ENGINEERS

Structural Calculations

For

Uintah Reservoir #3 Rebuild

Job Number: 15068

March 13, 2015

Prepared by
ARW Engineers
1594 West Park Circle
Ogden, Utah 84404

DESIGN CRITERIA

SNOW LOAD (PER SNOW LOAD STUDY)

ELEV. = 5,178 ft

WEBER COUNTY $A_o = 4.5$

$P_o = 43$

$A = 5.178$

$S = 63$

$$P_g = (P_o^2 + S^2(A-A_o)^2)^{1/2}$$

$$P_g = (43^2 + 63^2(5.178-4.5)^2)^{\frac{1}{2}} = 61 \text{ psf}$$

$P_g = 61$ psf

$SL = 61$ psf

USE ROOF LIVE LOAD = 100 psf

$L_R = 100$ psf ✓ CONTROLS OVER SNOW

SEISMIC PARAMETERS

SITE LOCATION - 2545 JACQUELINE DR., OGDEN UT

LAT → 41.163°

LONG → 111.918°

PER USGS →

$S_s = 1.261$ g	$S_{MS} = 1.261$ g	$S_{DS} = 0.841$ g
$S_1 = 0.473$ g	$S_{M1} = 0.722$ g	$S_{D1} = 0.481$ g

SOIL PARAMETERS

REPORT BY GEOSTRATA #1065-001

NET BEARING = 4,000 psf

ACTIVE = 31 pcf

AT-REST = 49 pcf

SEISMIC ACTIVE = 52 pcf (INVERTED TRIANGLE)

FRICTION = 0.49

DESIGN CRITERIA (CONT'D)

ENVIRONMENTAL DURABILITY FACTOR

FOR HOOP STRESSES: (TENSION)

LIQUID $\Rightarrow$ $\gamma = 1.4$ $\therefore S_d = \frac{0.9(60\,ksi)}{1.4(20\,ksi)} = 1.93$ $S_{d_{LIQUID}} = 1.93$

SOIL $\Rightarrow$ $\gamma = 1.6$ $\therefore S_d = \frac{0.9(60\,ksi)}{1.6(20\,ksi)} = 1.69$ $S_{d_{SOIL}} = 1.0$

SOIL CREATES COMPR. FORCES IN HOOP $\therefore$ USE $S_{d_{SOIL}} = 1.0$

FLEXURAL STRESSES:

LIQUID $\Rightarrow$ $\gamma = 1.4$ $\therefore S_{d_{LIQUID}} = 1.93$

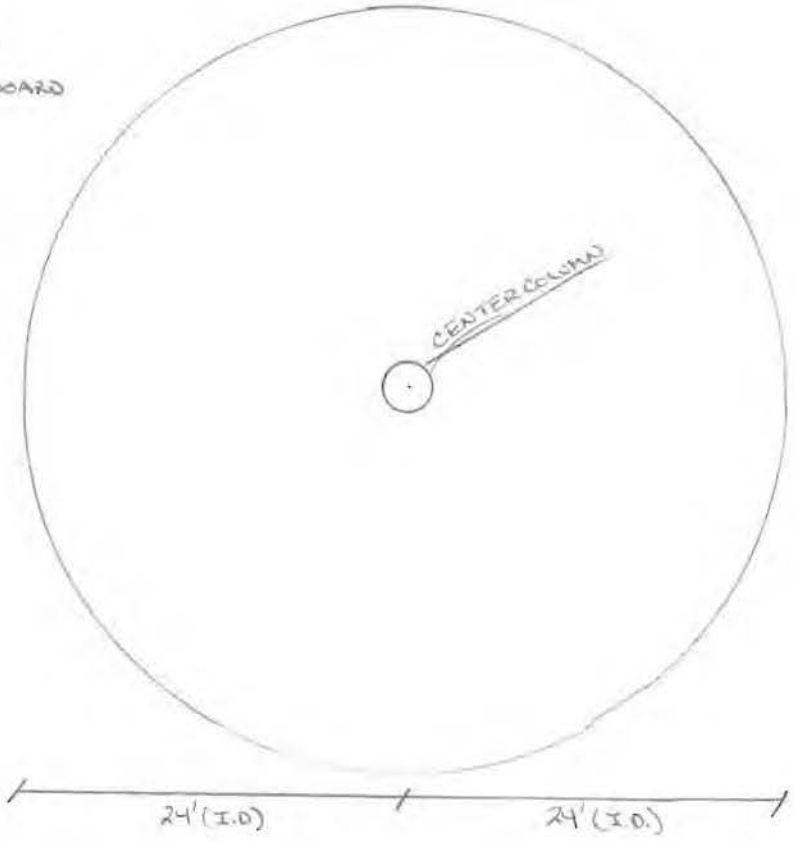
$f_s = 20\,ksi$ (CONSERVATIVE)

SOIL $\Rightarrow$ $\gamma = 1.6$ $\therefore S_{d_{SOIL}} = 1.69$

TANK LAYOUT

TANK = 16' TALL

1' FREEBOARD



USGS Design Maps Summary Report

User-Specified Input

Report Title Uintah Highlands Reservoir #3
Mon March 2, 2015 16:26:41 UTC

Building Code Reference Document ASCE 7-10 Standard
(which utilizes USGS hazard data available in 2008)

Site Coordinates 41.163°N, 111.918°W

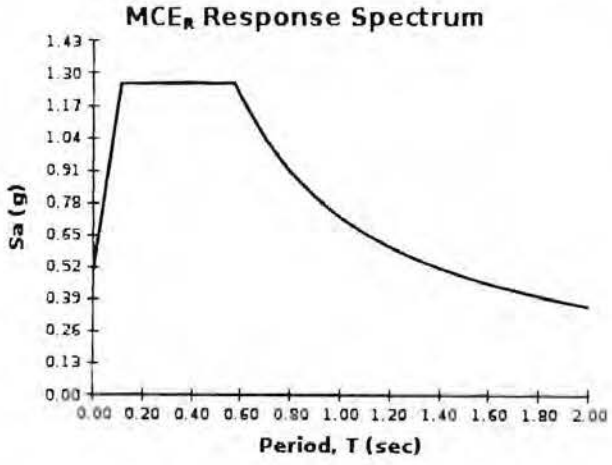
Site Soil Classification Site Class D - "Stiff Soil"

