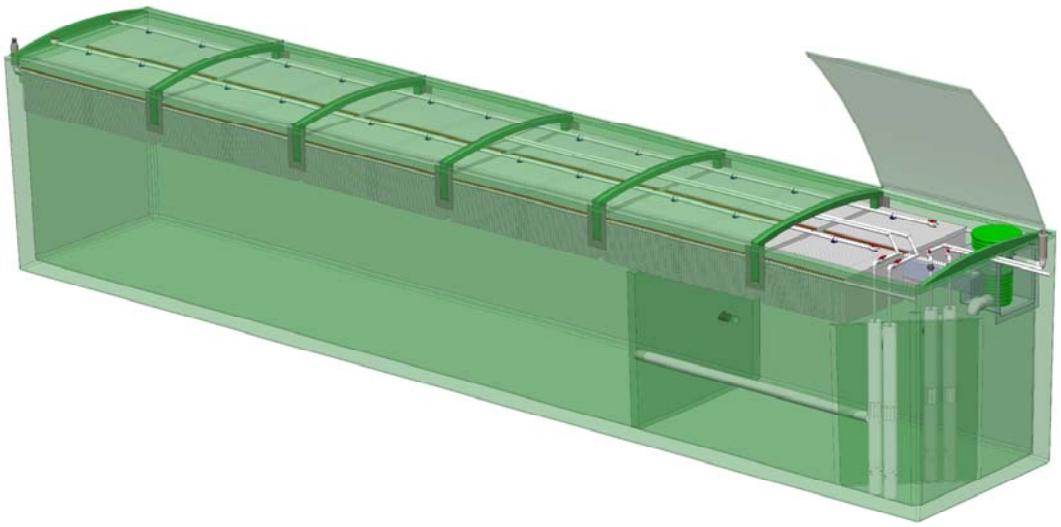
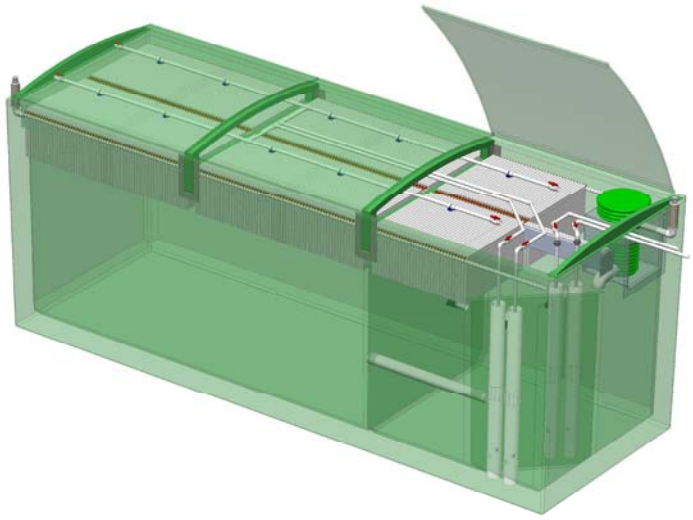
AX-MAX Units
Structural Evaluation
Orenco Systems, Inc.





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June, 2011

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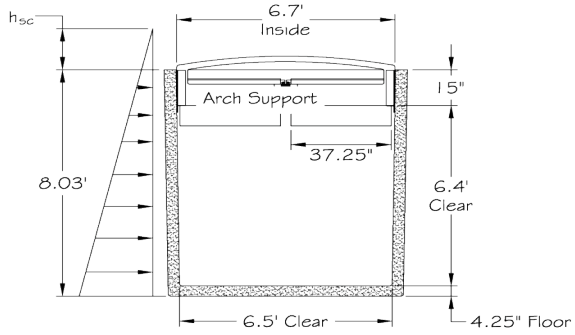
AXMax Structural Evaluation

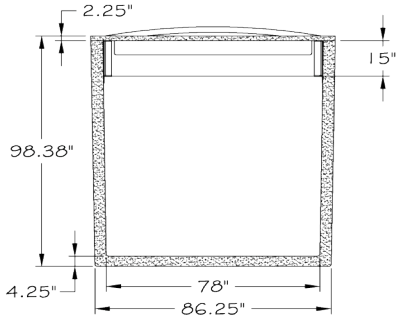
TB



Side View with Arch Rib/Lid

Dead Loads:

Panels 4" FRP: DL	4.12 psf	
Panels 3" FRP: DL	3.92 psf	
Panels 2" FRP: DL	3.71 psf	
AX Media (two rows, qty 18 sheets/lineal ft)		
Width =	37.25 in	
Volume =	310 ft3	
Dry Weight =	4.8 pcf	*5.2 psf surface area*
Wet Weight =	10 pcf	*13 psf surface area*
WHC =	15%	
Porocity =	90%	
Arch Supports: DL	100 lb/ea	
Lid Wt: DL	4 psf	



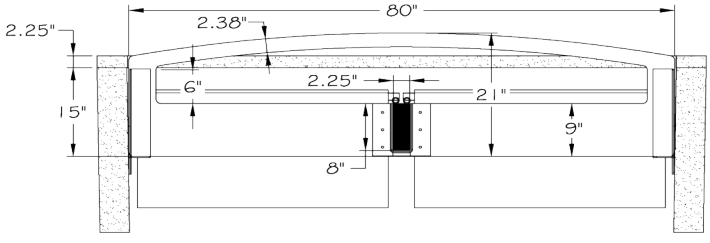
Side View with 2" Top

Live & Operating Loads:

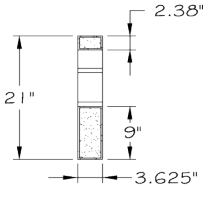
Hydrostatic LL:	62.4 pcf	
Surcharge (Traffic Load):	100 psf	
Misc. Live Loads:	25 psf	
EFP (Lateral Soil Pressure) =	62.4 pcf	
Soil Density, Dry unit wt:	140 pcf	
Soil Density, Wet unit wt:	127 pcf	
Soil Bearing, q_u =	1,000 psf	*Ref UBC*
E - Type Fiberglass:		
Fiberglass:	60%	
h_{sc} = Surcharge Height:		

Typical Properties:

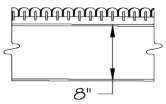
Ultimate Tensile Strength, F_t =	26,500 psi
Ultimate Flexural Strenght, F_{flex}=	39,500 psi
Ultimate Compressive Strength, F_c =	34,500 psi
Ultimate Shear Strength, F_s =	15,900 psi
Flexural Modulus, E_{flex}=	1,600,000 psi



Arch Support Detail

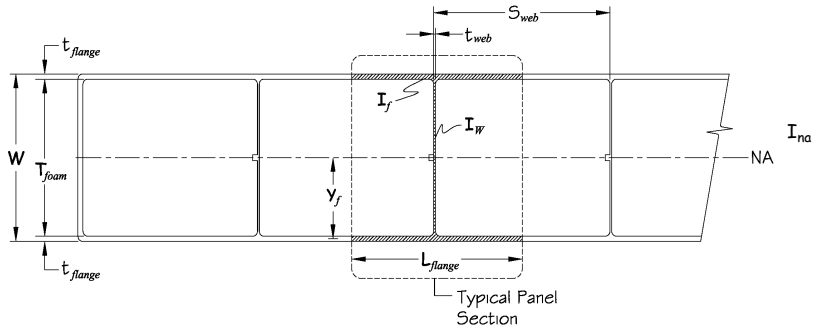


Arch Cross Section



Sheet Center Beam

AXMax … Infused Panel Section's Moment of Inertia, I_{na}:



Typical Infused Structural Sandwich Panel Section

$I_{na} = 2I_f + I_w + 2A_fY_f^2$

FRP Properties,

Yield stresses proportioned as a function of both the standard and Quad axial blend strengths

