE05121. Table-1)

Max.c/c distance between the Bolts (s_1) = 212 mm

Offset of concrete from base plate = 125 mm

Distance b/w centre of bolt to concrete edge (C_{a1}) = 175 mm

1.5 x h_{ef} = 525 mm

Check for C_{a1} & s_1:

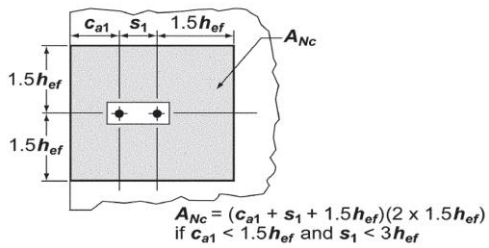
a)	$C_{a1} < 1.5 \times h_{ef}$	=	175 mm	<	525 mm	SAFE
b)	$s_1 < 3.0 \times h_{ef}$	=	212 mm	<	1050 mm	SAFE

Calculation of A_{Nc} Projected concrete failure area of group anchors

A_{Nc} = $(C_{a1} + s_1 + 1.5h_{ef}) \times (2 \times 1.5h_{ef})$

= (175+212+525) x (2 x 525)

= 957738.6 mm^2



A_{Nco} = $9.0 \times h_{ef}^2$

= 9.0 x 525 x 525

= 2480625.0 mm^2

Check

A_{Nc} shall not exceed nA_{Nco} Cl.17.4.2.1 (ACI-318-14)

n A_{Nco} = 2 x 2480625 n = 4

4961250 mm^2

A_{Nc} < A_{Nco} SAFE

Check

h_{ef} Shall be more than 11 inches and less than 25 inches Cl.17.4.2.2 (ACI 318-14)

11 inch < 13.78 inch < 25 inch

279 mm < 350 mm < 635 mm SAFE

The basic concrete breakout strength in tension in cracked concrete, N_b

$$N_b = k_c \lambda_a \sqrt{f_c'}\, h_{ef}^{1.5}$$ = 24 x 1 x SQRT(27.5) x 350^1.5 Cl.17.4.2.2 (ACI-318-14)

k_c = 24 = 824.10 kN

λ_a = 1.0

f'_c = 27.5 N/mm^2

h_{ef} = 350 mm

The nominal concrete breakout strength in tension, N_{cbg} of a group of anchors

$$N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b$$

ACI 318-14 Cl.17.4.2.1

$\Psi_{ec,N}$ = 1 $\Psi_{c,N}$ = 1.25

Eccentricity = 0 mm

1/1+((2*0)/(3*350))

A_{Nc} = 957738.6 mm^2

A_{Nco} = 2480625.0 mm^2

N_b = 824.1 kN

$\Psi_{ed,N}$ = 0.8 $\Psi_{cp,N}$ = 0.9

$C_{a1} < 1.5 \times h_{ef}$

175 mm < 525 mm

0.7+(0.3*(175/525))

N_{cbg} = 286.357166 kN

Steel Strength of Anchor in Shear :

A_{seV} = $A_{se,V} = \frac{\pi}{4}\left(d_a - \frac{0.9743}{n_t}\right)^2$ = 489 mm^2

f_{uta} = 500 N/mm^2

Vsa = $V_{sa} = 0.6 A_{se,V} f_{uta}$ = 245 kN **SAFE**

$N_{sa} = A_{se,N} f_{uta}$ (17.4.1.2)

Group Anchor Bolt check for Shear:

Projected concrete failure area of group of anchors A_{Vc}

$A_{vc} = 2(1.5c_{a1})h_a$ = 2*(1.5*175)*20
= 10500 mm^2

C_{a1} = 175 mm

h_a = 20 mm

$A_{Vco} = 2(1.5c_{a1}) \times (1.5c_{a1})$
$= 4.5c_{a1}^2$

C_{a1} = 175 mm = 4.5*175^2
= 1E+05 mm^2

Check $\ell_e \leq 8d_a$

8.0 x d_a = 200 mm

h_{ef} = 350 mm

ℓ_e = min of 8.0 x da & hef = MIN(200,350)
= 200 mm

$V_b = \left(7\left(\frac{\ell_e}{d_a}\right)^{0.2}\sqrt{d_a}\right)\lambda_a\sqrt{f'_c}(c_{a1})^{1.5}$

V_b = (7*((200/25)^0.2)*(25^0.5))*1*(30^0.5)*(175^0.5)/1000
= 3.84 kN

$\Psi_{ec,V}$ = 1 Eccentricity = **0** mm

$\Psi_{ed,V}$ = 1.0 0.7+(0.3*(262.5/(1.5*175)))
C_{a1} = 175 mm C_{a2} = 262.5 mm

$\Psi_{c,V}$ = **1.4**

$\Psi_{h,V}$ = 3.6

$V_{cbg} = \frac{A_{Vc}}{A_{Vco}}\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_b$ (17.5.2.1b) = (10500/137812.5)*1*1*1.4*3.6*3.8
1.4854 kN

A_{seV} = $A_{se,V} = \frac{\pi}{4}\left(d_a - \frac{0.9743}{n_t}\right)^2$ = (PI()/4)*(25-0.9743/25)^2
= 489 mm^2

f_{uta} = 500 N/mm^2

$V_{sa} = A_{se,V} f_{uta}$ = 244.7 kN **SAFE**

Table 1 - Minimum Anchor Dimensions – U.S. Customary Units

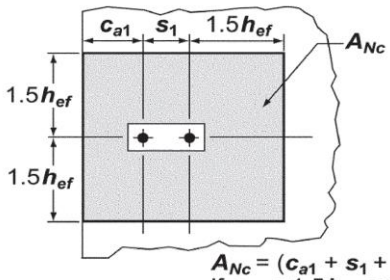
(See Figure 1 for dimension locations)