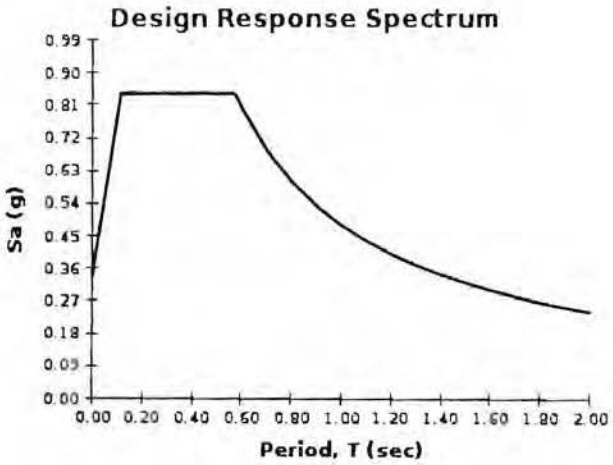
Risk Category IV (e.g. essential facilities)

USGS-Provided Output

S_S =	1.261 g	S_{MS} =	1.261 g	S_{DS} =	0.841 g
S_1 =	0.473 g	S_{M1} =	0.722 g	S_{D1} =	0.481 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

Google earth

feet 700
meters 200

Project Name Uintah Highlands Reservoir #3
Project # 15068
Prepared By ZCH
Date 3/4/2015

Program Authors: TAB & DOC
Last Revised: 10/20/2010
Reviewed By: TAB

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Circular Concrete Tanks without Prestressing

(Based on the 1993 PCA Document)

Design Criteria

f'c	4500	psi
D_{tank}	48	ft
H_{tank}	16	ft
t_{wall}	12	in
Fluid Pressure	62.4	pcf
Soil Pressure	50	pcf
E_s	29000000	psi
E_c	3823676.24	psi
n	7.6	
Surcharge	100	pcf
Soil on Lid	2	ft
Load Factor		
$F_{liquid\ pressure}$	1.4	
$F_{Soil\ pressure}$	1.6	
Environmental		
Durability Factor		
Flexure (liquid)	1.03	
Tension (liquid)	1.03	
Flexure (soil)	1.69	
Compression (soil)	1	
H^2/Dt	5.33	

Estimation of Tank Wall Thickness

Limit Ring Tension Stress in Concrete Wall from 7% to 12% of f'c

For given t and H^2/Dt, with a hinged base/free top (Table A-5)

Max Coefficient= 0.624 (Table A-5)

w_u	169	pcf
T_{max}	40422	lbs.
$T_{unfactored}$	14960	lbs.
$A_{s(req'd)}$	0.75	in^2
$A_{s(used)}$	0.88	in^2

OK

(2)#6@11"c.c.

Compression Check	
F'c	313
0.33f'c	1485
OK	

$F_{t(conc)}$ 150 psi

This equates to 3.34 % of f'c

Wall thickness is **OK**

The Following Load Cases were used in Analysis:

Load Case #1: **Full of Water, No Lid, No Backfill**
Load Case #2: **Empty, No Lid, w/Backfill**
Load Case #3: **Empty, w/Lid, w/Backfill**
Load Case #4: **Full of Water, w/Lid, Ignore Backfill**

Load Case #1-Full of Water, No Lid, No Backfill

Assume Free Top/Hinged Base (Tables A-5 and A-7)
Effects of Possible outward movement will be handled by designing the entire portion of the wall for the maximum Ring Tension and Moment

Ring Force=(A-5 Coef.)w_uHR w_uHR= 64744.2432

Moment =(A-7 Coef.)w_uH^3 w_uH^3= 690605.2608

	A-5 Coef.	RF (#)	A-7 Coef.	Moment (#-ft/ft)
Top	-0.009	-583	0	0
0.1H	0.110	7143	0.0000	0
0.2H	0.231	14956	0.0001	46
0.3H	0.352	22768	0.0005	322
0.4H	0.467	30236	0.0013	921
0.5H	0.563	36473	0.0029	2003
0.6H	0.624	40422	0.0051	3522
0.7H	0.618	40034	0.0074	5110
0.8H	0.518	33516	0.0089	6123
0.9H	0.305	19747	0.0075	5157
Bottom	0.000	0	0	0

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Load Case #2-Empty, No Lid, w/ Backfill

Use Durability Coefficients as Noted Previous

Soil Over Lid= 1 ft
p 100

Ring Force=(A-5 Coef.)w_uHR+(A-6 Coef.)pR

w_uHR= -59290
pR= -7411.2

Moment=(A-7 Coef.)($w_u h^3$+ph^2)

$w_u h^3$+ph^2= -623002

	A-5 Coef	RF (#)	A-6 Coef.	RF (#)	Total RF (#)	A-7 Coef.	Moment (#-ft/ft)
Top	-0.009	534	0.991	-7344.4992	-6811	0	0
0.1H	0.110	-6542	1.010	-7487.7824	-14029	0.0000	0
0.2H	0.231	-13696	1.031	-7640.9472	-21337	0.0001	-42
0.3H	0.352	-20850	1.052	-7794.112	-28644	0.0005	-291
0.4H	0.467	-27688	1.067	-7907.7504	-35596	0.0013	-831
0.5H	0.563	-33400	1.063	-7880.576	-41280	0.0029	-1807
0.6H	0.624	-37016	1.024	-7591.5392	-44608	0.0051	-3177
0.7H	0.618	-36661	0.918	-6805.952	-43467	0.0074	-4610
0.8H	0.518	-30692	0.718	-5318.7712	-36011	0.0089	-5524
0.9H	0.305	-18083	0.405	-3001.536	-21085	0.0075	-4652
Bottom	0.000	0	0.000	0	0	0	0

Load Case #3-Empty, w/Lid, w/Backfill

Apply a shear force (V) @ top of wall to make Ring Tension = 0 @ top of Wall

When top of tank is free, Ring Force (LC#2) = -6811 #

At top of wall (0.0H) from table A-8, Coefficient= -8.49 #

Therefore, the shear force (V) required to produce zero ring force at the top of the tank=
(Coef. A-8 @ 0.0H)(VR/H)=(Ring Force from LC#2)

Therefore

V= -535 #
VR/H= -803 #

$Delta_{RF}$=Change in Ring Force Due to V applied @ the top of wall

$Delta_{RF}$=(A-8 Coef.)(VR/H)

Find the change in moment ($Delta_{mom}$) due to the V applied @ top

If S_D for moment is less than S_D for compression, then V is reduced by (S_{DM}/S_{DC})