F_t =	26,500 psi
F_{flex} =	39,500 psi
F_c =	34,500 psi
F_s =	15,900 psi
E_{flex} =	1,600,000 psi

Foam Properties

	2 in	3 in	4 in
W_f =	310 psi	240 psi	180 psi
F_c =	410 psi	260 psi	120 psi
F_{si} =	26 psi	26 psi	26 psi
F_{st} =	2 pcf	2 pcf	2 pcf
Unit Weight Foam:	0.33 psf	0.50 psf	0.67 psf
Weigth/ft²:	2.13	3.26	4.40
R-value, m²K/W	12.1	18.5	25.0
LTTR			

FRP Properties Walls Samples:

	T_{actual}	Weight	Volume	Density/SG
1a		6,091 mg	3 ml	2.03 gm/cc
1b		6,340 mg	3 ml	2.11 gm/cc
2a		6,370 mg	3 ml	2.12 gm/cc
2b		6,413 mg	4 ml	1.83 gm/cc
			Average:	2.02 gm/cc
			Average	126.3 pcf

Wall Properties

	T_{foam} *in.*	S_{web} *in.*	t_{web} *in.*	d_{web} *in.*	t_{flange} *in.*	L_{flange} *in.*	A_{flange} in^2	Y_{flange} *in.*	I_{flange} in^4	I_{web} in^4	I_{na} in^4	S_{na} in^3	EI $lbs{\cdot}in^2$	A_{frp} in^2	A_{foam} in^2	Q_{frp} in^3
2" Design Panel:	2	8	0.125	2	0.125	8	1.0	1.0625	0.0013	0.08	2.3	2.1	3,750,000	2.25	16	1.13
3" Design Panel:	3	12	0.125	3	0.125	12	1.5	1.5625	0.0020	0.28	7.6	4.7	12,175,000	3.38	36	2.48
Test Panel:	3	12	0.08	3	0.155	12	1.86	1.5775	0.0037	0.18	9.4	5.7	15,111,506	3.96	36	3.02
4" Design Panel:	4	8	0.125	4	0.125	8	1.0	2.0625	0.0013	0.67	9.2	4.3	14,683,333	2.50	32	2.31
6" Design Panel:	6	8	0.125	6	0.125	8	1.0	3.0625	0.0013	2.25	21.0	6.7	33,616,667	2.75	48	3.63

Wall Dead Load and Total Thickness:

	Nominal, t	Actual, t	DL	**25% over**
2" Design Panel:	2 in	2.25 in	2.97 psf	3.71 psf
3" Design Panel:	3 in	3.25 in	3.13 psf	3.92 psf
4" Design Panel:	4 in	4.25 in	3.30 psf	4.12 psf

AXMax - Moment Distribution w/ Simple Top Connection

Outside Dimensions

Height, $H_{outside}$ =	96.38 in
Top width, W_{top} =	89.25 in
Bottom width, W_{bottom} =	86.25 in
Top length, L_{top} =	502.25 in
Bottom length, L_{bottom} =	498.75 in
Side Wall Taper =	*1.5 in*
End Wall Taper =	*1.75 in*
Outside Volume =	2,449 ft3
Outside Volume =	18,322 gal
Buoyancy tank =	152,847 lbs
Weight tank =	4,682 lbs
Weight Top =	1,868 lbs
Weight Steel Buoyancy Frame =	2,163 lbs
Net Buoyancy Empty =	144,134 lbs
Net Buoyancy 1/2 full =	79,484 lbs
Net Buoyancy 7.5' Bury =	134,593 lbs
Wall Surface Area =	787 ft2
Lateral Soil Bearing Sides =	100 psf/ft

Inside Dimensions

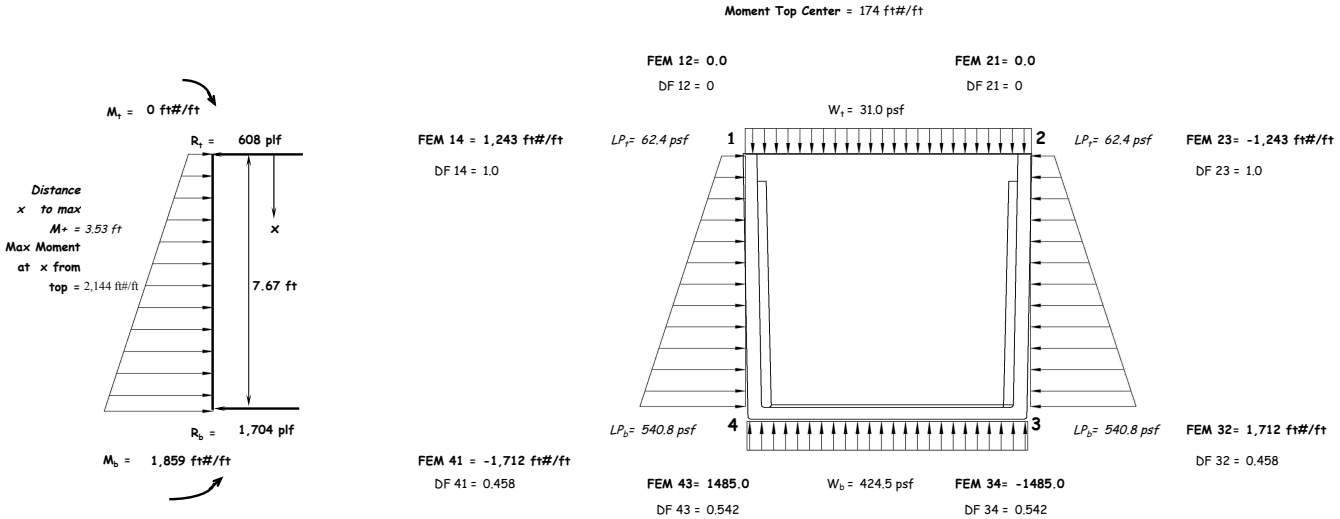
Height, H_{inside} =	92.00 in
Top width, $W_{top\ inside}$ =	80.50 in
Bottom width, $W_{bottom\ inside}$ =	77.75 in
Top length, L_{top} =	493.50 in
Bottom length, $L_{bottom\ inside}$ =	490.25 in
Side Wall Taper =	*1.4 in*
End Wall Taper =	*1.63 in*
Inside Volume =	2,072 ft3
Inside Volume =	15,499 gal
Ave Inside Volume =	2,022 gal/ft

Clear Spans ... L_c:

	W	I	K
Walls:	7.67 ft	4.25 in	9.20 in4	0.100
Top:	6.71 ft	2.25 in	2.30 in4	0.000
Bottom:	6.48 ft	4.25 in	9.20 in4	0.118

Top Dead Load:	6 psf	C_d:	0.9
Top Live Load:	25 psf	C_d:	1.15
Surcharge Load:	100 psf		
Soil Density:	100 pcf		
EFP:	62.4 pcf	C_d:	1.0

Pressure Height =	8.7 ft
Lateral Pressure Top =	62.4 psf
Lateral Pressure Bottom =	540.8 psf
Pressure Bottom (with buoyancy) =	424.5 psf
Max Vertical Soil Bearing =	2,000 psf
Typical Operating Liquid Level =	70.0 in
Wt at Operation depth =	107,093 lbs
Bottom Bearing Area =	299 ft2
Bottom Bearing Load @ 70" operating LL =	358 psf



