

Vertical Vessel Anchor Forces Calculation

Design Basis and Assumptions

The design of circular pattern anchor bolt group uses the Method 2 Sawcut with hef and Neutral Axis at Center as stated in the following references

- 1. ASCE Anchorage Design for Petrochemical Facilities 2013 Example 2 Step 5(c) on Page 145
- 2. ASCE 2010 Structural Congress Concrete Breakout Strength in Tension for Vertical Vessel Anchorage in Octagon Pedestals

The design of circular pattern anchor bolt group is simplified as design of a single anchor bolt with 3 side free edges sawcut at midway between adjacent anchors. The simplified design method uses the following assumptions

- 1. The moment is resisted only by the anchor bolt group and it does not take into account the contribution of concrete compression force against base plate in the moment equilibrium
- 2. The neutral axis is not shifted and is located at center of vessel
- 3. It does not consider strain compatibility between the concrete and steel elements which comprise the anchorage.
- 4. In the assumed 3 side free edges sawcut model, when anchor is located less than 1.5hef from three or more edges, the reduced h_{ef} is used to calculate concrete projected failure area A_{NC}

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The utilization ratio of simplified method used in this calculation is conservative compared to the accurate but more complex approach. The detail comparison and analysis of this simplified method is addressed in reference 2 above.

Octagon Concrete Mat Geometri	ics				
Octagon mat face-to-face distance	$D_p = $ from user input	= 196.85 [in]		ANC-	
Anchor bolt bolt circle diameter	D_{bc} = from user input	= 157.50 [in]			
No of anchor bolt	$N_a =$ from user input	= 20			
Anchor bolt edge distance	$C_1 = (D_p - D_{bc}) / 2$	= 19.68 [in]	×	17 N	(Gr)
	$c_{3} = D_{p} - c_{1}$	= 177.18 [in]	~	K	Dbc
	$c_2 = \frac{D_{bc}}{2} \tan \frac{360}{2 N_a}$	= 12.47 [in]		$\left \right\rangle$	
	$C_4 = C_2$	= 12.47 [in]			
		ACI 318-19 17.6.2.1.2	2		
Effective embedment depth	h _{ef} ' =	= 13.12 [in]			k → →
Octagon side edge length	$S_{p} = \frac{D_{p}}{(1 + \sqrt{2})}$	= 81.54 [in]		K	y
Octagon shape conc mat area	A _p =		= 32101.5	5 [in ²]	
Projected conc failure area	$A_{NC} = \frac{A_{p} - (\pi/4) [D_{bc} - \pi/4]}{2}$	· min(3h _e f' , D _{bc})] ² N _a	= 1056.9	[in ²]	
Single Anchor Bolt Tensile and S	Shear Load				PIP STE03350 -2008
Factored compression at top of concrete pedestal	$P_{u} = \frac{M_{u}}{0.667 D_{bc}} + 0$	$.9\frac{D_e}{2}$	= 135.54	[kips]	Section 4.6.1 Eq 5
Factored shear at base of vessel	$V_u =$ from user input		= 29.90	[kips]	
Vessel base to concrete support surface friction factor	μ = from user input		= 0.55		Section 4.6.2
Strength reduction factor	φ =		= 0.75		Section 4.6.2
Factored frictional resistance	$\phi V_f = \phi \mu P_u$		= 55.91	[kips]	Section 4.6.1 Eq 6
	> V _u shear load t	taken by the friction			Section 4.6.2 Eq 7
Factored <u>single</u> anchor shear load	V _{ua} = shear load taker	n by the friction	= 0.00	[kips]	
Anchor Tensile - Uplift LCB by W	/ind				
Factored base moment - wind	M_{uw} = from user input		= 1000.9	[kip-ft]	
Vessel empty weight	$D_e =$ from user input		= 47.00	[kips]	
Factored <u>single</u> anchor tensile load	$N_{uaw} = \frac{4 M_{uw}}{N D} - 0.9 \frac{1}{2}$	D _e	= 13.14	[kips]	Section 4.6.1 Eq 4

