ANCHOR BOLT DESIGN Com

Combined Tension and Shear

Result Summary

Anchor Rod Embedment, Spacing and Edge Distance		OK
Min Rquired Anchor Reinft. Development Length	ratio=0.87	OK
Overall	ratio=0.75	ОК
Seismic Design	Tension=	ОК
	Shear=	OK

Design Code Reference

Anchor bolt design based on	Code Abbreviation
ACI 318-11 Building Code Requirements for Structural Concrete and Commentary Appendix D	ACI 318-11
PIP STE05121 Anchor Bolt Design Guide-2006	PIP STE05121
AISC Design Guide 1: Base Plate and Anchor Rod Design 2nd Ed	AISC Design Guide 1
	Code Reference

Anchor Bolt Data

Factored <u>tensile</u> force	N _u = <mark>20.00</mark> [kips]			
Factored shear force	V _u = <mark>25.00</mark> [kips]			
Concrete strength	f' _{c=} <mark>5.2</mark> [ksi]			
Anchor bolt material	= F1554 Grade 36	\checkmark		
Anchor tensile strength	f _{uta} =58.0 [ksi]			ACI 318-11
	Anchor is ductile	steel element		D.1
Anchor bolt diameter	d _a = <mark>1 ∨</mark> [in]			
Anchor bolt has sleeve	= No 🗸			PIP STE05121
		Min Required		
Anchor bolt embedment depth	h _{ef} = <mark>14.00</mark> [in]	12.00	ОК	Page A -1 Table 1
Pedestal height	h _a = <mark>18.00</mark> [in]	17.00	ОК	
Pedestal width	b _c =16.00 [in]			
Pedestal depth	d _c =16.00 [in]			



No of anchor bolt carrying shear	n _s = <mark>4.0</mark>			
$ \begin{array}{c c} & & & & & \\ & & & & & \\ & & & & & \\ \hline & & & &$	Side eck			
For side-face blowout check use				
No of anchor bolt along width edge	n _{bw} = <mark>2.0</mark>			
No of anchor bolt along depth edge	$n_{bd} = 2.0$			
Anchor bolt head type	Heavy Hex			
Anchor effective cross section area	A _{se} =0.606 [in ²]			
Anchor bolt head bearing area	A _{brg} =1.501 [in ²]			
Anchor bolt 1/8" (3mm) corrosion a	Illowance = No			ACI 318-11
Provide built-up grout pad ?	= Yes 🗸			D.6.1.3
	<u> </u>			
Seismic design category SDC >= C	= Yes 🗸			D.3.3.1
Anchor bolt load E <= $0.2U$	Tensile= <mark>No 🗸</mark>	Shear= <mark>No</mark>	\checkmark	D.3.3.4.1 & D.3.3.5.1
Anchor bolt satisfies opion	Tensile= <mark>Option 4</mark>	Shear=Option	3 🗸	D.3.3.4.3 & D.3.3.5.3
Strength reduction factors				ACI 318-11
Anchor reinforcement	φ _s =0.75			D.5.2.9 & D.6.2.9
Anchor rod - ductile steel	φ _{t,s} =0.75	φ _{v,s} =0.65		D.4.3 (a)
Concrete - condition A	φ _{t,c} =0.75	φ _{v,c} =0.75		D.4.3 (c)
CONCLUSION				
Anchor Rod Embedment, Spacing a	nd Edge Distance		OK	ACI 318-11
Min Rquired Anchor Reinft. Develop	ment Length	ratio=0.87	OK	12.5.1
Overall		ratio=0.75	OK	
Tension				
Anchor Rod Tensile Resistance		ratio=0.19	ОК	

Anchor Rod Tensile Resistance	e			ACI 318-11
CACULATION				
				Section 3.5.3
8. Anchor bolt washer shall be ta	ck welded to base plate for all a	anchor bolts to transfer shear		AISC Design Guide 1
7. Anchor reinft used in structure	s with SDC>=C shall meet requ	irements specified in D.3.3.7		D.3.3.7
6. Strut-and-Tie model is used to	anlyze the shear transfer and t	to design the required tie reinft		
5. For tie reinft, only the top mos	st 2 or 3 layers of ties (2" from ⁻	TOC and 2x3" after) are effective		
ACI 318-11 Appendix D clause	P.5.2.9 and D.6.2.9			
4. Anchor reinft strength is used	to replace concrete tension / sh	ear breakout strength as per		D.5.2.9 & D.6.2.9
3. Load combinations shall be per	r ACI 318-11 9.2			D.4.3
2. Condition A - supplementary re	einforcement is provided			D.4.3 (c)
1. Concrete is cracked				D.5.2.6, D5.3.6, D.6.2.7
Assumptions				ACI 318-11
Seismic SDC>=C and E>0.2U , C per D.3.3.5.3	<pre>ption 3 is selected to satisfy ad </pre>	ditional seismic requirements as		
Shear	Applicable		ОК	D.3.3.5
per D.3.3.4.3	iption 4 is selected to satisfy ad	iditional seismic requirements as		
Tension	Applicable		OK	D.3.3.4
Seismic Design				ACI 318-11
Tension Shear Interaction		ratio=0.75	ОК	
Tension Shear Interaction			UK	
Conc. Pryout Not Govern When h	lef >= 12d₂	Tatio=0.09		
		ratio=0.43	UK OK	
Strut Popring Strongth	Sistance	ratio-0.45		
Anchor Rou Shear Resistance		ratio=0.57	UK	
Side Blowout Resistance		ratio=0.21	OK	
Anchor Pullout Resistance		ratio=0.15	OK	
Anchor Reinft Tensile Breakout R	esistance	ratio=0.18	ОК	
Anchor Painft Tancila Broakout P	osistanco	ratio = 0.18	OK	