Joints	3		4		1		2	
	$Wall_{32}$	$Bottom_{34}$	$Bottom_{43}$	$Wall_{41}$	$Wall_{14}$	Top_{12}	Top_{21}	$Wall_{23}$
DF	*0.458*	*0.542*	*0.542*	*0.458*	*1.000*	*0.000*	*0.000*	*1.000*
FEM	1711.6	-1485.0	1485.0	-1711.6	1243.0	0.0	0.0	-1243.0
D1	-103.8	-122.8	122.8	103.8	-1243.0	0.0	0.0	1243.0
CO1	621.5	61.4	-61.4	-621.5	51.9	0.0	0.0	-51.9
D2	-312.8	-370.1	370.1	312.8	-51.9	0.0	0.0	51.9
CO2	26.0	185.1	-185.1	-26.0	156.4	0.0	0.0	-156.4
D3	-96.6	-114.4	114.4	96.6	-156.4	0.0	0.0	156.4
CO3	78.2	57.2	-57.2	-78.2	48.3	0.0	0.0	-48.3
D4	-62.0	-73.4	73.4	62.0	-48.3	0.0	0.0	48.3
CO4	24.2	36.7	-36.7	-24.2	31.0	0.0	0.0	-31.0
D5	-27.9	-33.0	33.0	27.9	-31.0	0.0	0.0	31.0
CO5	15.5	16.5	-16.5	-15.5	13.9	0.0	0.0	-13.9
D6	-14.7	-17.3	17.3	14.7	-13.9	0.0	0.0	13.9
CO6	7.0	8.7	-8.7	-7.0	7.3	0.0	0.0	-7.3
D7	-7.2	-8.5	8.5	7.2	-7.3	0.0	0.0	7.3
Moments	*1859*	*-1859*	*1859*	*-1859*	*0*	*0*	*0*	*0*

AX comm RT - Moment Distribution w/ Fixed Top Connection

Outside Dimensions

Height, $H_{outside}$ =	96.38 in
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Net Buoyancy 7.5' Bury = 134,593 lbs
Wall Surface Area = 787 ft2
Lateral Soil Bearing Sides = 100 psf/ft

Inside Dimensions

Height, H_{inside} =	92.00 in
Top width, $W_{top\ inside}$ =	80.50 in
Bottom width, $W_{bottom\ inside}$ =	77.75 in
Top length, L_{top} =	493.50 in
Bottom length, $L_{bottom\ inside}$ =	490.25 in

Side Wall Taper = 1.4 in
End Wall Taper = 1.6 in

Inside Volume = 2,072 ft3
Inside Volume = 15,499 gal
Ave Inside Volume = 2,022 gal/ft

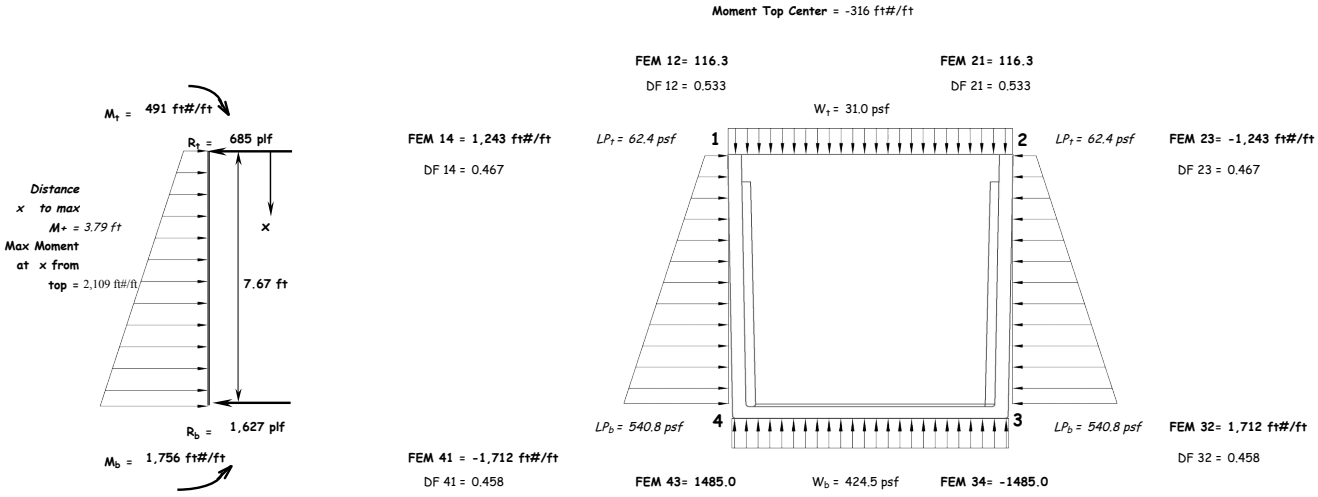
Clear Spans ... L_c:

	L_c	W	I	K
Walls:	7.67 ft	4.25 in	9.20 in4	0.100
Top:	6.71 ft	4.25 in	9.20 in4	0.114
Bottom:	6.48 ft	4.25 in	9.20 in4	0.118

Top Dead Load:	6 psf	C_d:	0.9
Top Live Load:	25 psf	C_d:	1.15
Surcharge Load:	100 psf		
Soil Density:	100 pcf		
EFP:	62.4 pcf	C_d:	1.0

Pressure Height = 8.7 ft
Lateral Pressure Top = 62.4 psf
Lateral Pressure Bottom = 540.8 psf
Pressure Bottom (with buoyancy) = 424.5 psf
Max Vertical Soil Bearing = 2,000 psf

Operating Liquid Level = 70.0 in
Wt at Operation depth = 107,093 lbs
Bottom Bearing Area = 299 ft2
Bottom Bearing Load @ 70" operating LL = 358 psf

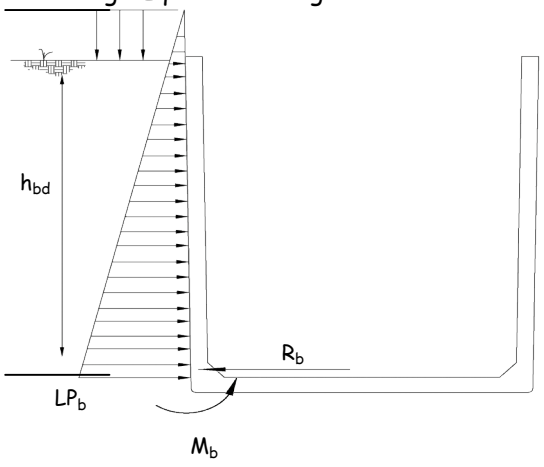


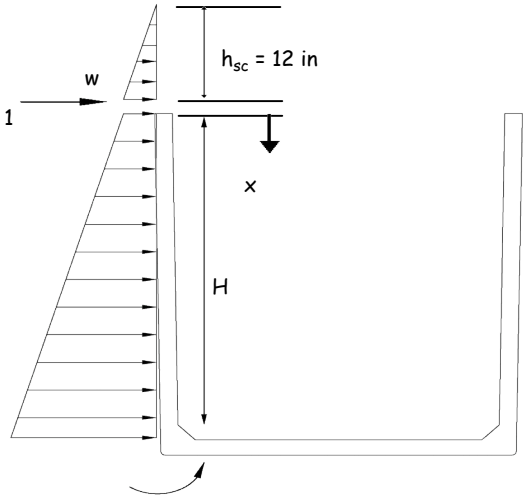
Joints	3		4		1		2	
	$Wall_{32}$	$Bottom_{34}$	$Bottom_{43}$	$Wall_{41}$	$Wall_{14}$	Top_{12}	Top_{21}	$Wall_{23}$
DF	*0.458*	*0.542*	*0.542*	*0.458*	*0.467*	*0.533*	*0.533*	*0.467*
FEM	1711.6	-1485.0	1485.0	-1711.6	1243.0	116.3	116.3	-1243.0
D1	-103.8	-122.8	122.8	103.8	-634.3	-724.9	600.9	525.8
CO1	262.9	61.4	-61.4	-317.1	51.9	300.5	-362.5	-51.9
D2	-148.5	-175.8	205.2	173.4	-164.4	-187.9	221.0	193.4
CO2	96.7	102.6	-87.9	-82.2	86.7	110.5	-94.0	-74.3
D3	-91.3	-108.0	92.2	77.9	-92.0	-105.2	89.7	78.5
CO3	39.3	46.1	-54.0	-46.0	39.0	44.9	-52.6	-45.6
D4	-39.1	-46.3	54.2	45.8	-39.1	-44.7	52.4	45.8
CO4	22.9	27.1	-23.1	-19.6	22.9	26.2	-22.4	-19.5
D5	-22.9	-27.1	23.1	19.6	-22.9	-26.2	22.3	19.6
CO5	9.8	11.6	-13.6	-11.5	9.8	11.2	-13.1	-11.5
D6	-9.8	-11.6	13.6	11.5	-9.8	-11.2	13.1	11.5
CO6	5.7	6.8	-5.8	-4.9	5.7	6.5	-5.6	-4.9
D7	-5.7	-6.8	5.8	4.9	-5.7	-6.5	5.6	4.9
Moments	*1728*	*-1728*	*1756*	*-1756*	*491*	*-491*	*571*	*-571*