	Vertical Vessel	Skirt Support on Octagon Conc Foundati יי _{a ט} איי _a	on An	chorage D	Design Anchor-
Anchor Tensile - U	plift LCB by Seism	lic			
Factored base mome	ent - seismic	M _{us} = from user input	= 434.20	[kip-ft]	
Vessel operating wei	ght	$D_0 =$ from user input	= 280.80	[kips]	
		When $\frac{4 M_{us}}{N_a D_{bc}} < 0.9 \frac{D_o}{N_a}$, there is no te	ensile load mobi	lized on ar	nchor
Factored <u>single</u> anch	or tensile load	$N_{uas} = \frac{4 M_{us}}{N_a D_{bc}} - 0.9 \frac{D_o}{N_a}$	= 0.00	[kips]	Section 4.6.1 Eq 4
Factored <u>single</u> anch max	or tensile load -	$N_{ua} = max (N_{uaw}, N_{uas})$	= 13.14	[kips]	
Vertical Vessel An	chor Bolt	P _t =13.1 kip V =0.0 kip			Code=ACI 318-1
Result Summary	geome	tries & weld limitations = PASS limi	it states max rai	tio = 0.50	PASS
Min Anchor Dime	ensions Check Pe	r PIP STE05121 - Optional			PASS
Min Anchor Dimen	sions Check				
Check min anchor di Facilities - 2018 Tal	mensions as per PII ple 1 as shown belo	STE05121 Application of ASCE Anchorage Desw.	sign for Petroche	emical	
This check is NOT a Anchor Bolt - Config	code requirement. & Setting> Chec	User can turn this check On/Off by changing s k min anchor spacing and edge distance as per	etting at Anchor PIP STE05121	· Bolt> Table 1	
Anchor Rod Inputs	;				
Anchor rod grade an	d dia	grade = F1554 Gr36	$d_{a} = 1.000$	[in]	
Anchor sleeve dia an	d height	d _s = 3.000 [in]	$h_{s} = 10.000$	[in]	
Min Anchor Edge D	Distance				
Anchor edge distance	e	c ₁ = 19.675 [in]	c ₂ = 12.473	[in]	
		c ₃ = 177.175 [in]	c ₄ = 12.473	[in]	
Min anchor edge dist	ance required	c _{min} = from PIP STE05121 Table 1 below	= 5.500	[in]	PIP STE05121 Table 1
Min anchor edge dist	ance	$c = min(c_1, c_2, c_3, c_4)$	= 19.675	[in]	
			≥ c _{min}	ОК	
Min Anchor Embed	ment Depth				
Min anchor embedm	ent required	h _{min} = from PIP STE05121 Table 1 below	= 16.000	[in]	PIP STE05121 Table 1
Min anchor embedm	ent depth	h _{ef} = from user input	= 18.000	[in]	
	·		≥ h _{min}	OK	
Table 1 from PIP STE	05121 Application	of ASCE Anchorage Design for Petrochemical Fa	cilities - 2018		
PIP STE05121		EDITO	ORIAL REVISIO	N	
Application of ASCE A	Anchorage Design for I	Petrochemical Facilities	January 20:	18	
(See Figure 1 for di	Table 1 - Minim	um Anchor Dimensions – U.S. Customary Un	its		
NAL NAL	. Ц . Ц . Ц	ASCE ANCHORAGE DESIGN REPORT MINIMUM DIMENSIONS (Note 1)			

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Vertical Vessel

Skirt Support on Octagon Conc Foundation

Anchorage Design

Anchor-1

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ROD DIAMET	ROSS-SECTI NNCHOR ROE ON (Note 3)	EX HEAD/ NL VIDTH	ANCHOR T THREA	BOTTOM	h _{ef}	EDGE DISTANCE ca (Note 2) SPAC		(S	SLEEVE	s (d))	
ANCHOR	EFFECTIVE C AREA OF / TENSI	НЕАVY Н V	WITH NO AP	WITH AP (Note 4)	12da	A307/ A36 F1554 GRADE 36	HIGH- STRENGTH (> 36 ksi) OR TORQUED ANCHORS	4da	SHEL	L SIZE	h'e
da	A _{se,N}	Wh	TB1	TB2]	<mark>4da≥4.5"</mark>	6da≥ 4.5"		Diam d₅	Height h₅	6da ≥ 6''
in.	in ²	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			