$Delta_{mom}$=(A-9 Coef.)VH

VH= -8560

	A-8 Coef.	$Delta_{RF}$ (#)	LC#2 RF (#)	Total RF (#)	A-9 Coef.	$Delta_{mom}$ (#-ft/ft)	LC #2 Moment (#-ft/ft)	Total Moment (#-ft/ft)
Top	-8.487	6811	-6811	0	0	0	0	0
0.1H	-5.050	4053	-14029	-9977	0.0633	-542	0	-542
0.2H	-2.390	1918	-21337	-19419	0.0753	-645	-42	-686
0.3H	-0.693	556	-28644	-28088	0.0633	-542	-291	-833
0.4H	0.187	-150	-35596	-35746	0.0433	-371	-831	-1202
0.5H	0.510	-409	-41280	-41690	0.0247	-211	-1807	-2018
0.6H	0.510	-409	-44608	-45017	0.0107	-91	-3177	-3269
0.7H	0.363	-292	-43467	-43758	0.0020	-17	-4610	-4627
0.8H	0.190	-152	-36011	-36164	-0.0030	26	-5524	-5498
0.9H	0.043	-35	-21085	-21120	-0.0063	54	-4652	-4598
Bottom	0.000	0	0	0	-0.0093	80	0	80

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Load Case #4-Full of Water, w/Lid, ignore Backfill

Add the effects of shear @ the top of the tank to LC #1

At the top of the wall - Coefficient from Table A-8= -8.49 #

(Coef. A-8 @ 0.0H)(VR/H) = (Ring Force from LC#1)

V= -46 #
VR/H= -69 # (For Ring Force)
VH= -732 # (For Moment)

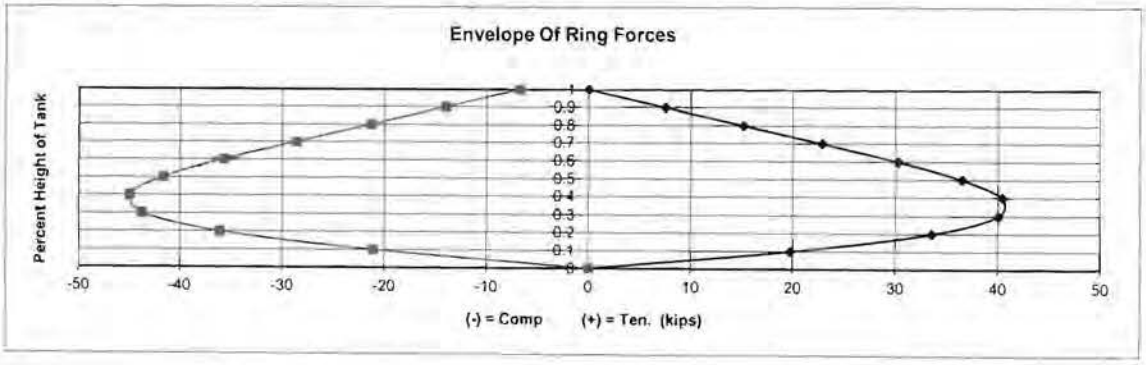
	A-8 Coef.	$Delta_{RF}$ (#)	LC#1 RF (#)	Total RF (#)	A-9 Coef.	$Delta_{mom}$ (#-ft/ft)	LC#1 Moment (#-ft/ft)	Total Moment (#-ft/ft)
Top	-8.49	583	-583	0	0	0	0	0
0.1H	-5.05	347	7143	7490	0.063	-46	0	-46
0.2H	-2.39	164	14956	15120	0.075	-55	46	-9
0.3H	-0.69	48	22768	22816	0.063	-46	322	276
0.4H	0.19	-13	30236	30223	0.043	-32	921	889
0.5H	0.51	-35	36473	36438	0.025	-18	2003	1985
0.6H	0.51	-35	40422	40387	0.011	-8	3522	3514
0.7H	0.36	-25	40034	40009	0.002	-1	5110	5109
0.8H	0.19	-13	33516	33503	-0.003	2	6123	6126
0.9H	0.04	-3	19747	19744	-0.006	5	5157	5161
Bottom	0	0	0	0	-0.009	7	0	7

Envelope of Ring Forces

	LC#1	LC#2	LC#3	LC#4	Max	Min
Top	-583	-6811	0	0	0	-6811
0.1H	7143	-14029	-9977	7490	7490	-14029
0.2H	14956	-21337	-19419	15120	15120	-21337
0.3H	22768	-28644	-28088	22816	22816	-28644
0.4H	30236	-35596	-35746	30223	30236	-35746
0.5H	36473	-41280	-41690	36438	36473	-41690
0.6H	40422	-44608	-45017	40387	40422	-45017
0.7H	40034	-43467	-43758	40009	40034	-43758
0.8H	33516	-36011	-36164	33503	33516	-36164
0.9H	19747	-21085	-21120	19744	19747	-21120
Bottom	0	0	0	0	0	0

CONTROLS

	Tension	Compression
Bottom	0	0
0.9H	20	-21
0.8H	34	-36
0.7H	40	-44
0.6H	40	-45
0.5H	36	-42
0.4H	30	-36
0.3H	23	-29
0.2H	15	-21
0.1H	7	-14
Top	0	-7



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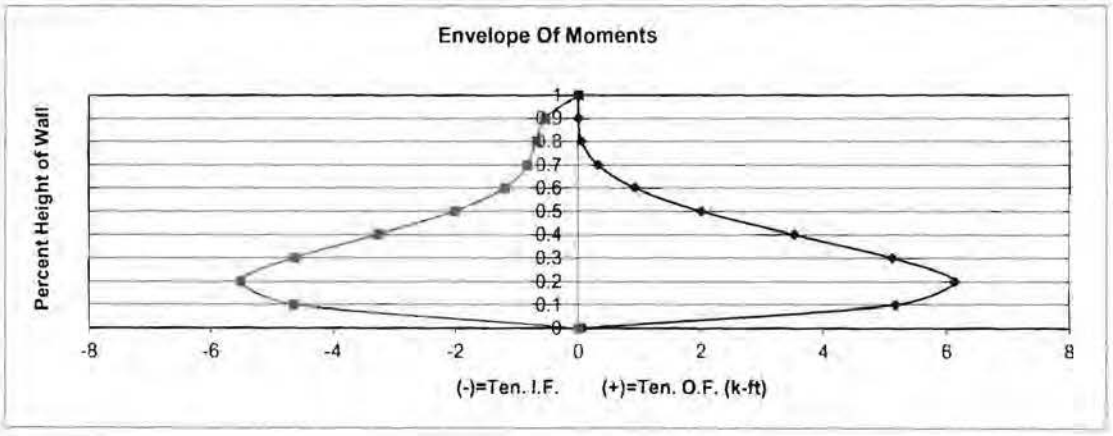
Envelope of Moments