AX Max - Lateral Load Evaluation w/ Surcharge

Unsupported at Top (*Sheet Open area*)

Surcharge Equivalent Height





$$M = \frac{EFP\ x^3}{6} + \frac{wx^2}{2}$$

m = 1 x *Visual Integration moment*

w = EFP(h_{sc})

H = 92 in

Lateral Load

Surcharge	100 psf
EFP =	62.4 pcf
h_{bd} =	8.70 ft
LP_b =	543 psf
M_b =	6,848 ft#/ft
R_b =	2,362 plf
C_d =	1.0

4" Panel Section

S_{web} =	8.0 in
I_{na} =	9.18 in4
S_{na} =	4.32 in3
A_{frp} =	2.50 in2
Q_{frp} =	2.31 in2
t_{web} =	0.13 in2

Bending and Shear Stress

$F_{flex\ max}$ =	39,500 psi	
f_{flex} =	*12,686 psi*	**OK**
$F_{s\ max}$ =	15,900 psi	
f_v =	*3,174 psi*	**OK**

Lateral Deflection

$$\Delta_{top} = \int_0^H \frac{Mmdx}{EI}$$

$$\Delta_{top} = \int_0^H \left(\frac{EFPx^3}{6EI} + \frac{wx^2}{2EI}\right) 1x\ dx$$

Top Unsupported Deflection

$$\Delta_{top} = \frac{EFP}{6EI} \int_0^H (x^3 + 3h_{sc}x^2)\, 1x\, dx$$

$$\Delta_{top} = \frac{EFP}{6EI} \int_0^H (x^4 + 3h_{sc}x^3)\, dx$$

$$\Delta_{top} = \frac{EFP}{6EI} \left(\frac{x^5}{5} + \frac{3h_{sc}x^4}{4} \right) \Bigg|_0^H$$

Δ_{top} = 6.4 in

Bottom Empty Deflection

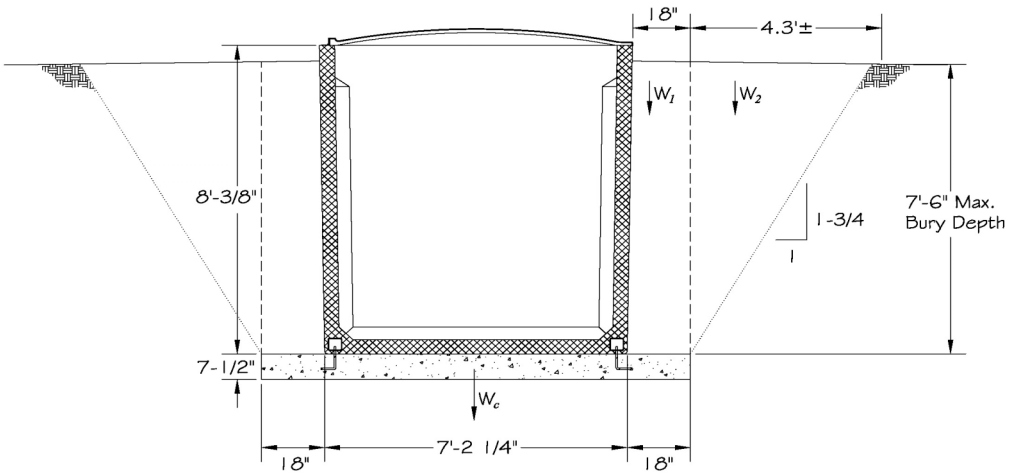
Buoyancy load on empty bottom, W_b = 424.5 psf

Clear Spans bottom, L_c = 6.48 ft

$\Delta_{bottom\ center\ span} = W_b L^4/384EI$ = 0.23 in

AXMax - Buoyancy Opt 1

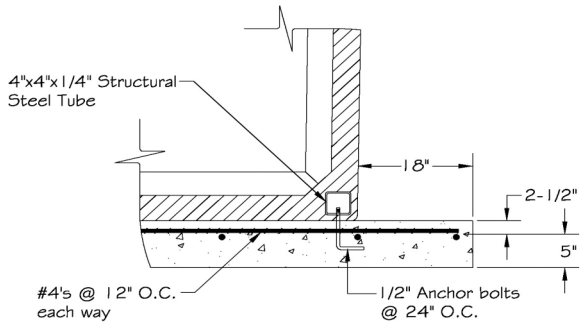
TB



End View

Buoyancy Load

Net Buoyancy Empty =	144,134 lbs
h_d =	7.5 ft
Net Buoyancy 7.5' Bury =	134,600 lbs
L_{bottom} =	41.6 ft
X_{Bottom} =	1.5 ft
A_1=	10.8 ft2
Soil Shear Line:	1.75
A_2=	16.1 ft2
Soil Density Saturated:	130 pcf
water:	62.4 pcf
Net effective soil load:	67.6 pcf



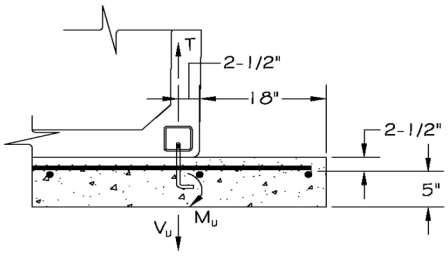
Concrete base:	
Width:	10.2 ft
Length:	44.6 ft
Thickness:	7.5 in
Unit weight concrete:	150 pcf
Net effective conc wt.:	87.6 pcf
Anti-buoyancy load =	223,624 lbs
SF =	1.66

Perimeter loading

$W_{buoy\ net}$ per side :	1,619 plf
$W_{1\ perimeter}$:	729 plf
$W_{2\ perimeter}$:	1,086 plf
$W_{C\ length}$:	94 plf
W_{total} DL :	1,909 plf

Flexural Strength

$\mathbf{M_U} = 1.4[(W_1 + Wc)w_B/2 + W_2(w_B+h_{bury}/1.75/3)(W_{buoy\ net}/W_{total\ DL})] =$ 5,031 ft#/ft



f_y :	60,000 psi
f_c' :	4,000 psi
Reinforcement, #4 ... A_s :	0.20 in2
b :	14.0 in
d :	5.25 in
φ bending :	0.9
C_d :	1.33
$\rho = A_s/bd$ =	0.0027