NOTES:

1. If sleeves are used, the following dimensional modifications apply:

 $\begin{array}{ll} \mbox{(a)} & \mbox{Embedment should be the greater of } 12d_a \mbox{ or } (h_s + h'_e) \\ \mbox{(b)} & \mbox{Edge distance should be increased by } 0.5(d_s - d_a) \\ \end{array}$

(c) Spacing should be increased by (d_s - d_a)

(d) Partial length sleeves are not recommended for anchors greater than 1 in. See ASCE Anchorage Design Report, Section 3.2.3.1.

Anchor Rod Tensile Resistance		ratio = 13.1 / 26.4	= 0.50	PASS
Anchor rod effective section area	$A_{se} = 0.61$ [in ²]	f _{uta} = 58.0	[ksi]	
Anchor rod steel strength in tension	$N_{sa} = A_{se} f_{uta}$	= 35.15	[kips]	ACI 318-19 17.6.1.2
Max Single Anchor Tensile Force				
Anchor group axial tensile force	P = from user load input	= -13.14	[kips]	in tension
No of anchors in the group	n _t =	= 1		
Single anchor tensile force	$T = P / n_t$	= 13.14	[kips]	
Strength reduction factor	$\phi_{ts} = 0.75$			ACI 318-19 17.5.3(a)
	$\phi_{ts} N_{sa} = 0.75 \times 35.15$	= 26.36	[kips]	
	ratio = 0.50	> T	ОК	

