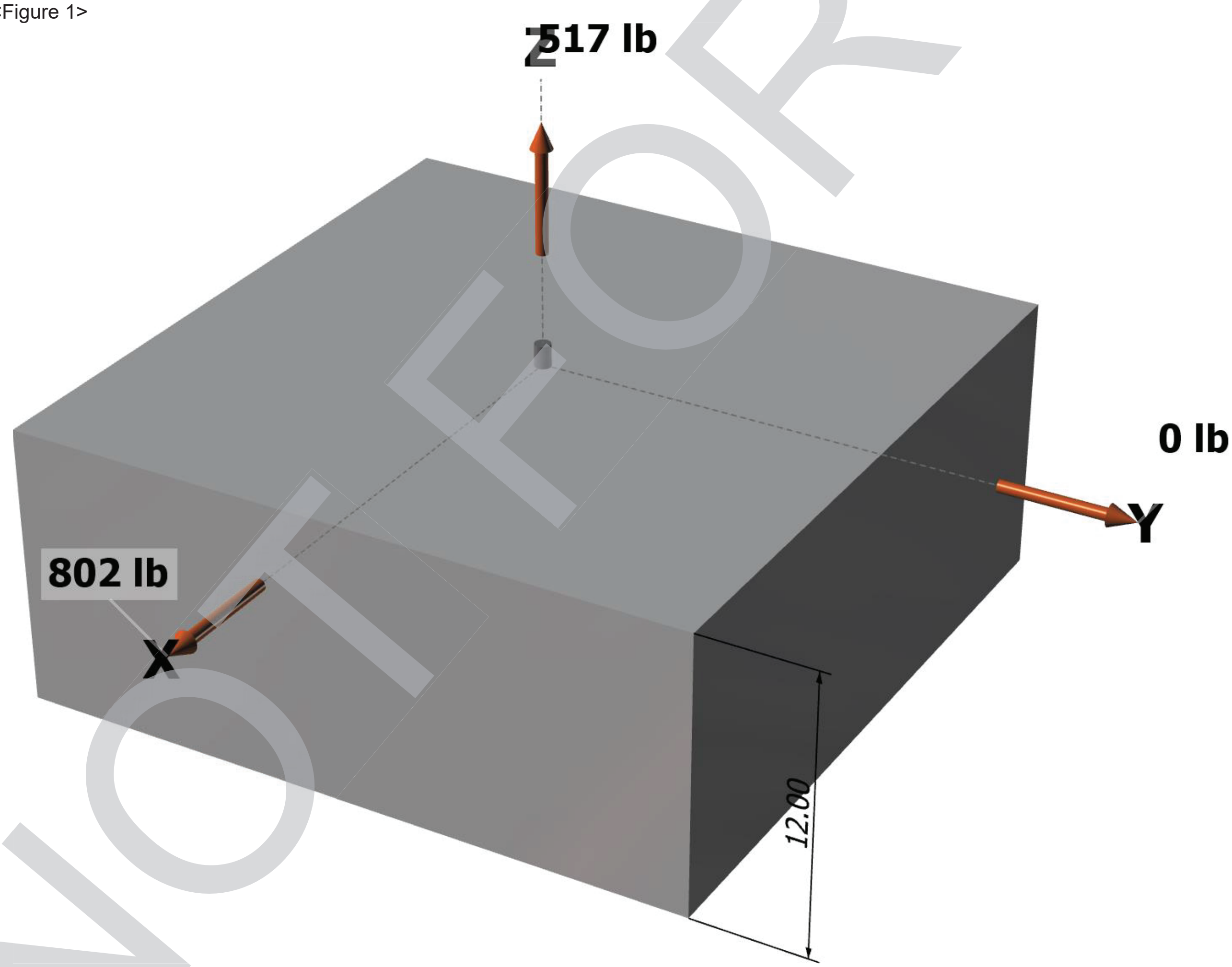
Company:	Innovative Structural Engr.	Date:	5/21/2021
Engineer:	SK	Page:	2/6
Project:	21-7178		
Address:	27369 Via Industria, Temecula, CA 92590		
Phone:	(951) 600-0032		
E-mail:	scott@iseengineers.com		