	LC#1	LC#2	LC#3	LC#4	Max	Min
Top	0	0	0	0	0	0
0.1H	0	0	-542	-46	0	-542
0.2H	46	-42	-686	-9	46	-686
0.3H	322	-291	-833	276	322	-833
0.4H	921	-831	-1202	889	921	-1202
0.5H	2003	-1807	-2018	1985	2003	-2018
0.6H	3522	-3177	-3269	3514	3522	-3269
0.7H	5110	-4610	-4627	5109	5110	-4627
0.8H	6123	-5524	-5498	6126	6126	-5524
0.9H	5157	-4652	-4598	5161	5161	-4652
Bottom	0	0	80	7	80	0

	Tension O.F.	Tension I.F.
Bottom	0	0
0.9H	5	-5
0.8H	6	-6
0.7H	5	-5
0.6H	4	-3
0.5H	2	-2
0.4H	1	-1
0.3H	0	-1
0.2H	0	-1
0.1H	0	-1
Top	0	0



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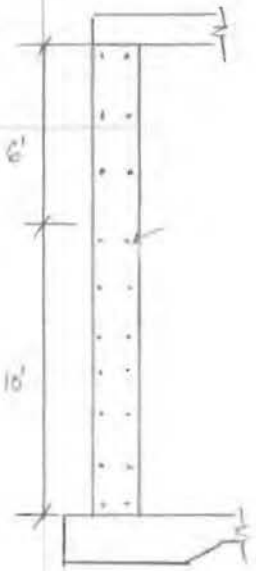
Project No. 15068 Sheet No.

Project UINTAH HIGHLANDS RES #3

Prepared By ZCH Date 3/5/15

WALL DESIGN

* SEE SPREADSHEET FOR MAX TENSION AND COMPRESSION CHECK



RING STEEL (HORIZONTAL BARS)

MAX RING FORCE => BOTTOM 10' OF WALL = 40.4K

∴ USE (2) #6 @ 12" O.C. (SEE SPREADSHEET)

TOP 6' OF WALL = 30.2K @ 0.4H

$$A_{s\,REQ'D} = \frac{30.2K}{0.9(60ksi)} = 0.56\,in^2/ft$$

∴ USE (2) #5 @ 12" O.C. (0.62 in^2/ft)

CHECK MIN. SHRINKAGE STEEL:

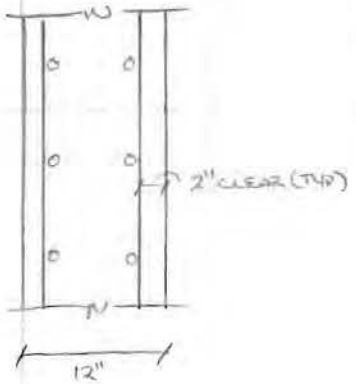
$$A_{s\,min} = 0.005(12")(12") = 0.72\,in^2/ft$$

∴ USE (2) #6 @ 12" O.C. ENTIRE HEIGHT OF WALL

WALL DESIGN (CONT'D)

MOMENT REINF. (VERT. BARS)

MAX MOMENT = 6 K-FT (+ AND − BENDING)



$f'_c = 4{,}500$ psi

$d = 9.5$ in

$b = 12$ in

$$\frac{M_u}{\phi b d^2} = \frac{6{,}000 \text{ lb-ft}(12)}{0.9(12)(9.5)^2} = 73.87$$

$$\rho = \frac{0.85(4.5)}{60}\left(1 - \sqrt{1 - \frac{2(73.87)}{0.85(4{,}500)}}\right)$$

$\rho = 0.0012$ ✓

ρ_{min} ⇒ TEMP. SHRINKAGE = 0.003

$A_{s\,min} = 0.003(12)(12)$

$A_{s\,min} = 0.43 \text{ in}^2/\text{FT}$ (BOTH FACES)

$A_{s\,min}$ BASED ON FLEXURE:

$$A_{s\,min} = \frac{3\sqrt{4{,}500}}{60{,}000}(12")(9.5) = 0.38 \text{ in}^2/\text{FT}$$

↑ ONE FACE OF WALL

∴ FLEXURE CONTROLS

$A_{s\,REQ'D} = 0.38 \text{ in}^2/\text{FT}$ EACH WALL FACE

∴ USE #6 @ 12" o.c. EA. FACE

SHEAR STRENGTH OF WALL

WALL CAPACITY ⇒ $\phi V_c = 0.75(2)\sqrt{4{,}500}(12\text{in})(9.5\text{in}) = 11.5 \text{ K}$

$\phi V_c = 11.5 \text{ K}$

$V_{MAX\ IN\ WALL} = 0.121(1.6)(62.4 \text{ PCF})(16^2) = 3.1 \text{ K} < 11.5 \text{ K}$

↑ COEFF. PCA TABLE A-12

∴ WALL SHEAR STRENGTH IS GOOD ✓

ENGINEERS

CONCRETE LAP SPLICE TABLE

05-Mar-15
10:21 AM

JOB TITLE: Uintah Highlands Reservoir #3
BUILDING LOCATION : Uintah, UT

JOB #: 15068
PREPARED BY: ZCH

CONCRETE DEVELOPMENT AND LAP SPLICE DESIGN TABLE

BASED ON CHAPTER 12 OF THE 2011 ACI 318
Author: Matt McBride

Version: June 17, 2013

Concrete Properties

ψ_t = 1.0 For horizontal reinforcement placed such that more than 12 in. of fresh concrete is cast below the development length or splice (i.e. Top Splice) = 1.3 - Otherwise = 1.0
ψ_e = 1.0 For Epoxy-coated bars or wires with cover less than 3db , or clear spacing less than 6db = 1.5 - For all other Epoxy-coated bars or wires = 1.2 -Otherwise = 1.0
λ = 1.0 When Light-weight Aggregate Concrete is used = 0.75 - Otherwise = 1.0
ψ_s = 1.0 For No. 6 smaller bars and deformed wires = 0.8 - Otherwise = 1.0