$\mathbf{M_b} = \varphi A_S df_y(1 - A_s f_y/1.7bdf_c')C_d(12/B) =$ 5,257 ft#/ft

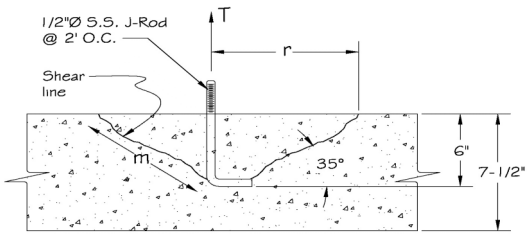
$M_b \geq M_u$: 1.04

Shear Strength

$\mathbf{V_U} = 1.4[W_{buoy\ net/side}] =$ 2,267 ft#/ft

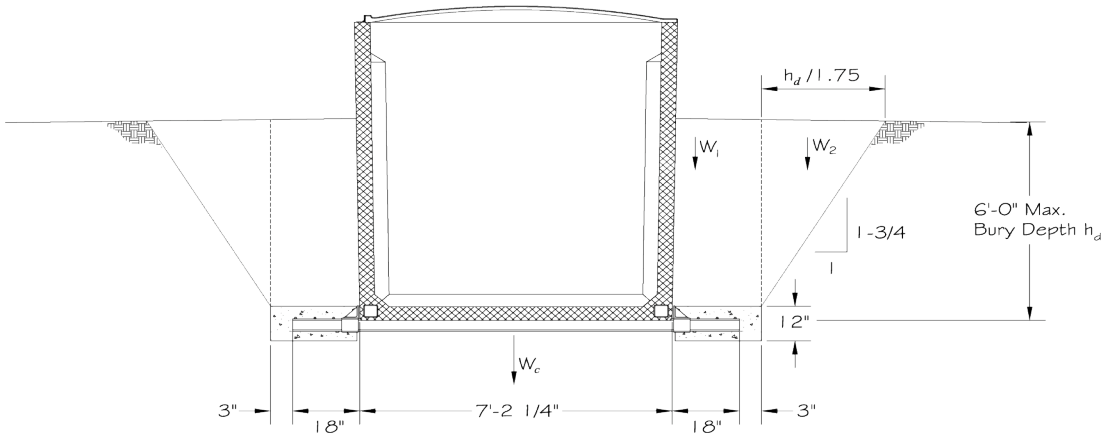
φ shear :	0.85
$v_c = 2\sqrt{f_c'}$ =	126.5 psi
$\mathbf{V_c} = \varphi bdv_cC_d$ =	10,510 lbs
$V_c \geq 2V_u$:	4.64

Pullout Load



1/2"dia anchor bolt, h_{anchor} :	6.0 in
Ø :	35
r :	8.6 in
m :	10.5 in
$A_{shear\ surface}$; Shear cone Area :	281.6 in2
$\mathbf{f_r} = 7.5\sqrt{f_c'}$ =	474 psi
$\mathbf{T_{max}}$ =	133,575 lbs

AXMax - Buoyancy Opt 2



End View

Buoyancy Load

h_d=	6.0 ft
Net Buoyancy h_d Bury =	107,680 lbs
L_{bottom} =	41.6 ft
w_{Bottom} =	1.5 ft
A_1=	8.6 ft2
Soil Shear Line:	1.75
A_2=	10.3 ft2
Soil Density Saturated:	130 pcf
water:	62.4 pcf
Net effective soil load:	67.6 pcf
Concrete base Option 1 slab:	
Width:	10.2 ft
Length:	44.6 ft
Thickness:	7.5 in
Unit weight concrete:	150 pcf
Net effective conc wt.:	87.6 pcf
Anti-buoyancy load =	164,836 lbs
SF =	1.53

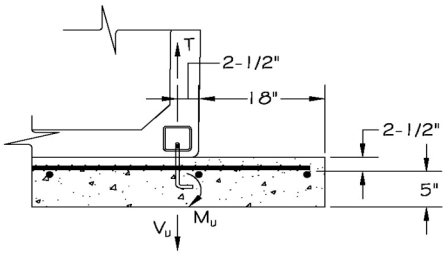
AXMax - Buoyancy

Perimeter loading

$W_{buoy\ net}$ per side :	1,295 plf
$W_{1\ perimeter}$:	583 plf
$W_{2\ perimeter}$:	695 plf
$W_{C\ length}$:	94 plf
W_{total} DL :	1,372 plf

Flexural Strength

$\mathbf{M_U} = 1.4[(W_1 + Wc)w_B/2 + W_2(w_B+h_{bury}/1.75/3)(W_{buoy\ net}/W_{total\ DL})] =$ 3,430 ft#/ft



f_y :	60,000 psi
f_c' :	4,000 psi
Reinforcement, #4 ... A_s :	0.20 in2
b :	18.0 in
d :	5.0 in
φ bending :	0.9
C_d :	1.33
$\rho = A_s/bd =$	0.0022

$\mathbf{M_b} = \varphi A_S d f_y(1 - A_s f_y/1.7bdf_c')C_d(12/b) =$ 3,912 ft#/ft

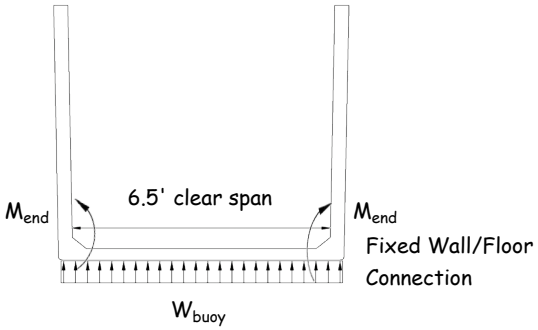
$M_b \geq M_u$: 1.14

Shear Strength

$\mathbf{V_U} = 1.4[W_{buoy\ net/side}] =$ 1,814 ft#/ft

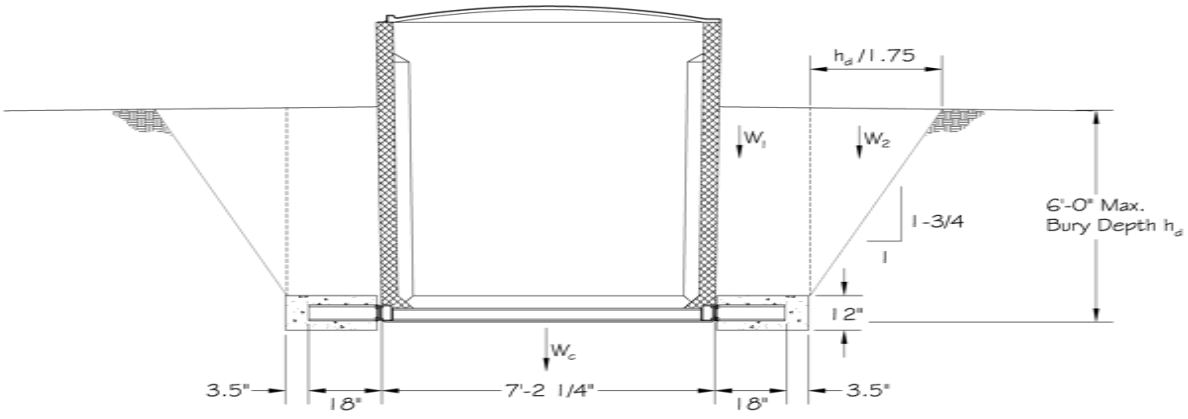
φ shear :	0.85
$v_c = 2\sqrt{f_c'} =$	126.5 psi
$\mathbf{V_c} = \varphi bdv_cC_d =$	12,870 lbs
$V_c \geq 2V_u$:	7.10

Buoyancy Load Bottom (4" Infused section)