ANCHOR ROD DIAMETER	EFFECTIVE CROSS-SECTIONAL AREA OF ANCHOR ROD IN TENSION (Note 3)	HEAVY HEX HEAD/ NUT WIDTH	ANCHOR TYPE 2 THREAD LENGTH AT BOTTOM OF ANCHOR		*ASCE ANCHORAGE DESIGN REPORT* MINIMUM DIMENSIONS (Note 1)				SLEEVES (See Note 1 (d))		
					h_{ef}	EDGE DISTANCE c_a (Note 2)		SPAC -ING			
			WITH NO AP	WITH AP (Note 4)	$12d_a$	*A307/ A36 F1554* GRADE 36	HIGH-STRENGTH (> 36 ksi) OR TORQUED ANCHORS	$4d_a$	SHELL SIZE		h'_e
d_a	$A_{se,N}$	W_h	TB1	TB2		$4d_a \geq 4.5"$	$6d_a \geq 4.5"$		Diam d_s	Height h_s	$6d_a \geq 6"$
in.	in²	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
5/8	0.226	1.25	1.25	–	7.5	4.5	4.5	2.5	2	7	6
3/4	0.334	1.44	1.25	2.25	9.0	4.5	4.5	3.0	2	7	6
7/8	0.462	1.69	1.50	2.50	10.5	4.5	5.3	3.5	2	7	6
1	0.606	1.88	1.75	3.00	12.0	4.5	6.0	4.0	3	10	6
1-1/4	0.969	2.31	2.00	3.50	15.0	5.0	7.5	5.0	—	—	—
1-1/2	1.405	2.75	2.25	4.00	18.0	6.0	9.0	6.0	—	—	—
1-3/4	1.900	3.19	2.50	4.75	21.0	7.0	10.5	7.0	—	—	—
2	2.500	3.63	2.75	5.25	24.0	8.0	12.0	8.0	—	—	—
2-1/4	3.250	4.06	3.00	5.75	27.0	9.0	13.5	9.0	—	—	—
2-1/2	4.000	4.50	3.50	6.50	30.0	10.0	15.0	10.0	—	—	—
2-3/4	4.930	4.94	3.75	7.00	33.0	11.0	16.5	11.0	—	—	—
3	5.970	5.31	4.00	7.75	36.0	12.0	18.0	12.0	—	—	—

$$A_{Nco} = (2 \times 1.5h_{ef}) \times (2 \times 1.5h_{ef}) = 9h_{ef}^2$$

(b) For a group of anchors

$$N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b \quad (17.4.2.1b)$$



$A_{Nc} = (c_{a1} + s_1 + 1.5h_{ef})(2 \times 1.5h_{ef})$ if $c_{a1} < 1.5h_{ef}$ and $s_1 < 3h_{ef}$

$$\psi_{ec,N} = \frac{1}{\left(1 + \frac{2e'_N}{3h_{ef}}\right)}$$

If $c_{a,min} \geq 1.5h_{ef}$, then $\psi_{ed,N} = 1.0$

If $c_{a,min} < 1.5h_{ef}$, then $\psi_{ed,N} = 0.7 + 0.3 \frac{c_{a,min}}{1.5h_{ef}}$

(a) $\psi_{c,N} = \mathbf{1.25}$ for cast-in anchors
(b) $\psi_{c,N} = \mathbf{1.4}$ for post-installed anchors, where the value of k_c used in Eq. (17.4.2.2a) is 17

If $c_{a,min} \geq c_{ac}$, then $\psi_{cp,N} = 1.0$

If $c_{a,min} < c_{ac}$, then $\psi_{cp,N} = \frac{c_{a,min}}{c_{ac}}$

17.5.2 *Concrete breakout strength of anchor in shear*

17.5.2.1 The nominal concrete breakout strength in shear, V_{cb} of a single anchor or V_{cbg} of a group of anchors, shall not exceed:

(a) For shear force perpendicular to the edge on a single anchor

$$V_{cb} = \frac{A_{Vc}}{A_{Vco}} \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_b \quad (17.5.2.1a)$$

(b) For shear force perpendicular to the edge on a group of anchors

$$V_{cbg} = \frac{A_{Vc}}{A_{Vco}} \psi_{ec,V} \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_b \quad (17.5.2.1b)$$

$$\text{(a) } V_b = \left(7\left(\frac{\ell_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda_a \sqrt{f'_c} (c_{a1})^{1.5} \quad (17.5.2.2a)$$

$$V_{cbg} = \frac{A_{Vc}}{A_{Vco}} \psi_{ec,V} \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_b \qquad (17.5.2.1b)$$

$$A_{Vco} = 4.5(c_{a1})^2 \qquad (17.5.2.1c)$$

$$A_{vc} = 2(1.5c_{a1})h_a$$

$$\psi_{ed,V} = 0.7 + 0.3\frac{c_{a2}}{1.5c_{a1}}$$

$$\psi_{ec,Na} = \frac{1}{\left(1 + \frac{e'_N}{c_{Na}}\right)}$$

$$\psi_{c,V} = 1.4$$

$$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \qquad (17.5.2.8)$$

$$V_{sa} = A_{se,V} f_{uta} \qquad (17.5.1.2a)$$

$$A_{se,V} = \frac{\pi}{4}\left(d_a - \frac{0.9743}{n_t}\right)^2$$