Rebar Properties
fy = 60000 psi

CONCRETE REINFORCING DEVELOPMENT & SPLICE LENGTHS																																			
Bar Location	Concrete		BAR SIZE																																	
	Type	Strength	#3			#4			#5			#6			#7			#8			#9			#10			#11			#14		#18				
			l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_{dh}	l_d	l_{dh}				
Vert. Wall Bars, Fill on Metal Deck	NWC	3000 psi	17	22	8	22	29	8	28	36	10	33	43	12	48	62	13	55	72	15	62	81	17	69		19	76		30	96	38	124	49				
Horiz. Wall Bars, Footing Top Bars	NWC	3000 psi	17	22	8	22	29	8	28	36	10	33	43	12	48	62	13	55	72	15	62	81	17	69		19	76		30	96	38	124	49				
Beam Bottom Bars, Column Bars	NWC	3000 psi	17	22	8	22	29	11	28	36	14	33	43	16	48	62	19	55	72	22	62	81	25	69		27	76		30	96	38	124	49				
Footing Bottom Bars	NWC	3000 psi	12	16	8	14	18	8	17	22	10	20	26	12	29	38	13	33	43	15	37	48	17	42		19	46		30								
Beam Top Bars	NWC	3000 psi	22	29	8	29	38	11	36	47	14	43	56	16	63	82	19	72	94	22	81	105	25	90		27	98		30	125	38	161	49				
Slab on Grade	NWC	3000 psi	12	16	8	14	18	8	17	22	10	20	26	12	32	42	13	42	55	15	53	69	17	69		19	76		30								

CONCRETE REINFORCING DEVELOPMENT & SPLICE LENGTHS																																			
Bar Location	Concrete		BAR SIZE																																	
	Type	Strength	#3			#4			#5			#6			#7			#8			#9			#10			#11			#14		#18				
			l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_{dh}	l_d	l_{dh}				
Vert. Wall Bars, Fill on Metal Deck	NWC	4000 psi	15	20	7	19	25	7	24	31	8	29	38	10	42	55	12	48	62	13	54	70	15	60		17	66		26	84	33	107	43				
Horiz. Wall Bars, Footing Top Bars	NWC	4000 psi	15	20	7	19	25	7	24	31	8	29	38	10	42	55	12	48	62	13	54	70	15	60		17	66		26	84	33	107	43				
Beam Bottom Bars, Column Bars	NWC	4000 psi	15	20	7	19	25	9	24	31	12	29	38	14	42	55	17	48	62	19	54	70	21	60		24	66		26	84	33	107	43				
Footing Bottom Bars	NWC	4000 psi	12	16	7	12	16	7	15	20	8	18	23	10	25	33	12	29	38	13	33	43	15	36		17	40		26								
Beam Top Bars	NWC	4000 psi	19	25	7	25	33	9	31	40	12	37	48	14	54	70	17	62	81	19	70	91	21	78		24	85		26	108	33	139	43				
Slab on Grade	NWC	4000 psi	12	16	7	12	16	7	15	20	8	18	23	10	28	36	12	36	47	13	46	60	15	60		17	66		26								

CONCRETE REINFORCING DEVELOPMENT & SPLICE LENGTHS

Bar Location	Concrete		BAR SIZE																													
	Type	Strength	#3			#4			#5			#6			#7			#8			#9			#10			#11			#14		#18	
			l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_{dh}	l_d	l_{dh}
Vert. Wall Bars, Fill on Metal Deck	NWC	4500 psi	14	18	7	18	23	6	23	30	8	27	35	9	40	52	11	45	59	13	51	66	14	56		16	62		25	79	31	101	40
Horiz. Wall Bars, Footing Top Bars	NWC	4500 psi	14	18	7	18	23	6	23	30	8	27	35	9	40	52	11	45	59	13	51	66	14	56		16	62		25	79	31	101	40
Beam Bottom Bars, Column Bars	NWC	4500 psi	14	18	7	18	23	9	23	30	11	27	35	13	40	52	16	45	59	18	51	66	20	56		22	62		25	79	31	101	40
Footing Bottom Bars	NWC	4500 psi	12	16	7	12	16	6	14	18	8	17	22	9	24	31	11	27	35	13	31	40	14	34		16	37		25				
Beam Top Bars	NWC	4500 psi	18	23	7	24	31	9	30	39	11	35	46	13	51	66	16	59	77	18	66	86	20	73		22	80		25	102	31	131	40
Slab on Grade	NWC	4500 psi	12	16	7	12	16	6	14	18	8	17	22	9	27	35	11	34	44	13	44	57	14	56		16	62		25				

CONCRETE REINFORCING DEVELOPMENT & SPLICE LENGTHS

Bar Location	Concrete		BAR SIZE																													
	Type	Strength	#3			#4			#5			#6			#7			#8			#9			#10			#11			#14		#18	
			l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_s	l_{dh}	l_d	l_{dh}	l_d	l_{dh}
Vert. Wall Bars, Fill on Metal Deck	NWC	5000 psi	13	17	6	17	22	6	22	29	7	26	34	9	38	49	10	43	56	12	48		13	54		15	59		23	75	30	96	38
Horiz. Wall Bars, Footing Top Bars	NWC	5000 psi	13	17	6	17	22	6	22	29	7	26	34	9	38	49	10	43	56	12	48		13	54		15	59		23	75	30	96	38
Beam Bottom Bars, Column Bars	NWC	5000 psi	13	17	6	17	22	8	22	29	11	26	34	13	38	49	15	43	56	17	48		19	54		21	59		23	75	30	96	38
Footing Bottom Bars	NWC	5000 psi	12	16	6	12	16	6	13	17	7	16	21	9	23	30	10	26	34	12	29		13	32		15	36		23				
Beam Top Bars	NWC	5000 psi	17	22	6	23	30	8	28	36	11	34	44	13	49	64	15	56	73	17	63		19	69		21	76		23	97	30	125	38
Slab on Grade	NWC	5000 psi	12	16	6	12	16	6	13	17	7	16	21	9	25	33	10	32	42	12	41		13	54		15	59		23				

ARW ENGINEERS

Project No. 15068 Sheet No.

Project DIAMOND HIGHLANDS RES #3

Prepared By ZCH Date 3/5/15

TANK LID

DEAD LOAD

ASSUME 10" THICK SLAB + 18" Ø COLUMN

$DL = 150\,pcf\,(10"/12") + 15\,psf = 140\,psf$

LID DESIGN

FACTORED LOAD ON THE LID $\Rightarrow$ $U = 1.2(140\,psf) + 1.6(100\,psf) = 328\,psf$

LOAD ON CENTER COLUMN $\Rightarrow$

$c/d = 8'/48' = 0.167$ (ASSUME A DROP PANEL WIDTH OF 8')

FOR TABLE A-13, LOAD COEF. = 1.463

$LOAD = 328\,psf\,(24')^2(1.463) = 276.4\,K$

COLUMN LOAD = 276.4K ✓

LOAD DIRECTLY APPLIED ABOVE DROP PANEL = $\pi(8')^2/4\,(328\,psf) = 16.5K$

SHEAR AT FACE OF COLUMN = $V_{u\,COLUMN} = 276.4K$

SHEAR AT FACE OF DROP PANEL = $V_{u\,DROP\,PANEL} = 276.4K - 16.5K = 260K$

SHEAR CAPACITY:

@ COLUMN $\Rightarrow$ $b_o = \pi(30in + 13.5) = 105.2\,in$

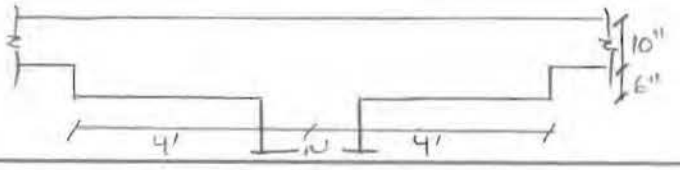
TRY 6" DROP PANEL

$\phi V_c = 4\sqrt{4,500}\,(105.2in)(13.5")(0.75) = 286K > 276.4K$ ✓ GOOD

@ DROP PANEL $\Rightarrow$ $b_o = \pi(96in + 7.5) = 326\,in$

$\phi V_c = \left(\frac{40(7.5)}{326} + 2\right)\sqrt{4,500}\,(326in)(7.5in)(0.75) = 359K > 260K$ ✓ GOOD

$\therefore$ TRY



TANK LID (CONT'D)

RADIAL MOMENTS (TABLE A-18) SEE ATTACHED TABLE FOR COEF. & MOMENT CALCS.

$C/D = 20/12/24 = 0.069$ ∴ USE 0.05

$pR^2 = 328 psf (24')^2 = 188{,}928$ ft-lb/ft

NEGATIVE MOMENT (TOP BARS):

MAX OCCURS AT FACE OF COLUMN $= M_u = 69{,}110$ lb-ft

$R_n = 12(69{,}110 \text{ lb-ft}) / 0.9(12")(13.5)^2 = 421.3$

$\rho = \frac{0.85(4.5)}{60}\left(1 - \sqrt{1 - \frac{2(421.3)}{0.85(4{,}500)}}\right) = 0.0075$

$\rho_{MAX \text{ FOR } \phi=0.9} = 0.319(0.85)\left(\frac{4.5}{60}\right) = 0.019 > 0.0129$ ∴ o.k.

$A_{S\,REQ'D} = 0.0075(12")(13.5") = 1.22 in^2/ft$

TOTAL $A_S = 1.7'(\pi)(1.22 in^2/ft) = 6.49 in^2$

CHECK MOMENT AT FACE OF DROP PANEL:

$4/24 = 0.167$ ∴ USE 0.15 ∴ $M_u = 12{,}091$ lb-ft

$R_n = 12(12{,}091 \text{ lb-ft}) / 0.9(12")(7.5)^2 = 239$

$\rho = \frac{0.85(4.5)}{60}\left(1 - \sqrt{1 - \frac{2(239)}{0.85(4{,}500)}}\right) = 0.0041$

$A_{S\,REQ'D} = 0.0041(12")(7.5") = 0.37 in^2/ft$

TOTAL $A_S = 8'(\pi)(0.37 in^2/ft) = 9.29 in^2$

USE (20) #7 BARS $A_S = 12 in^2$

$A_{S\,min}$ FOR FLEXURE $= \frac{200}{60{,}000}(8')(12)(\pi)(7.5) = 7.54 in^2$

∴ USE (20) #7 BARS (TOP OF SLAB)

SLAB INFLECTION POINT $= 0.25(24) = 6'-0"$

∴ RUN TOP BARS 40" (l_d) PAST 6'-0" SAY 11' FROM CENTER

$+1.5' =$

TANK LID (CONT'D)

RADIAL MOMENTS (CONT'D)

POSITIVE MOMENT: (BOTTOM BARS)

MAX MOMENT PER SEGMENT OCCURS @ 0.7R $0.7(24') = 16.8'$

$\therefore M_u = 10{,}700$ lb-ft

$R_n = 12(10{,}700 \text{ lb-ft})/0.9(12")(7.5")^2 = 211$

$\rho = \frac{0.85(4.5)}{60}\left(1 - \sqrt{1 - \frac{2(211)}{0.85(4{,}500)}}\right) = 0.0036$

$A_{s\,REQ'D} = 0.0036(12")(7.5") = 0.33 in^2/ft$

TOTAL $A_s = 33.6'(\pi)(0.33 in^2/ft) = 35.8 in^2$ ✓ CONTROLS

$A_{s\,min}$ FOR FLEXURE $= \frac{200}{60{,}000}(33.6')(12")(\pi)(7.5") = 31.6 in^2$

TRY #6 BARS $\Rightarrow$ $35.8 in^2 / 0.44 in^2/BAR = 82$ BARS

BAR SPACING @ $33.6(\pi)/82 = 15"$

USE (82) #6 BARS

TANGENTIAL MOMENTS

NEGATIVE REINF @ DROP PANEL: (TOP STEEL)

$M_u = 24{,}126$ lb-ft

$R_n = 12(24{,}126 \text{ lb-ft})/0.9(12")(12.5")^2 = 171$

$\rho = \frac{0.85(4.5)}{60}\left(1 - \sqrt{1 - \frac{2(171)}{0.85(4{,}500)}}\right) = 0.0029$

$A_{s\,REQ'D} = 0.0029(12")(13.5") = 0.473 in^2/ft$

$A_{s\,min} = \frac{200}{60{,}000}(12")(13.5") = 0.54 in^2/ft$

USE #7 @ 12" O.C. EXTEND 5'-0" INTO LID

TANK LID (CONT'D)

TANGENTIAL MOMENTS (CONT'D)

NEGATIVE REINF. @ TYP. SLAB: (TOP STEEL)

WORSTE CASE MOMENT occurs @ 0.2R (4.8') M_u = 14.85 K-FT

$R_n = 12(14{,}850\ \text{lb-ft})/0.9(12"\times 6.5")^2 = 390.5$

$$\rho = \frac{0.85(4.5)}{60}\left(1-\sqrt{1-\frac{2(391)}{0.85(4{,}500)}}\right) = 0.0069$$

$A_{s\,REQ'D} = 0.0069(12")(6.5") = 0.537\ in^2/FT$

∴ USE #7 @ 12" O.C.