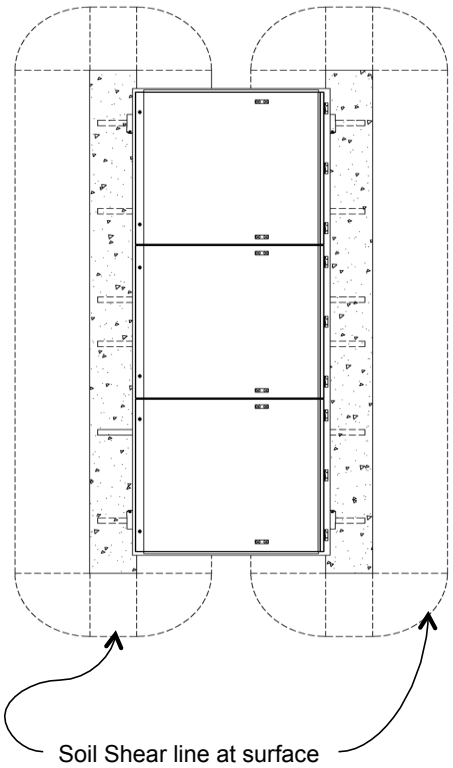
$W_{buoy\ 7.5'}$ bottom :	450.6 psf
$W_{buoy\ 6'}$ bottom :	360.5 psf
Clear Span ;	6.5 ft
$\mathbf{M_{end}} =$	1,586 ft#/ft
$f_b =$	3,314 psi
Δ, center span =	0.25 in

AXMax - Buoyancy Opt 3



End View

Buoyancy Load



h_d=	7.5 ft	6.0 ft
Net Buoyancy h_d Bury =	134,600 lbs	107,680 lbs
L_{bottom} =	41.6 ft	41.6 ft
w_{Bottom} =	1.50 ft	1.80 ft
A_1=	9.8 ft2	9.3 ft2
Soil Shear Line:	1.75	1.75
A_2=	13.3 ft2	8.1 ft2
Soil Density Saturated:	130 pcf	130 pcf
water:	62.4 pcf	62.4 pcf
Net effective soil load:	67.6 pcf	67.6 pcf
Concrete base:		
Width (both sides:	3.0 ft	3.6 ft
Length w/1' extended each end:	43.6 ft	43.6 ft
Thickness:	12.0 in	12.0 in
Unit weight concrete:	150 pcf	150 pcf
Net effective conc wt.:	87.6 pcf	87.6 pcf
Anti-buoyancy load =	171,647 lbs	129,347 lbs
SF =	1.275	1.201

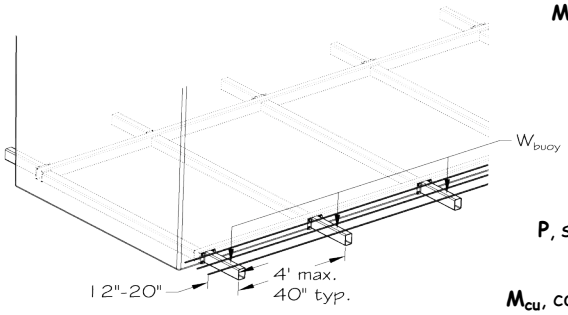
AXMax - Buoyancy

Perimeter loading

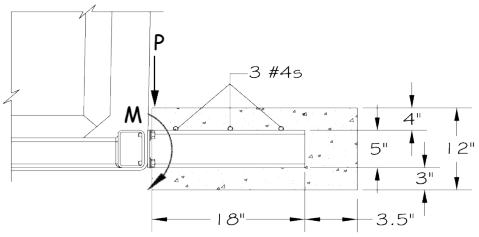
$W_{buoy\ net}$ per side :	1,619 plf	1,295 plf
$W_{1\ perimeter}$:	664.0 plf	626.4 plf
$W_{2\ perimeter}$:	901.9 plf	549.4 plf
$W_{C\ length}$:	131.4 plf	157.7 plf
W_{total} DL :	1,697 plf	1,333 plf

Flexural and Attachment Strength

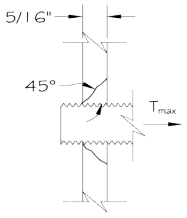
M = $(W_1 + W_C)w_B/2 + W_2(w_B+(h_{bury}/1.75/3))(W_{buoy\ net}/W_{total\ DL})$ =	3,007 ft#/ft	2,208 ft#/ft
C_d :	1.33	1.33
M per 3' spacing =	6,783 ft#/ft	4,982 ft#/ft
M per 4' spacing =	9,044 ft#/ft	6,642 ft#/ft
M per 40" spacing =	7,536 ft#/ft	5,535 ft#/ft



S_b at 3' oc =	3.77 in3	2.77 in3
S_b at 4' oc =	5.02 in3	3.69 in3
S_b at 40" oc =	4.19 in3	3.08 in3
P, shear load at 40" =	5,397 lbs	4,318 lbs
M_{cu}, concrete 40" span =	3,598 '#	2,879 '#
Reinforcement, #4 ... A_s :	0.60 in2	0.60 in2
$M_b = \varphi A_S df_y(1 - A_s f_y/1.7bdf_c')C_d$ =	12,410 '#	12,586 '#
$M_b \geq M_{cu}$:	3.45	4.37

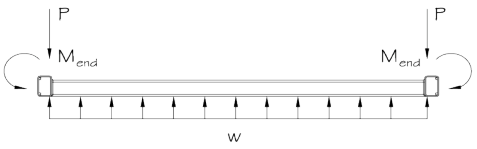


Rec Tubing :	5"x 3"x 1/4"	4"x 4"x 1/4"
t =	0.250 in	0.250 in
A =	3.54 in2	3.59 in2
S =	4.38 in3	4.11 in3
I =	11.00 in4	8.22 in4
wt =	12.0 plf	12.2 plf



Bolts/Tubing :	5/8 "	5/8 "
	Coarse Thread	*Fine Thread*
n (per inch) =	11	18
D =	0.625 in	0.625 in
A_{ts} =	0.226 in2	0.256 in2
S, ultimate Strength 307A minimum =	60,000 psi	60,001 psi
P_b =	13,560 lbs	15,358 lbs
Spacing Bolts =	4.00 in	4.00 in
T, bolts =	11,305 lbs	8,303 lbs
V, rec-tube =	12,246 psi	8,994 psi
F_v, A36 =	14,400 psi	14,400 psi

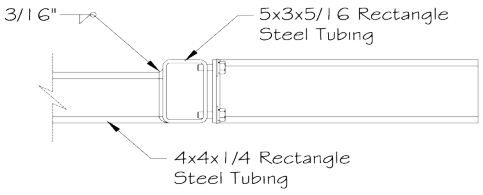
Bottom Frame Deflection

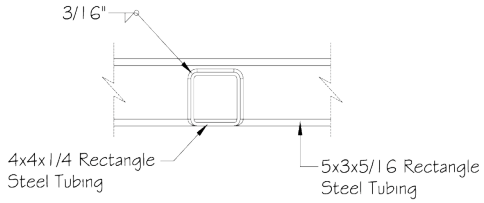


Crossmember 4x4

h_d =	7.5 ft	6.0 ft
$w_{frame\ crossmember}$ =	0.0 plf	0.0 plf
M_b per 40" spacing/C_d =	10,023 ft#/ft	7,362 ft#/ft
L_{frame} =	6.50 ft	6.50 ft
$\Delta_{frame\ crossmember} = 6M_bL^2/48EI$ =	0.384 in	0.282 in
P =	1619.2 plf	1295.4 plf
f_t infused section =	1,079 psi	864 psi
$F_t > f_t$:	24.5	30.7

Frame Welds



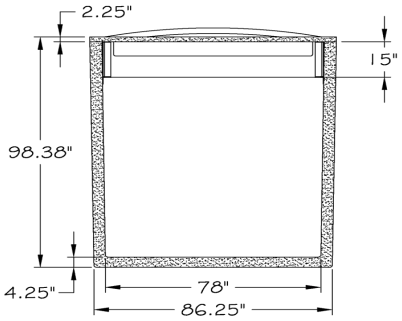


	$^3/_{16}$" E70
D =	3
C_1=	1
F_v =	21,000 psi
F_r =	2,784 lb/in

AXMax - Buoyancy

Bury Depths	h_d=	7.5 ft	6.0 ft
Net Buoyancy per side	$W_{buoy\ net}$ per side :	1,619 plf	1,295 plf
Net Anti-Buoyancy per side	W_{total} DL :	1,697 plf	1,333 plf
AX Max Unit Nominal Length			
42 ft	Net Anti-buoyancy:	20,135 lbs	13,868 lbs
35 ft	Net Anti-buoyancy:	8,859 lbs	5,334 lbs
28 ft	Net Anti-buoyancy:	4,371 lbs	2,133 lbs
21 ft	Net Anti-buoyancy:	16,857 lbs	12,268 lbs
14 ft	Net Anti-buoyancy:	8,975 lbs	6,401 lbs