Load and Geometry
Load factor source: ACI 318 Section 5.3
Load combination: not set
Seismic design: Yes
Anchors subjected to sustained tension: Not applicable
Ductility section for tension: 17.2.3.4.3 (d) is satisfied
Ductility section for shear: 17.2.3.5.3 (c) is satisfied
Ω_0 factor: not set
Apply entire shear load at front row: No
Anchors only resisting wind and/or seismic loads: Yes

Strength level loads:

N_{ua} [lb]: 517
V_{uax} [lb]: 802
V_{uay} [lb]: 0

<Figure 1>



Company:	Innovative Structural Engr.	Date:	5/21/2021
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Project:	21-7178		
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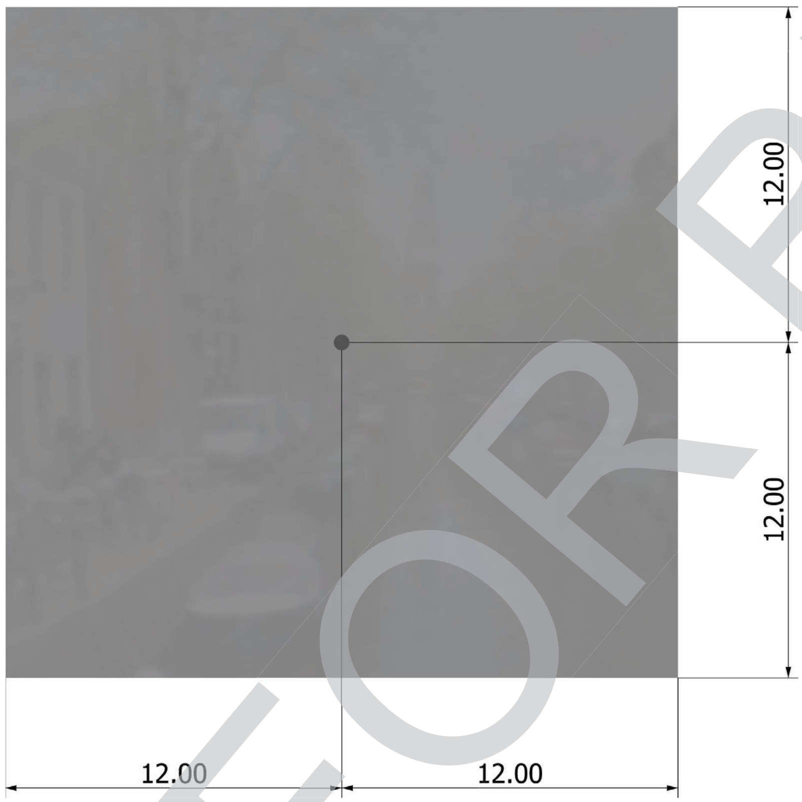
<Figure 2>



3. Resulting Anchor Forces

Anchor	Tension load, N_{ua} (lb)	Shear load x, V_{uax} (lb)	Shear load y, V_{uay} (lb)	Shear load combined, $\sqrt{(V_{uax})^2+(V_{uay})^2}$ (lb)
1	517.0	802.0	0.0	802.0
Sum	517.0	802.0	0.0	802.0

Maximum concrete compression strain (‰): 0.00
Maximum concrete compression stress (psi): 0
Resultant tension force (lb): 517
Resultant compression force (lb): 0
Eccentricity of resultant tension forces in x-axis, e'_{Nx} (inch): 0.00
Eccentricity of resultant tension forces in y-axis, e'_{Ny} (inch): 0.00
Eccentricity of resultant shear forces in x-axis, e'_{Vx} (inch): 0.00
Eccentricity of resultant shear forces in y-axis, e'_{Vy} (inch): 0.00