EXTEND REINFORCING $0.5(24') + 2' = 14'\text{-}0"$ (↑ INFLECTION POINT)

POSITIVE REINF. @ TYP. SLAB: (BOTTOM STEEL)

WORSTE CASE MOMENT = M_u = 4,742 K-FT

$R_n = 12(4{,}742\ \text{lb-ft})/0.9(12")(6.5")^2 = 125$

$$\rho = \frac{0.85(4.5)}{60}\left(1-\sqrt{1-\frac{2(125)}{0.85(4{,}500)}}\right) = 0.0021$$

$A_{s\,REQ'D} = 0.0021(12")(6.5") = 0.165\ in^2/FT$

$A_{s\,min} = \frac{200}{60{,}000}(12"\times 6.5") = 0.26\ in^2/FT$ ✓ CONTROLS

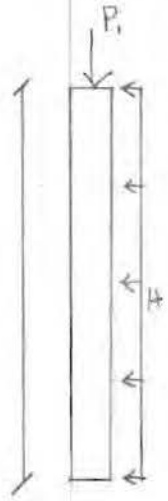
∴ USE #5 @ 12" O.C.

188928 ft-lb/ft	= pR^2				
Tank Lid Moments					
Point	Radial Coefficient	Radial Moment	Radial Moment Per Segment	Tangential Coefficient	Tangential Moment
0.05	-0.3658	-69110	-3455	-0.0731	-13811
0.1	-0.1388	-26223	-2622	-0.1277	-24126
0.15	-0.064	-12091	-1814	-0.104	-19649
0.2	-0.0221	-4175	-835	-0.0786	-14850
0.25	0.0058	1096	274	-0.0569	-10750
0.3	0.0255	4818	1445	-0.0391	-7387
0.4	0.0501	9465	3786	-0.0121	-2286
0.5	0.0614	11600	5800	0.0061	1152
0.6	0.0629	11884	7130	0.0175	3306
0.7	0.0566	10693	7485	0.0234	4421
0.8	0.0437	8256	6605	0.0251	4742
0.9	0.0247	4667	4200	0.0228	4308
1	0	0	0	0.0168	3174

COLUMN DESIGN

LOADS

LOAD ON COLUMN USES PCA TABLE A-13 COEFF = 1.463



$P_1 \Rightarrow$ {
- DEAD LOAD = $140\,psf\,(24')^2(1.463) = 118K$
- SNOW LOAD = $100\,psf\,(24')^2(1.463) = 84.3K$
- VERT. SEISMIC = $0.2(0.841)(118K) = 19.8K$

$H = \pi(1.0)(62.4\,pcf)(10'/12)^2 + 0.4(0.841)(1.25)(\pi(1.67)^2/4)(150pcf) = 135\,PLF$

↑ WEIGHT OF WATER PER PCA SEISMIC MANUAL SEC. 5.3

↑ WEIGHT OF COLUMN

USE 18" ø COLUMN W/ (8) #6 BARS

FIND TRANSVERSE REINF. $\Rightarrow$ PER ACI 350 CH. 21.4.4

$\rho_s = 0.12(4,500)/60,000 = 0.009$

SPACING $\Rightarrow$ $18"/4 = 4.5in$

$6(6/8) = 4.5in$

$S_x = 4 + \left(\frac{14-14}{3}\right) = 4in$ ✓ CONTROLS

PER 10.9.3 ($\rho_s \Rightarrow$) $A_g = \pi(18")^2/4 = 254in^2$

$A_{CH} = \pi(14")^2/4 = 154in^2$

$\rho_s = 0.45\left(\frac{254}{154} - 1\right)\frac{4.5}{60} = 0.022$ ✓ CONTROLS

REQ'D PITCH OF #3 SPIRAL = $0.022 = \frac{0.11(\pi)(13.625)}{154\,s}$ $s_{REQ'D} = 1.39in$

REQ'D PITCH OF #4 SPIRAL = $0.022 = \frac{0.20(\pi)(13.50)}{154(s)}$ $s_{REQ'D} = 2.5in$ ✓

SPACING OF #3 HOOPS = $0.009 = \frac{0.11(\pi)(13.625)}{154\,s} = 3.39in$

USE #4 SPIRAL W/ 2.5" PITCH OR #3 HOOPS @ 3" O.C.

Title Block Line 1
You can changes this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project Descr:

Project ID:

Printed: 3 MAR 2015, 9:35AM

Concrete Column

Description : Typical Center Column

Code References

Calculations per ACI 318-05, IBC 2006, CBC 2007, ASCE 7-05
Load Combinations Used : 2006 IBC & ASCE 7-05

General Information

f'c : Concrete 28 day strength	=	4.50 ksi
E =	=	3,823.68 ksi
Density	=	145.0 pcf
β	=	0.8250
fy - Main Rebar	=	60.0 ksi
E - Main Rebar	=	29,000.0 ksi
Allow. Reinforcing Limits		*ASTM A615 Bars Used*
Min. Reinf.	=	1.0 %
Max. Reinf.	=	8.0 %

Load Combination : 2006 IBC & ASCE 7-05

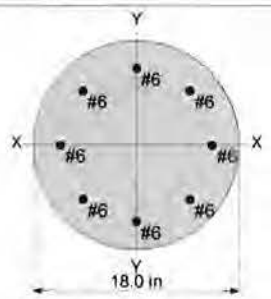
Overall Column Height = 16.50 ft
End Fixity Top & Bottom Pinned

Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for X-X Axis buckling = 16.50 ft, K = 1.0
Y-Y (depth) axis :
Unbraced Length for X-X Axis buckling = 16.50 ft, K = 1.0

Column Cross Section

Column Dimensions : 18.0in Diameter, Column Edge to Rebar Edge Cover = 2.0in

Column Reinforcing : 8.0 - #6 bars



Applied Loads

Entered loads are factored per load combinations specified by user.

Column self weight included : 4,227.90 lbs * Dead Load Factor
AXIAL LOADS . . .
Axial Load at 16.50 ft above base, Xecc = 3.0in, Yecc = 3.0in, D = 118.0, S = 84.30, E = 19.80 k
BENDING LOADS . . .
Lat. Uniform Load creating Mx-x, E = 0.1380 k/ft

DESIGN SUMMARY

Load Combination +1.20D+0.50L+1.60S
Location of max.above base 16.389 ft

Maximum Stress Ratio **0.698 : 1**
Ratio = (Pu^2+Mu^2)^.5 / (PhiPn^2+PhiMn^2)^.5

Pu =	281.553 k	φ * Pn =	402.015 k
Mu-x =	-68.656 k-ft	φ * Mn-x =	-98.312 k-ft
Mu-y =	-68.656 k-ft	φ * Mn-y =	98.312 k-ft
Mu Angle =	45.0 deg		
Mu at Angle =	97.094 k-ft	φMn at Angle =	139.203 k-ft

Pn & Mn values located at Pu-Mu vector intersection with capacity curve

Column Capacities . . .