AX Max - Baffle Walls



Side View with 2" Top

Hydrostatic Loading

C_d =	1.0	
EFP =	62.4 pcf	
h =	5.67 ft	
LP_b =	354 psf	
W =	1,003 plf	
M_v =	1,896 ft#/ft	
b =	6.50 ft	
x =	3.78 ft	
Δ_{vx} =	2.43	W/EI
Δ_{hx} =	4.65	W/EI
α =	0.522	ratio Δ_{vx}:Δ_{hx}
$M_{max} = M_v - \alpha M_h$ =	974 ft#/ft	

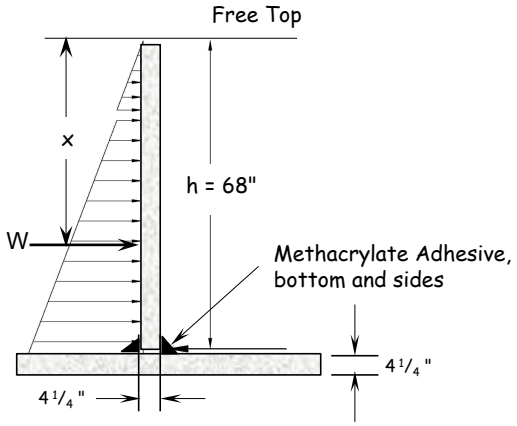
Common Deflection Center Baffle

Vertical

$$\Delta_{vx} = \frac{W(x^5 - 5h^4x + 4h^5)}{60EIh^2}$$

Horizontal

$$\Delta_{hx} = \frac{Wb^4}{384EI}$$



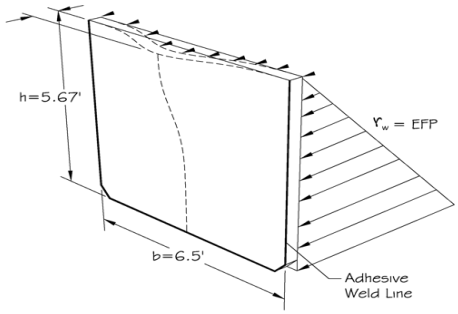
Baffle Wall

4" Panel Section

I_{na} =	9.18 in4
S_{na} =	4.32 in3
A_{frp} =	2.50 in2
Q_{frp} =	2.31 in2
t_{web} =	0.13 in2

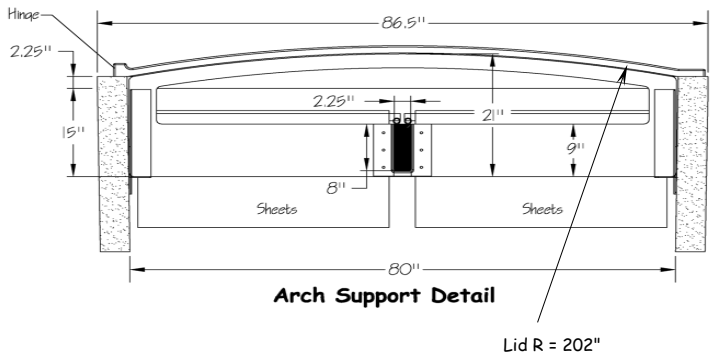
Bending and Shear Stress

$F_{flex\ max}$ =	39,500 psi	
f_{flex} =	*1,805 psi*	**OK**
$F_{s\ max}$ =	15,900 psi	
f_v =	*1,348 psi*	**OK**
E_{flex} =	1,600,000 psi	
$F_{v\ adhesive}$ =	2,500 psi	
$f_{v\ bond}$ =	*44 psi*	**OK**
$f_{tension\ bond}$ =	*487 psi*	**OK**

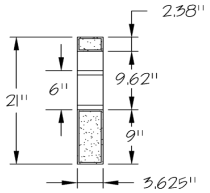


Baffle Wall Fixed Bottom & Sides

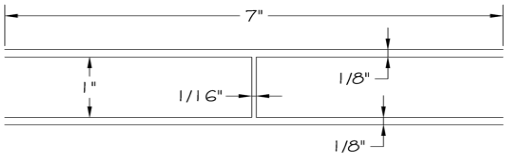
AX Max - Lid / Arch Supports



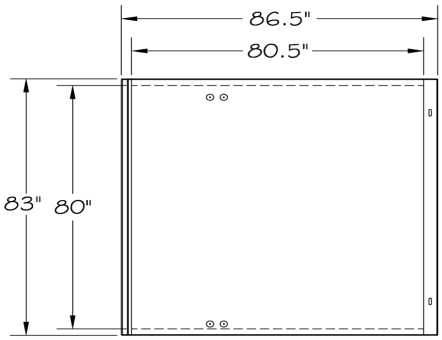
Arch Support Detail



Arch Cross Section



Lid FRP Section



Lid Top View

Lid Loading

W =	DL + LL + SN
DL =	4 psf
SN+ LL	96 psf
Snow C_D =	1.15

FRP Section

t_{flange} =	0.125 in
L_{flange} =	7.0 in
t_{web} =	0.1 in
d_{web} =	1.0 in

Arch Span

I_{ax} =	0.561 in4
S_{ax} =	0.281 in3
A_{ax} =	1.81 in2

Short span

I_{sx} =	0.556 in4
S_{sx} =	0.278 in3
A_{sx} =	1.75 in2

Clear Span, Bearing all four sides

$L_{arch\ span}$ =	80.5 in
$L_{short\ span}$ =	80.0 in
L_a/L_s =	1.006

F_{flex}=	39,500 psi
F_c =	34,500 psi
F_s =	15,900 psi
E_{flex}=	1,600,000 psi

Single Span (7" wide section)

Straight beam

M_{max} =	924 '#
V_{max} =	19,213 lbs
Δ_{max} =	1.01 in

Arch beam

R =	202.0 in
R_i =	201.375 in
R_o =	202.625 in
R_n =	201.999 in
e =	0.0006 in
$M_{max\ arch}$ =	1239 '#
W_{max} =	220 plf

378 psf

AX Max - Lid / Arch Supports

Lid Cross Section

Two-way Spans (4 sides simply supported)

$L_{arch\ span}$ / $L_{short\ span}$ =	1.006	
β_a =	0.06250	
β_s =	0.06328	

Deflection control … 7" wide section

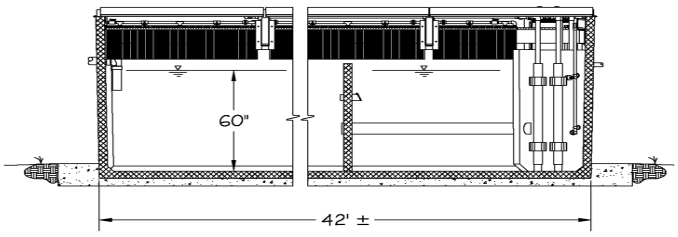
I_{ax} / I_{sx} =	1.009	
W_{arch} / W_{short} =	0.98 plf	
W_{max} =	40 plf	69 psf