		Offit Oup	pon on oou	ayon Conc Found	auton		chorage D	colgin	
Anchor Concrete Te	ensile Breakou	ut Resistance		ratio	= 13.1	/ 35.1	= 0.37	PASS	
Anchor embedment dep	oth-adjusted	h _{ef} = from	n Anchor Fo	orces Calculation	above	= 13.117	[in]		
Conc strength & lightwe factor	eight conc	$f_{c} = 4.4$	[ksi]		λ	= 1.0		ACI 318-19	17.2.4.:
Single anchor concrete l	breakout	$N_b = 24\lambda$	$\sqrt{f_c} h^{1.5}_{ef}$	If h _{ef} < 11" or h	_{ef} > 25"	= 76.98	[kips]	ACI 318-19	17.6.2.2
		16λ	$\sqrt{f_c} h^{5/3}_{ef}$	If 11" $\leq h_{ef} \leq$	25"			ACI 318-19	17.6.2.2
Refer to Vertical Vessel calculation and design a	Anchor Forces	Calculation above	e for vertica	I vessel $c_1 \sim c_4$				Y	
Anchor edge distance		c ₁ = 19.675	[in]	c ₂ = 12.473	[in]			••	~×
		c ₃ = 177.175	[in]	c ₄ = 12.473	[in]		X	>	<u>5</u>
Anchor out-out spacing		s ₁ = 0.000	[in]	s ₂ = 0.000	[in]		•	•••	< C3 ×
							(^{C2})	$\frac{Y}{S_2}$ \times C4	
							P.	+ V ₂ + M ₂	
Refer to Vertical Vessel and single anchor of that	Anchor Forces (at group project	Calculation above ed failure area A	e for the det _{NC1} calculat	tails of vertical ve tion as shown bel	essel circ low	ular ancho	r group		
Refer to Vertical Vessel and single anchor of that	Anchor Forces (at group project	Calculation above red failure area A A _{NC1} =	e for the det _{NC1} calculat	tails of vertical ve cion as shown bel	essel circ low	 cular ancho = 1056.9	r group [in ²]	ACI 318-10	1762
Refer to Vertical Vessel and single anchor of tha	Anchor Forces (at group project	Calculation above ed failure area A A _{NC1} = A _{Nco} = 9 h;	e for the det _{NC1} calculat	tails of vertical ve cion as shown bel	essel circ	 cular ancho = 1056.9 = 1548.4	r group [in ²] [in ²]	ACI 318-19	17.6.2.2
Refer to Vertical Vessel and single anchor of that No of anchors in the grottension	Anchor Forces (at group project	Calculation above red failure area A $A_{NC1} =$ $A_{Nco} = 9 h_1^2$ $n_t = from$	e for the det _{NC1} calculat _{ef} n Anchor Fo	tails of vertical ve cion as shown bel prces Calculation	essel ciro ow above	 cular ancho = 1056.9 = 1548.4 = 1	r group [in ²] [in ²]	ACI 318-19	17.6.2.3
Refer to Vertical Vessel and single anchor of that No of anchors in the grottension	Anchor Forces (at group project	Calculation above red failure area A $A_{NC1} =$ $A_{Nco} = 9 h_{1}^{2}$ $n_{t} = from$ $A_{Nc} = min$	e for the det _{NC1} calculat ef n Anchor Fo (A _{Nc1} , n _t A	tails of vertical ve tion as shown bel prces Calculation A _{Nco})	essel circ low above	 cular ancho = 1056.9 = 1548.4 = 1 = 1056.9	r group [in ²] [in ²] [in ²]	ACI 318-19 ACI 318-19	17.6.2. 17.6.2.
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension	Anchor Forces (at group project pup resisting	Calculation above ted failure area A $A_{NC1} =$ $A_{Nco} = 9 h_{1}^{2}$ $n_{t} = from$ $A_{Nc} = min$ $\Psi_{ec,N} = from$	e for the det _{NC1} calculat ef n Anchor Fo (A _{Nc1} , n _t A n Anchor Fo	tails of vertical ve cion as shown bel prces Calculation A _{Nco}) prces Calculation	essel circ ow above above	<pre>cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000</pre>	r group [in ²] [in ²] [in ²]	ACI 318-19 ACI 318-19 ACI 318-19	17.6.2. 17.6.2. 17.6.2.
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension Eccentricity modification Min edge distance	Anchor Forces (at group project oup resisting n factor	Calculation above ted failure area A $A_{NC1} =$ $A_{Nco} = 9 h_{1}^{2}$ $n_{t} = from$ $A_{Nc} = min$ $\Psi_{ec,N} = from$ $c_{min} = min$	e for the det $_{NC1}$ calculat ef n Anchor Fo (A_{Nc1} , $n_t A$ n Anchor Fo (c_1 , c_2 , c_3 ,	tails of vertical ve cion as shown bel prces Calculation A _{Nco}) prces Calculation ,c ₄)	essel circ ow above above	 cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473	r group [in ²] [in ²] [in ²] [in]	ACI 318-19 ACI 318-19 ACI 318-19	17.6.2. 17.6.2. 17.6.2.