ACI 318-11

Min required $\underline{full\ yield}$ tension I_{dh}

Actual development lenngth

I_{dh} =180 degree hook case	=11.65	[in]	12.5.2, 12.5.3(a)
$l_{a}=h_{ef}$ - c (2 in) - d_{ar} x tan35	=9.20	[in]	
	>8.00	ОК	12.5.1



				ACI 318-11
Anchor reinft breakout resistance	$\phi_{s} \; N_{n} {=} \phi_{s} \; x \; f_{y {\scriptscriptstyle -} v} \; x \; n_{v} \; x \; A_{s} \; x \; (I_{a} \; / \; I_{d} \; , \; if \; I_{a} \; < \; I_{d})$	=112.30	[kips]	D.3.3.4.5, D.5.2.9, 12.2.5
	ratio=0.18	>N _u	ОК	

Anchor Pullout Resistance					ACI 318-11
Single bolt pullout resistance	$N_p = 8 A_{brg} f_c$	1	=62.44	[kips]	D.5.3.4 (D-14)
	$\phi_{t,c} N_{pn} = \phi_{t,c} n_t \Psi$	J _{c,p} N _p	=174.84	[kips]	D.5.3.1 (D-13)
	$\Psi_{c,p}=1$ for cra	acked conc			D.5.3.6
	φ _{t,c} =0.70	pullout strength is always	Condition B		D.4.3(c)
Seismic design strength reduction	=x 0.75 a	applicable	=131.13	[kips]	D.3.3.4.4
	ratio=0.15		>Nu	OK	

Failure Along Pedestal Width Edge					ACI 318-11
Tensile load carried by anchors close	e to edge which ma	ay cause side-face blowout			
along pedestal width edge	$N_{buw} = N_u \times n_{bw}$, / n _t	=10.00	[kips]	RD.5.4.2
	c=min (c1	, C ₃)	=5.00	[in]	
	s=s ₂		=6.00	[in]	
Check if side blowout applicable	h _{ef} =14.00	[in]			
	>2.5c	side bowout is applicable			D.5.4.1
Single anchor SB resistance	$\phi_{t,c} N_{sb} = \phi_{t,c} (16)$	$0 c \sqrt{A_{brg}} \lambda \sqrt{f'_c}$	=53.01	[kips]	D.5.4.1 (D-16)
Multiple anchors side blowout					
work as group	$\phi_{tc}N_{sbgw}=(1+s/6)$	c) x $\phi_{t,c}$ N _{sb}	=63.61	[kips]	D.5.4.2 (D-17)
Seismic design strength reduction	=x 0.75 a	applicable	=47.71	[kips]	D.3.3.4.4
	ratio=0.21		>N _{buw}	OK	

Side Blowout Resistance

Failure Along Pedestal Depth Edge					ACI 318-11
Tensile load carried by anchors close	e to edge which ma	ay cause side-face blowout			
along pedestal depth edge	long pedestal depth edge $N_{bud}=N_u \times n_{bd} / n_t$			[kips]	RD.5.4.2
	c=min (c ₂	, C4)	=5.00	[in]	
	$s=s_1$		=6.00	[in]	
Check if side blowout applicable	h _{ef} =14.00	[in]			
	>2.5c	side bowout is applicable			D.5.4.1
Single anchor SB resistance	$\phi_{t,c} N_{sb} = \phi_{t,c} (16)$	$0 c \sqrt{A_{brg}} \lambda \sqrt{f'_c}$	=53.01	[kips]	D.5.4.1 (D-16)
Multiple anchors side blowout					
work as group	$\phi_{tc}N_{sbgd} = (1+s/6)$	c) x $\phi_{t,c}$ N _{sb}	=63.61	[kips]	D.5.4.2 (D-17)
Seismic design strength reduction	=x 0.75 a	applicable	=47.71	[kips]	D.3.3.4.4
	ratio=0.21		>N _{bud}	OK	
Group side blowout resistance	$\phi_{tc} N_{sbg} = \phi_{t,c} min$	${ m n} igg(\ {{ m N_{sbg,w}}\over { m n_{bw}}} { m n_t} \ , \ {{ m N_{sbg,d}}\over { m n_{bd}}} { m n_t} \ igg)$	=95.41	[kips]	
Govern Tensile Resistance	N_r =min (ϕ	$N_{sa}, \phi N_n, \phi N_{pn}, \phi N_{sbg}$)	=95.41	[kips]	
Anchor Rod Shear Resistance					ACI 318-11
	$\phi_{v,s}V_{sa}=\phi_{v,s} n_s 0$	0.6 A _{se} f _{uta}	=54.83	[kips]	D.6.1.2 (b) (D-29)
Reduction due to built-up grout pad	=x 0.8 , a	applicable	=43.86	[kips]	D.6.1.3
	ratio=0.57		>Vu	OK	
Anchor Reinft Shear Breakout Re	esistance				ACI 318-11
Strut-and-Tie model is used to anlyz	e the shear transf	er and to design the required	tie reinft		
STM strength reduction factor	$\phi_{st}=0.75$				9.3.2.6