4. Steel Strength of Anchor in Tension (Sec. 17.4.1)

N_{sa} (lb)	ϕ	ϕN_{sa} (lb)
12100	0.75	9075

5. Concrete Breakout Strength of Anchor in Tension (Sec. 17.4.2)

$N_b = k_c \lambda_a \sqrt{f'_c} h_{ef}^{1.5}$ (Eq. 17.4.2.2a)

k_c	λ_a	f'_c (psi)	h_{ef} (in)	N_b (lb)
17.0	1.00	2500	2.250	2869

$0.75\phi N_{cb} = 0.75\phi (A_{Nc} / A_{Nco}) \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b$ (Sec. 17.3.1 & Eq. 17.4.2.1a)

A_{Nc} (in²)	A_{Nco} (in²	$c_{a,min}$ (in)	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	$0.75\phi N_{cb}$ (lb)
45.56	45.56	12.00	1.000	1.00	1.000	2869	0.65	1399

6. Pullout Strength of Anchor in Tension (Sec. 17.4.3)

$0.75\phi N_{pn} = 0.75\phi \Psi_{c,P} \lambda_a N_p (f'_c / 2{,}500)^n$ (Sec. 17.3.1, Eq. 17.4.3.1 & Code Report)

$\Psi_{c,P}$	λ_a	N_p (lb)	f'_c (psi)	n	ϕ	$0.75\phi N_{pn}$ (lb)
1.0	1.00	2870	2500	0.50	0.65	1399

8. Steel Strength of Anchor in Shear (Sec. 17.5.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\phi_{grout}\phi V_{sa}$ (lb)
6510	1.0	0.65	4232

9. Concrete Breakout Strength of Anchor in Shear (Sec. 17.5.2)

Shear perpendicular to edge in x-direction:

$V_{bx} = \min|7(l_e / d_a)^{0.2}\sqrt{d_a}\lambda_a\sqrt{f'_c}c_{a1}^{1.5}; 9\lambda_a\sqrt{f'_c}c_{a1}^{1.5}|$ (Eq. 17.5.2.2a & Eq. 17.5.2.2b)

l_e (in)	d_a (in)	λ_a	f'_c (psi)	c_{a1} (in)	V_{bx} (lb)
2.25	0.500	1.00	2500	8.00	7565

$\phi V_{cbx} = \phi\ (A_{Vc} / A_{Vco})\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{bx}$ (Sec. 17.3.1 & Eq. 17.5.2.1a)

A_{Vc} (in^2)	A_{Vco} (in^2)	$\Psi_{ed,V}$	$\Psi_{c,V}$	$\Psi_{h,V}$	V_{bx} (lb)	ϕ	ϕV_{cbx} (lb)
288.00	288.00	1.000	1.000	1.000	7565	0.70	5296

Shear parallel to edge in x-direction:

$V_{by} = \min|7(l_e / d_a)^{0.2}\sqrt{d_a}\lambda_a\sqrt{f'_c}c_{a1}^{1.5}; 9\lambda_a\sqrt{f'_c}c_{a1}^{1.5}|$ (Eq. 17.5.2.2a & Eq. 17.5.2.2b)

l_e (in)	d_a (in)	λ_a	f'_c (psi)	c_{a1} (in)	V_{by} (lb)
2.25	0.500	1.00	2500	8.00	7565

$\phi V_{cbx} = \phi\ (2)(A_{Vc} / A_{Vco})\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{by}$ (Sec. 17.3.1, 17.5.2.1(c) & Eq. 17.5.2.1a)

A_{Vc} (in^2)	A_{Vco} (in^2)	$\Psi_{ed,V}$	$\Psi_{c,V}$	$\Psi_{h,V}$	V_{by} (lb)	ϕ	ϕV_{cbx} (lb)
288.00	288.00	1.000	1.000	1.000	7565	0.70	10592