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension Eccentricity modification Min edge distance Edge modification factor	Anchor Forces (at group project oup resisting n factor	Calculation above ted failure area A $A_{NC1} =$ $A_{Nco} = 9 h_{1}^{2}$ $n_{t} = from$ $A_{Nc} = min$ $\Psi_{ec,N} = from$ $c_{min} = min$ $\Psi_{ed,N} = min$	e for the det $_{NC1}^{2}$ calculat ef n Anchor Fo (A _{Nc1} , n _t A n Anchor Fo (c ₁ , c ₂ , c ₃ , [0.7 + $\frac{0.36}{1.5}$	tails of vertical vertication of the second se	essel circ ow above above	<pre>cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473 = 0.890</pre>	r group [in ²] [in ²] [in ²]	ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19	17.6.2. 17.6.2. 17.6.2. 17.6.2.
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension Eccentricity modification Min edge distance Edge modification factor Conc cracking modificat	Anchor Forces (at group project oup resisting n factor r	Calculation above ted failure area A $A_{NC1} =$ $A_{Nco} = 9 h_1^2$ $n_t = from$ $A_{Nc} = min$ $\Psi_{ec,N} = from$ $c_{min} = min$ $\Psi_{ed,N} = min$ $\Psi_{c,N} =$	e for the det $_{NC1}^{2}$ calculat ef n Anchor Fo (A _{Nc1} , n _t A n Anchor Fo (c ₁ , c ₂ , c ₃ , [0.7 + $\frac{0.3c}{1.5}$	tails of vertical shown below $A_{\rm Nco}$) and $A_{\rm Nco}$) by the constant of the constan	essel circ ow above above	 cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473 = 0.890 = 1.00	r group [in ²] [in ²] [in]	ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19	17.6.2. 17.6.2. 17.6.2. 17.6.2.
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension Eccentricity modification Min edge distance Edge modification factor Conc cracking modificat Conc splitting modificat	Anchor Forces (at group project oup resisting n factor r ion factor	Calculation above ted failure area A $A_{NC1} =$ $A_{Nco} = 9 h_{1}^{2}$ $n_{t} = from$ $A_{Nc} = min$ $\Psi_{ec,N} = from$ $\Psi_{ed,N} = min$ $\Psi_{ed,N} = min$ $\Psi_{c,N} =$ $\Psi_{cp,N} =$	e for the det $_{NC1}^{2}$ calculat ef n Anchor Fo (A _{Nc1} , n _t A n Anchor Fo (c ₁ , c ₂ ,c ₃ , [0.7 + $\frac{0.36}{1.5}$	tails of vertical sector vertical vert	above	 cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473 = 0.890 = 1.00 = 1.00	r group [in ²] [in ²] [in]	ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19	17.6.2. 17.6.2. 17.6.2. 17.6.2. 17.6.2.
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension Eccentricity modification Min edge distance Edge modification factor Conc cracking modificat Conc splitting modificati	Anchor Forces (at group project pup resisting n factor r ion factor ion factor itance	Calculation above ted failure area A $A_{NC1} =$ $A_{Nco} = 9 h_{1}^{2}$ $n_{t} = from$ $A_{Nc} = min$ $\Psi_{ec,N} = from$ $C_{min} = min$ $\Psi_{ed,N} = min$ $\Psi_{cp,N} =$ $W_{cp,N} =$ $N_{cbg} = \frac{A_{p}}{A_{N}}$	e for the det $_{NC1}^{2}$ calculat ef n Anchor Fo (A _{Nc1} , n _t A n Anchor Fo (c ₁ , c ₂ , c ₃ , [0.7 + $\frac{0.3c}{1.5}$ $\frac{4c}{co}$ $\Psi_{ec,N} \Psi_{ec}$	tails of vertical vertical vertical vertical solution as shown belen below the solution A_{Nco}) brces Calculation A_{Nco}) brces Calculation (C_4) $(C_{min}, 1.0]$ $(C_{hef}, 1.0]$	above	<pre>cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473 = 0.890 = 1.00 = 1.00 = 1.00 = 46.78</pre>	r group [in ²] [in ²] [in] [kips]	ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19	17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.:
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension Eccentricity modification Min edge distance Edge modification factor Conc cracking modificati Conc splitting modificati Concrete breakout resis Sum of anchors tensile f anchor group	Anchor Forces (at group project oup resisting n factor r ion factor ion factor itance force in	Calculation above ted failure area A $A_{NC1} =$ $A_{Nco} = 9 h_1^2$ $n_t = from$ $A_{Nc} = min$ $\Psi_{ec,N} = from$ $C_{min} = min$ $\Psi_{ed,N} = min$ $\Psi_{c,N} =$ $\Psi_{cp,N} =$ $N_{cbg} = \frac{A_p}{A_N}$ $N_u = from$	e for the det $_{NC1}^{2}$ calculat $_{ef}^{2}$ n Anchor Fo (A _{Nc1} , n _t A n Anchor Fo (c ₁ , c ₂ , c ₃ , [0.7 + $\frac{0.3c}{1.5}$ $\frac{4c}{co}$ $\Psi_{ec,N} \Psi_{e}$ n Anchor Fo	tails of vertical vertical vertical vertical vertical shown believes calculation A_{Nco}) proces Calculation A_{Nco}) proces Calculation (c_4) (c_{min}) (c_{d})	above above above	Lular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473 = 0.890 = 1.00 = 1.00 = 46.78 = 13.14	r group [in ²] [in ²] [in ²] [in] [kips]	ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19	17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.:
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension Eccentricity modification Min edge distance Edge modification factor Conc cracking modificat Conc splitting modificat Concrete breakout resis Sum of anchors tensile fanchor group Strength reduction factor	Anchor Forces (at group project oup resisting n factor r ion factor ion factor itance force in or	Calculation above ted failure area A $A_{NC1} =$ $A_{Nco} = 9 h_{1}^{2}$ $n_{t} = from$ $A_{Nc} = min$ $\Psi_{ec,N} = from$ $C_{min} = min$ $\Psi_{ed,N} = min$ $\Psi_{c,N} =$ $\Psi_{cp,N} =$ $N_{cbg} = \frac{A_{p}}{A_{N}}$ $N_{u} = from$ $\phi_{tc} = 0.75$	e for the det $_{NC1}^{2}$ calculat ef n Anchor Fo (A _{Nc1} , n _t A n Anchor Fo (c ₁ , c ₂ , c ₃ , [0.7 + $\frac{0.36}{1.5}$ $\frac{10}{100}$ $\Psi_{ec,N} \Psi_{e}$ n Anchor Fo 5 supp	tails of vertical vertical vertical vertical vertical solution as shown below the solution A_{Nco}) orces Calculation A_{Nco}) orces Calculation $A_{C_{d}}$, A	above above above present	<pre>cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473 = 0.890 = 1.00 = 1.00 = 46.78 = 13.14</pre>	r group [in ²] [in ²] [in ²] [in] [kips]	ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19	17.6.2. 17.6.2. 17.6.2. 17.6.2. 17.6.2. 17.6.2. 17.6.2.
Refer to Vertical Vessel A and single anchor of tha No of anchors in the gro tension Eccentricity modification Min edge distance Edge modification factor Conc cracking modificati Conc splitting modificati Concrete breakout resis Sum of anchors tensile f anchor group Strength reduction factor	Anchor Forces (at group project oup resisting n factor r ion factor ion factor itance force in or	Calculation above the failure area A A _{NC1} = A _{Nc0} = 9 h n _t = from A _{Nc} = min $\Psi_{ec,N}$ = from C _{min} = min $\Psi_{ed,N}$ = min $\Psi_{cp,N}$ = N _{cbg} = $\frac{A_p}{A_N}$ N _u = from Φ_{tc} = 0.75	e for the det $_{NC1}^{2}$ calculat $_{ef}^{2}$ n Anchor Fo (A _{Nc1} , n _t A n Anchor Fo (c ₁ , c ₂ , c ₃ , [0.7 + $\frac{0.3c}{1.5}$ $\frac{4c}{co}$ $\Psi_{ec,N} \Psi_{e}$ n Anchor Fo 5 supp 5 x 46.78	tails of vertical vertical vertical vertical vertical vertical vertical vertical vertical sector as shown below of the sector o	above above above present	<pre>cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473 = 0.890 = 1.00 = 1.00 = 46.78 = 13.14 = 35.08</pre>	r group [in ²] [in ²] [in] [kips] [kips]	ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19	17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.: 17.5.3(1
Refer to Vertical Vessel and single anchor of that No of anchors in the grot tension Eccentricity modification Min edge distance Edge modification factor Conc cracking modificat Conc splitting modificat Concrete breakout resis Sum of anchors tensile f anchor group Strength reduction factor Seismic design strength	Anchor Forces (at group project oup resisting n factor r ion factor ion factor itance force in or	Calculation above the failure area A A _{NC1} = A _{Nco} = 9 h n _t = from A _{Nc} = min $\Psi_{ec,N}$ = from C_{min} = min $\Psi_{ed,N}$ = min $\Psi_{c,N}$ = N _{cbg} = $\frac{A_{p}}{A_{N}}$ N _u = from $\phi_{tc} = 0.7!$ $\phi_{tc} N_{cbg} = 0.7!$ = x 1.	e for the det $_{NC1}^{2}$ calculat $_{ef}^{2}$ fn Anchor Fo (A _{Nc1} , n _t A n Anchor Fo (c ₁ , c ₂ , c ₃ , [0.7 + $\frac{0.36}{1.5}$ $\frac{kc}{co} \Psi_{ec,N} \Psi_{e}$ n Anchor Fo 5 supp 5 x 46.78 0 not appl	tails of vertical vertical vertical vertical vertical vertical vertical vertical vertical sector as shown below on the sector of the sector o	above above above present	<pre>cular ancho = 1056.9 = 1548.4 = 1 = 1056.9 = 1.000 = 12.473 = 0.890 = 1.00 = 1.00 = 46.78 = 13.14 = 35.08 = 35.08</pre>	r group [in ²] [in ²] [in ²] [in] [kips] [kips] [kips]	ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19 ACI 318-19	17.6.2.: 17.6.2.: 17.6.2.: 17.6.2.5 17.6.2.6 17.6.2.1 17.5.3(f