$\begin{array}{c} V_{u}/2 & V_{u}/2 \\ \hline \\ T_{t} & T_{t} \\ \hline \\ C_{s} \\ \hline \\ \theta \\ \hline \\ \end{array}$			35°
Strut-and-Tie model geometry	d _v =2.250 [in]	d _h =2.250	[in]
	θ=45	dt=3.182	[in]
Strut compression force	$C_s=0.5 V_u / sin\theta$	=17.68	[kips]
Strut Bearing Strength			ACI 318-11
Strut compressive strength	f_{ce} =0.85 f'_c	=4.4	[ksi] A.3.2 (A-3)
* Bearing of anchor bolt			
Anchor bearing length	$I_e=min(8d_a, h_{ef})$	=8.00	[in] D.6.2.2
Anchor bearing area	$A_{brg} = I_e \times d_a$	=8.00	[in ²]
Anchor bearing resistance	$C_r {=} n_s \mathrel{x} \varphi_{st} \mathrel{x} f_{ce} \mathrel{x} A_{brg}$	=106.08	[kips]
		>Vu	ОК
* Bearing of ver reinft bar			
Ver bar bearing area	$A_{brg} = (I_e + 1.5 \times d_t - d_a/2 - d_b/2)$) x d _b =11.77	[in ²]
Ver bar bearing resistance	$C_r = \phi_{st} \times f_{ce} \times A_{brg}$	=39.03	[kips]
	ratio=0.45	>Cs	ОК

Tie Reinforcement

- * For tie reinft, only the top most 2 or 3 layers of ties (2" from TOC and 2x3" after) are effective
- * For enclosed tie, at hook location the tie cannot develop full yield strength f_y . Use the pullout resistance in tension of a single hooked bolt as per ACI 318-11 Eq. (D-15) as the max force can be developed at hook T_h
- \ast Assume 100% of hor. tie bars can develop full yield strength

Total number of hor tie bar

n=n_{leg} (leg) x n_{lay} (layer)

=4

Pull out resistance at hook	$T_h {=} \varphi_{t,c} \ 0.9 \ f_c' \ e_h \ d_a$	=3.95	[kips] D.5.3.5 (D-15)
	$e_h=4.5 d_b$	=2.250	[in]
Single tie bar tension resistance	$T_r {=} \varphi_s \mathrel{x} f_{y{\text{-}}h} \mathrel{x} A_s$	=9.00	[kips]
Total tie bar tension resistance	$\phi_s V_n = 1.0 \text{ x n x Tr}$	=36.00	[kips] D.3.3.5.4 & D.6.2.9
	ratio=0.69	>Vu	ОК

Conc. Pryout Shear Resistance

The pryout failure is only critical for short and stiff anchors. It is reasonable to assume that for general cast-in place headed anchors with $h_{ef} > = 12d_a$, the pryout failure will not govern

	12d _a =12.00 [in]	$h_{ef}=14.00$	[in]
		>12da	OK
Govern Shear Resistance	$V_r{=}min$ ($\phi_{v,s}V_{sa}$, ϕ_sV_n)	=36.00	[kips]
Tension Shear Interaction			ACI 318-11
Check if $N_u > 0.2\phi N_n$ and $V_u > 0.2\phi N_n$	2¢ V _n =Yes		D.7.1 & D.7.2
	N_u / ϕ N_n + V_u / ϕ V_n	=0.90	D.7.3 (D-42)
	ratio=0.75	<1.2	ОК
Seismic Design			
Tension	Applicable		ОК
Option 4 is selected.			ACI 318-11
User has to ensure that the tensi by multiplying overstrength facto	lle load N_u user input above includes the set or Ω_o	eismic load E, with E i	ncreased D.3.3.4.3(d)
Seismic SDC>=C and E>0.2U , C per D.3.3.4.3	Option 4 is selected to satisfy additional sei	ismic requirements as	;
Shear	Applicable		ОК
Option 3 is selected.			ACI 318-11
User has to ensure that the shea by multiplying overstrength facto	r load V_u user input above includes the seior Ω_0	ismic load E, with E in	creased D.3.3.5.3(c)
Seismic SDC>=C and E>0.2U , C per D.3.3.5.3	Option 3 is selected to satisfy additional sei	ismic requirements as	;