10. Concrete Pryout Strength of Anchor in Shear (Sec. 17.5.3)

$\phi V_{cp} = \phi k_{cp}N_{cb} = \phi k_{cp}(A_{Nc} / A_{Nco})\Psi_{ed,N}\Psi_{c,N}\Psi_{cp,N}N_b$ (Sec. 17.3.1 & Eq. 17.5.3.1a)

k_{cp}	A_{Nc} (in^2)	A_{Nco} (in^2)	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	ϕV_{cp} (lb)
1.0	45.56	45.56	1.000	1.000	1.000	2869	0.70	2008

11. Results

Interaction of Tensile and Shear Forces (Sec. R17.6)

Tension	Factored Load, N_{ua} (lb)	Design Strength, $øN_n$ (lb)	Ratio	Status
Steel	517	9075	0.06	Pass
Concrete breakout	**517**	**1399**	**0.37**	**Pass (Governs)**
Pullout	517	1399	0.37	Pass

Shear	Factored Load, V_{ua} (lb)	Design Strength, $øV_n$ (lb)	Ratio	Status
Steel	802	4232	0.19	Pass
T Concrete breakout x+	802	5296	0.15	Pass
|| Concrete breakout y-	802	10592	0.08	Pass
Pryout	**802**	**2008**	**0.40**	**Pass (Governs)**

Interaction check	$(N_{ua}/\phi N_{ua})^{5/3}$	$(V_{ua}/\phi V_{ua})^{5/3}$	Combined Ratio	Permissible	Status
Sec. R17.6	0.19	0.22	40.7%	1.0	Pass

1/2"Ø CS Strong-Bolt 2, hnom:2.75" (70mm) meets the selected design criteria.

12. Warnings

- Per designer input, ductility requirements for tension have been determined to be satisfied – designer to verify.

- Per designer input, ductility requirements for shear have been determined to be satisfied – designer to verify.

- Designer must exercise own judgement to determine if this design is suitable.

- Refer to manufacturer's product literature for hole cleaning and installation instructions.

INNOVATIVE
STRUCTURAL ENGINEERING

GUARDRAIL CONNECTION COVER

Steel Column

DESCRIPTION: Minimum Guardrail Post Size - Sheet A4.1

Code References

Calculations per AISC 360-16, IBC 2018, CBC 2019, ASCE 7-16
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : Pipe2STD
Analysis Method : Allowable Strength
Steel Stress Grade , A53, Grade B, Fy = 35 ksi, Carbon
Fy : Steel Yield 35.0 ksi
E : Elastic Bending Modulus 29,000.0 ksi

Overall Column Height 3.50 ft
Top & Bottom Fixity Top Free, Bottom Fixed
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 3.50 ft, K = 2.1
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 3.50 ft, K = 2.1

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 12.810 lbs * Dead Load Factor
BENDING LOADS . . .
Guardrail Load: Lat. Point Load at 3.50 ft creating Mx-x, L = 0.30 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = 0.8438 : 1
Load Combination +D+L
Location of max.above base 0.0 ft
At maximum location values are . . .
Pa : Axial 0.01281 k
Pn / Omega : Allowable 11.339 k
Ma-x : Applied -1.050 k-ft
Mn-x / Omega : Allowable 1.245 k-ft
Ma-y : Applied 0.0 k-ft
Mn-y / Omega : Allowable 1.245 k-ft

PASS Maximum Shear Stress Ratio = 0.04678 : 1
Load Combination +D+L
Location of max.above base 0.0 ft
At maximum location values are . . .
Va : Applied 0.30 k
Vn / Omega : Allowable 6.413 k

Maximum Load Reactions . .
Top along X-X 0.0 k
Bottom along X-X 0.0 k
Top along Y-Y 0.0 k
Bottom along Y-Y 0.30 k

Maximum Load Deflections . . .
Along Y-Y 0.4054 in at 3.50 ft above base
for load combination : +D+L
Along X-X 0.0 in at 0.0 ft above base
for load combination :