		Skirt Support on Octa	agon Conc Foundatior	n An	chorage De	esign Anchor
Anchor Pullout Re	sistance		ratio = 13	.1 / 36.6	= 0.36	PASS
Anchor head net beari conc strength	ng area &	$A_{brg} = 1.50$ [in ²]		$f_{c} = 4.4$	[ksi]	
Single bolt pullout resi	istance	$N_p = 8 A_{brg} f_c$		= 52.23	[kips]	ACI 318-19 17.6.3.2.
Pullout cracking factor		Ψ_{cP} = for cracked con	crete	= 1.00		ACI 318-19 17.6.3.3
Max Single Anchor 1	Tensile Force					
Anchor group axial ter	nsile force	P = from user load	input	= -13.14	[kips]	in tension
No of anchors in the g	roup	n _t =		= 1		
<u>Single</u> anchor tensile f	orce	$T = P / n_t$		= 13.14	[kips]	
Strength reduction fac	tor	$\phi_{tc} = 0.70$ pullor	it strength is always (Condition B		ACI 318-19 17.5.3(c)
		$\phi_{tc} N_{pn} = \phi_{tc} \Psi_{cP} N_{p}$		= 36.56	[kips]	
Seismic design strengt	th reduction	= x 1.0 not appl	icable	= 36.56	[kips]	ACI 318-19 17.10.5.4
		ratio = 0.36		> T	ОК	
Anchor Inputs						
	<u> </u>					
Anchor edge distance		c ₁ = 19.675 [in]	c ₂ = 12.473 [in]			Y
Anchor edge distance		c ₁ = 19.675 [in] c ₃ = 177.175 [in]	c ₂ = 12.473 [in] c ₄ = 12.473 [in]			Y
Anchor edge distance Anchor out-out spacin	g	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in]	$c_2 = 12.473$ [in] $c_4 = 12.473$ [in] $s_2 = 0.000$ [in]		•	Y
Anchor edge distance Anchor out-out spacin	g	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in]	$c_2 = 12.473$ [in] $c_4 = 12.473$ [in] $s_2 = 0.000$ [in]		× •	× 100 × 100
Anchor edge distance Anchor out-out spacin	g	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in]	$c_2 = 12.473$ [in] $c_4 = 12.473$ [in] $s_2 = 0.000$ [in]		× •	Y
Anchor edge distance Anchor out-out spacin	g	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in]	$c_2 = 12.473$ [in] $c_4 = 12.473$ [in] $s_2 = 0.000$ [in]		× •	
Anchor edge distance Anchor out-out spacin	g	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in]	$c_2 = 12.473$ [in] $c_4 = 12.473$ [in] $s_2 = 0.000$ [in]		x •	Y • X · S2 * C4
Anchor edge distance Anchor out-out spacin	g	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in]	$c_2 = 12.473$ [in] $c_4 = 12.473$ [in] $s_2 = 0.000$ [in]		x • • • •	$\begin{array}{c} Y \\ \bullet \\ \bullet \\ Y \\ \hline \\ S2 \\ \hline \\ \hline \\ \hline \\ \\ \hline \\ \\ \\ \hline \\ \\ \\ \\ \\ \\ $
Anchor edge distance Anchor out-out spacin Anchor edge distance	g - min	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in] $c_{a1} = min (c_1, c_2, c_3)$	$c_2 = 12.473$ [in] $c_4 = 12.473$ [in] $s_2 = 0.000$ [in]	= 12.473	x •	$\begin{array}{c} Y \\ \bullet \\ Y \\ \bullet \\ Y \\ S_2 \\ + \\ V_y + \\ M_x \end{array}$
Anchor edge distance Anchor out-out spacin Anchor edge distance Anchor embedment de	g - min epth	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in] $c_{a1} = min (c_1, c_2, c_1)$ $h_{ef} = from user input$	c ₂ = 12.473 [in] c ₄ = 12.473 [in] s ₂ = 0.000 [in]	= 12.473 = 18.000	x • • • • • • • • • • • • • • • • •	$\begin{array}{c} Y \\ \bullet \\ Y \\ \hline \\ Y \\ \hline \\ S_2 \\ \hline \\ \hline \\ \\ \hline \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $
Anchor edge distance Anchor out-out spacin Anchor edge distance Anchor embedment de Side blowout check is this edge or not	g - min epth required on	$c_1 = 19.675$ [in] $c_3 = 177.175$ [in] $s_1 = 0.000$ [in] $c_{a1} = min (c_1, c_2, c_1)$ $h_{ef} = from user input$ $= check if h_{ef} > 2$	c ₂ = 12.473 [in] c ₄ = 12.473 [in] s ₂ = 0.000 [in] , c ₄)	= 12.473 = 18.000 = False	x • • • • • • • • • • • • • • • • • • •	Y • X 5 X X X X X X X X X X X X X