Moment control … 7" wide section

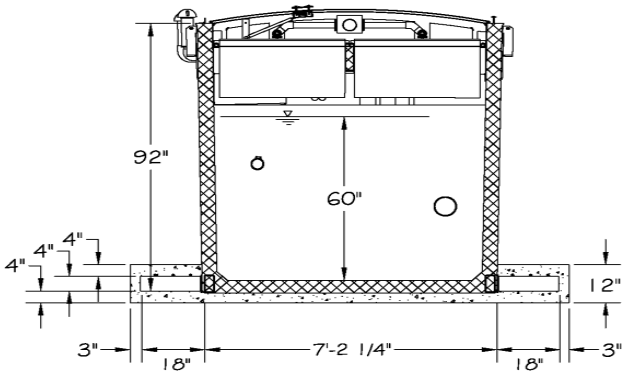
$W_{max\ short}$ =	330 plf	566 psf
W_a =	446 plf	765 psf
W_s =	328 plf	563 psf

Seismic Evaluation

Above Ground AXMax and TMax



Side View



End View

Site Location and Conditions

General:	USC Wrigley, CA	
Latitude:	33.264158 ° N	
Longitude:	118.28480 ° W	
Soil Profile Type:	Stiff Soil	
Site Class:	D	
Occupancy:	III - WWT structure	
I =	1.25	*Tabel 11.5-1*

Response Coef for an FRP structure. Flat bottom tank - Ground-supported - Mechanically anchore

ASCE 7- 05	Table 15.4.2	
R =	3	*Response Modification*
Ω_o =	2	*System Overstrength*
C_d =	2.5	*Deflection Amplification*

Specific site information can be found at …

www.eqhazmap.usgs.gov

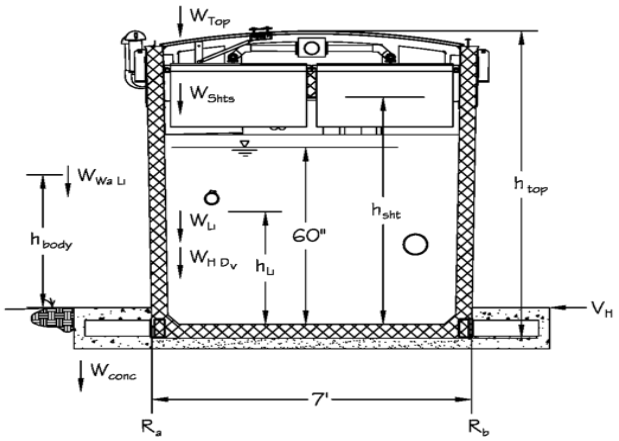
http://geohazards.usgs.gov/designmaps/us/application.php

USGS Maps

S_s =	80-100%	*% g*
S_1 =	32-36%	*% g*
S_s =	0.964 g	*USGS Calc*
S_1 =	0.346 g	*USGS Calc*
F_a =	1.114	*Table 11.4-1*
F_v =	1.708	*Table 11.4-2*
S_{ms} =	1.074 g	*USGS Calc*
S_{m1} =	0.591 g	*USGS Calc*
S_{ds} =	0.716 g	
S_{d1} =	0.394 g	
C_u =	1.4	*Table 12.8-1*
T_o =	0.11 sec	
T_s =	0.55 sec	
T_L =	8.0 sec	*Fig. 22-15*

Seismic Evaluation

Above Ground AXMax and TMax



End View AXMax

T_a = $C_t\ h_h^x$

C_t = 0.02 *Table 12.8-2*

x = 0.75 *Table 12.8-2*

h = 7.0 ft

T_a = 0.09 sec

T <= $C_u\ T_a$

T <= 0.12 sec

$T_a < T_o < T_s < T_L$

S_a = $S_{ds}\ (0.4 + 0.6\ T/T_o)$ *Eq 11.4-5*

S_a = 0.757 g

For nonbuilding tank Structures located where S1 >= 0.6g

C_s = S_{ds} / (R/I) *Sec 12.8.1*

C_s = 0.30 *Sec 11.6*

Note: use max C_s for worst case scenario

Max C_s = 1.36 *Sec 12.8.1*

Min C_s = 0.01 *Sec 12.8.1*

Hydrodynamic (lateral and vertical increases).

Δ_{hydro} = $0.25I(\gamma_w)$

Δ_{hydro} = 19.5 pcf

Operational Loads in lbs/ft of length.		**Dist from floor, h**
W_{top} =	42 plf	8.0 ft
$W_{shts\ wet}$ =	105 plf	6.5 ft
W_{liq} =	2028 plf	3.0 ft
W_{hydro} =	634 plf	3.0 ft
W_{body} =	95 plf	4.0 ft
W_T =	**2,904 plf**	

W_{conc} = 540 plf

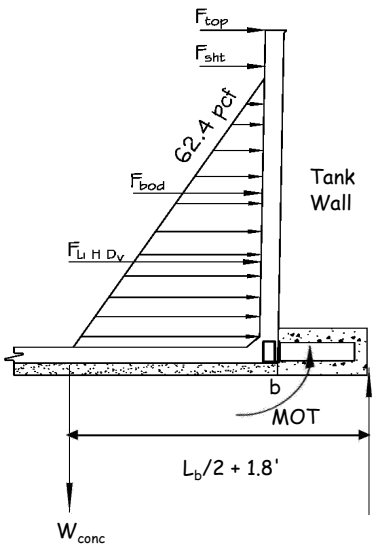
Horiz Base Shear

V_h = $C_s W_T$

Max Horiz Base Shear *SF-Site C_s to max C_s*

Max V_h = **3,956 plf** *4.6*

V_h = **866 plf** *C_s*



Vertical Distribution Factor

$$C_{vx} = \frac{W_x h_x}{\Sigma W_i h_i}$$

$W_{top}\ h_{top}$ =	336 ft-plf
$W_{shts\ wet}\ h_{shts}$ =	683 ft-plf
$W_{liq}\ h_{liq}$ =	7985 ft-plf
$W_{body}\ h_{body}$ =	256 ft-plf
$W_T\ h_x$ =	**9,260 ft-plf**

Cv_{top} =	0.036
$Cv_{shts\ wet}$ =	0.074
Cv_{liq} =	0.862
Cv_{body} =	0.028

		Dist from floor, h
F_{top} =	144 plf	8.0 ft
$F_{shts\ wet}$ =	292 plf	6.5 ft
F_{liq} =	3,411 plf	3.0 ft
F_{body} =	109 plf	4.0 ft

ΣM_b

$$MOT\ pt.\ b = F_t h_t + F_{sht} h_{sht} + F_{liq} h_{liq} + F_{bdy} h_{bdy} - W_T(L_b/2)$$

L_b =	7.2 ft	
MOT pt. b =	**3,261.6 ft-plf**	
MOT pt. b =	*-7,450.0 ft-plf*	*C_s*

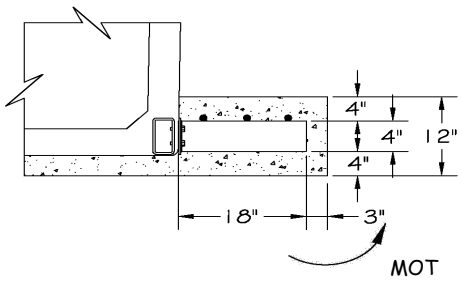
Note: based on use max C_s for worst case scenario

Wall Shear

F_s =	15,900 psi	
$A_{frp\ 4"}$ =	2.5 in2	
v =	3,101 plf	
f_v =	622 psi	< F_s

Wall Bending

F_{flex} =	39,500 psi	
$S_{4"}$ =	4.3 in3	
M =	15,445 ft-plf	
f_b =	21,606 psi	< F_{flex}



Outrigger Footing

MOT Outrigger Footing

$$MOT_{OF} = F_t h_t + F_{sht} h_{sht} + F_{liq} h_{liq} + F_{bdy} h_{bdy} - (W_T + W_{conc})(L_b/2+1.8)$$

Note: based on use max C_s for worst case scenario

MOT_{OF} =	-4,881 ft-plf
SF_{MOT} =	1.4
M outrigger at 40" centers =	-16,270 ft-lbs