Load Combination Results

	Maximum Axial + Bending Stress Ratios							Maximum Shear Ratios		
Load Combination	Stress Ratio	Status	Location	Cbx	Cby	KxLx/Rx	KyLy/Ry	Stress Ratio	Status	Location
D Only	0.001	PASS	0.00 ft	1.67	1.00	111.50	111.50	0.000	PASS	0.00 ft
+D+L	0.844	PASS	0.00 ft	1.67	1.00	111.50	111.50	0.047	PASS	0.00 ft
+D+0.750L	0.633	PASS	0.00 ft	1.67	1.00	111.50	111.50	0.035	PASS	0.00 ft
+0.60D	0.001	PASS	0.00 ft	1.67	1.00	111.50	111.50	0.000	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	0.013								
+D+L	0.013			0.300		-1.050			
+D+0.750L	0.013			0.225		-0.788			
+0.60D	0.008								
L Only				0.300		-1.050			

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments @ Top	My - End Moments @ Base	My - End Moments @ Top
Axial @ Base	Maximum	0.013								
"	Minimum				0.300		-1.050			

Steel Column

DESCRIPTION: Minimum Guardrail Post Size - Sheet A4.1

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction (k) @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments (k-ft) @ Top	My - End Moments @ Base	My - End Moments @ Top
Reaction, X-X Axis Base	Maximum	0.013								
"	Minimum	0.013								
Reaction, Y-Y Axis Base	Maximum	0.013			0.300		-1.050			
"	Minimum	0.013								
Reaction, X-X Axis Top	Maximum	0.013								
"	Minimum	0.013								
Reaction, Y-Y Axis Top	Maximum	0.013								
"	Minimum	0.013								
Moment, X-X Axis Base	Maximum	0.013								
"	Minimum	0.013	-1.050		0.300		-1.050			
Moment, Y-Y Axis Base	Maximum	0.013								
"	Minimum	0.013								
Moment, X-X Axis Top	Maximum	0.013								
"	Minimum	0.013								
Moment, Y-Y Axis Top	Maximum	0.013								
"	Minimum	0.013								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
+D+L	0.0000	in	0.000	ft	0.405	in	3.500	ft
+D+0.750L	0.0000	in	0.000	ft	0.304	in	3.500	ft
+0.60D	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.401	in	3.477	ft

Steel Section Properties : Pipe2STD

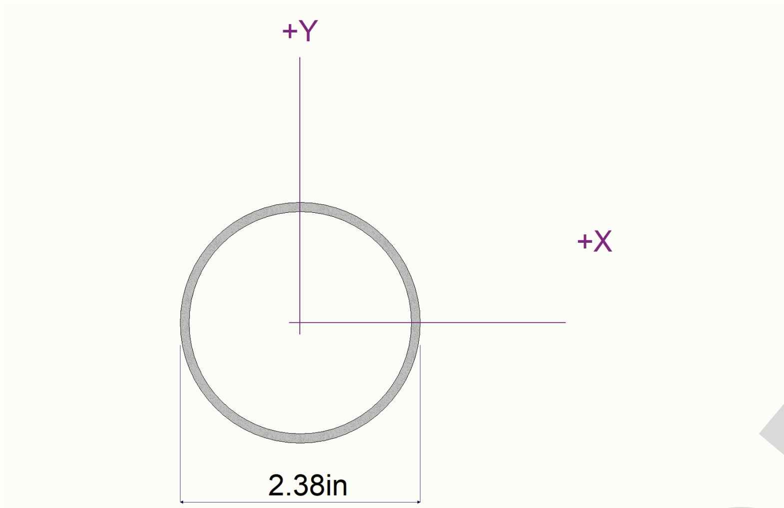
Depth	=	2.375 in	I xx	=	0.63 in^4	J	=	1.250 in^4
			S xx	=	0.53 in^3			
Diameter	=	2.375 in	R xx	=	0.791 in			
Wall Thick	=	0.154 in	Zx	=	0.713 in^3			
Area	=	1.020 in^2	I yy	=	0.627 in^4			
Weight	=	3.660 plf	S yy	=	0.528 in^3			
			R yy	=	0.791 in			
Ycg	=	0.000 in						