Anchor Group Governing Tensile Resistance

Anchor group governing tensile resista the following limit states	nce is the minimum value of the resistance values in		
No of anchors in anchor group resisting tension	$n_t =$ from Anchor Forces Calculation above	= 1	
Anchor rod tensile resistance	$n_t \phi N_{sa} = 1 \times 26.36$	= 26.36	[kips]
Anchor concrete breakout resistance	φ N $_{cbg}$ = from anchor conc breakout calc above	= 35.08	[kips]
Anchor pullout resistance	$n_{t} \phi N_{pm} = 1 \times 36.56$	= 36.56	[kips]
Anchor side blowout resistance	φ N $_{sbg}$ = from anchor side blowout calc above	= N/A	
Anchor group governing tensile resistance	ϕ N _n = minimum of above values	= 26.36	[kips]

Skirt Support on Octagon Conc Foundation

Anchor Shear Resista	N/A							
There is no shear load from user load input or shear key is used and all shear is taken by shear key, so Anchor Shear Resistance and Tension - Shear Interaction checks are Not Applicable								
Anchor Seismic Desig	gn	N/A						
Seismic - Tension	Not Applicable	ACI 318-19 17.10.5.1						
Seismic SDC < C or E <=	\sim 0.2U , additional seismic requirements in ACI 318-19 17.10.5.3 is NOT required	ACI 318-19 17.10.5.3						
Seismic - Shear	Not Applicable	ACI 318-19 17.10.6.1						
There is no shear load ap	plied to anchor/anchor group, so Seismic Shear check is NOT required							