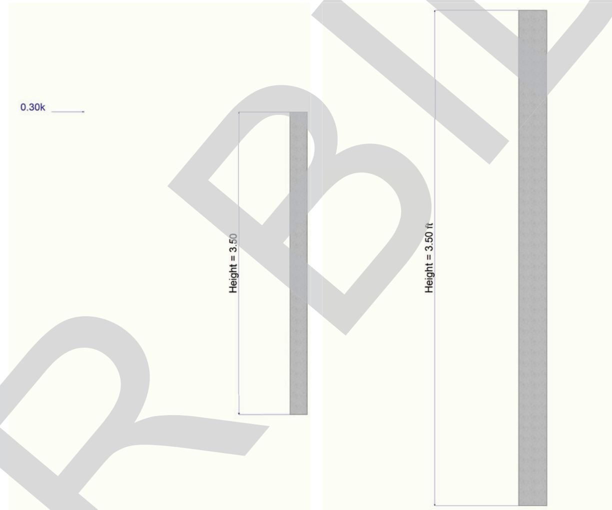
Steel Column

Lic. # : KW-06008078 **Innovative Structural Engineering, Inc. (ISE)**

DESCRIPTION: Minimum Guardrail Post Size - Sheet A4.1

Sketches





INNOVATIVE
STRUCTURAL ENGINEERING
40810 COUNTY CENTER DR. #110
TEMECULA, CA 92591
ISEENGINEERS.COM

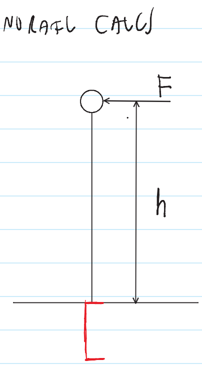
PROJECT: San Bernardino, Public Works, Rancho Yard Maintenance - Guardrail

JOB NO: 21-7178

CALCULATED BY: SK

DATE: 05/21/21 SHEET NO. 1 OF 1

HANDRAIL CALCS



$F = \max(50\,plf * S,\ 200\#) = \max(300\#, 200\#)$

$S = 6'\text{-}0''$

$F = 300\#\ (1.0L)$

$M_0 = Fh = 1050\ \#\text{-ft} = 12{,}600\ \#\text{-in.} = 12.6\ \text{k-in.}$

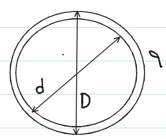
$h = 3'\text{-}6''$

WELDED CONNECTION:

STEEL CHANNEL TO 2" Ø, SCHEDULE 40 PIPE

A53, GRADE B, 2"Ø STANDARD/SCHEDULE 40 PIPE

$F_y = 35\ ksi,\ F_u = 60\ ksi$



CIRCULAR WELD

$t_1 = 9/64''\ (\text{PIPE}),\ a = 1/4''$

$d_{pipe} = 2.375'',\quad d_{weld} = d_{pipe} + 2a = 2.875''$

CHECK WELD STRENGTH:

$F_W = 0.60\ F_{exx} = 42\ ksi,\quad \phi = 0.75,\ \Omega = 2.0$

$F_{exx} = 70\ ksi$

$\phi F_W = 31.5\ ksi,\quad F_W/\Omega = 21\ ksi$

$I_{wx} = \dfrac{\pi(d_{weld}^4 - d_{pipe}^4)}{64} = 1.792\ in.^4$

$r_y = d_{weld}/2 = 1.4375'',\quad S_{wx} = I_{wx}/r_y = 1.247\ in.^3$

$\sigma_b = M_0/S_{wx} = 10.11\ ksi,\quad \sigma_b < F_W/\Omega$

USE 2" Ø STANDARD PIPE W/ 1/4" thick CIRCULAR FILLET WELD AT THE BASE.