Pnmax : Nominal Max. Compressive Axial Capacity	1,171.08 k
Pnmin : Nominal Min. Tension Axial Capacity	-211.20 k
φ Pn, max : Usable Compressive Axial Capacity	696.79 k
φ Pn, min : Usable Tension Axial Capacity	-147.840 k

Maximum SERVICE Load Reactions . .

Top along Y-Y	3.065 k	Bottom along Y-Y	3.065 k
Top along X-X	3.501 k	Bottom along X-X	3.065 k

Maximum SERVICE Load Deflections . . .

Along Y-Y -0.07814 in at 9.634 ft above base
for load combination : +D+S

Along X-X -0.07814 in at 9.634 ft above base
for load combination : +D+S

General Section Information . φ = 0.70 β = 0.8250 θ = 0.850

ρ : % Reinforcing	1.383 % Rebar % Ok
Reinforcing Area	3.520 in^2
Concrete Area	254.469 in^2

Concrete Column

Lic. # : KW-06002489 **Licensee : ARW ENGINEERS**

Description : Typical Center Column

Governing Load Combination Results

Governing Factored Load Combination	Moment Source X-X	Moment Source Y-Y	Dist. from base ft	Axial Load k Pu	φ * Pn	δx	δx * Mux	δy	δy * Muy	Bending Analysis k-ft Alpha (deg)	δ Mu	φ Mn	Utilization Ratio
+1.40D	Actual	Actual	16.39	171.12	409.80	1.000	-41.02	1.000	-41.02	45.000	58.02	138.48	**0.419**
+1.20D+0.50Lr+1.60L+1.60H	Actual	Actual	16.39	146.67	409.80	1.000	-35.16	1.000	-35.16	45.000	49.73	138.48	**0.359**
+1.20D+0.50L+0.50S+1.60H	Actual	Actual	16.39	188.82	405.87	1.000	-45.63	1.000	-45.63	45.000	64.53	138.85	**0.465**
+1.20D+1.60Lr+0.50L	Actual	Actual	16.39	146.67	409.80	1.000	-35.16	1.000	-35.16	45.000	49.73	138.48	**0.359**
+1.20D+1.60Lr+0.50L+0.80W	Actual	Actual	16.39	146.67	409.80	1.000	-35.16	1.000	-35.16	45.000	49.73	138.48	**0.359**
+1.20D+0.50L+1.60S	Actual	Actual	16.39	281.55	402.01	1.000	-68.66	1.000	-68.66	45.000	97.09	139.20	**0.698**
+1.20D+0.50L+1.60S+0.80W	Actual	Actual	16.39	281.55	402.01	1.000	-68.66	1.000	-68.66	45.000	97.09	139.20	**0.698**
+1.20D+0.50Lr+0.50L+1.60W	Actual	Actual	16.39	146.67	409.80	1.000	-35.16	1.000	-35.16	45.000	49.73	138.48	**0.359**
+1.20D+0.50L+0.50S+1.60W	Actual	Actual	16.39	188.82	405.87	1.000	-45.63	1.000	-45.63	45.000	64.53	138.85	**0.465**
+1.20D+0.50L+0.20S+E	Actual	Actual	16.39	183.33	405.87	1.246	-54.98	1.000	-44.27	45.000	70.58	138.85	**0.505**
+0.90D+1.60W+1.60H	Actual	Actual	16.39	110.01	409.80	1.000	-26.37	1.000	-26.37	45.000	37.30	138.48	**0.269**
+0.90D+E+1.60H	Actual	Actual	16.39	129.81	405.87	1.162	-36.22	1.000	-31.29	45.000	47.86	138.85	**0.343**

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Reaction along X-X Axis @ Base	Reaction along X-X Axis @ Top	Reaction along Y-Y Axis @ Base	Reaction along Y-Y Axis @ Top	Axial Reaction @ Base
D Only	1.788	1.788 k	1.788	1.788 k	118.000 k
+D+L	1.788	1.788 k	1.788	1.788 k	118.000 k
+D+Lr	1.788	1.788 k	1.788	1.788 k	118.000 k
+D+S	3.065	3.065 k	3.065	3.065 k	202.300 k
+D+0.750Lr+0.750L	1.788	1.788 k	1.788	1.788 k	118.000 k
+D+0.750L+0.750S	2.746	2.746 k	2.746	2.746 k	181.225 k
+D+W	1.788	1.788 k	1.788	1.788 k	118.000 k
+D+0.70E	1.201	2.795 k	1.998	1.998 k	131.860 k
+D+0.750Lr+0.750L+0.750W	1.788	1.788 k	1.788	1.788 k	118.000 k
+D+0.750L+0.750S+0.750W	2.746	2.746 k	2.746	2.746 k	181.225 k
+D+0.750Lr+0.750L+0.5250E	1.348	2.543 k	1.945	1.945 k	128.395 k
+D+0.750L+0.750S+0.5250E	2.306	3.501 k	2.903	2.903 k	191.620 k
+0.60D+W	1.073	1.073 k	1.073	1.073 k	70.800 k
+0.60D+0.70E	0.486	2.080 k	1.283	1.283 k	84.660 k
D Only	1.788	1.788 k	1.788	1.788 k	118.000 k
Lr Only		k		k	k
L Only		k		k	k
S Only	1.277	1.277 k	1.277	1.277 k	84.300 k
W Only		k		k	k
E Only	0.839	1.439 k	0.300	0.300 k	19.800 k
H Only		k		k	k

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
D Only	-0.0456	in	9.634	ft	-0.046	in	9.634	ft
+D+L	-0.0456	in	9.634	ft	-0.046	in	9.634	ft
+D+Lr	-0.0456	in	9.634	ft	-0.046	in	9.634	ft
+D+S	-0.0781	in	9.634	ft	-0.078	in	9.634	ft
+D+0.750Lr+0.750L	-0.0456	in	9.634	ft	-0.046	in	9.634	ft
+D+0.750L+0.750S	-0.0700	in	9.634	ft	-0.070	in	9.634	ft
+D+W	-0.0456	in	9.634	ft	-0.046	in	9.634	ft
+D+0.70E	-0.0509	in	9.634	ft	-0.043	in	9.856	ft
+D+0.750Lr+0.750L+0.750W	-0.0456	in	9.634	ft	-0.046	in	9.634	ft
+D+0.750L+0.750S+0.750W	-0.0700	in	9.634	ft	-0.070	in	9.634	ft
+D+0.750Lr+0.750L+0.5250E	-0.0496	in	9.634	ft	-0.044	in	9.745	ft
+D+0.750L+0.750S+0.5250E	-0.0740	in	9.634	ft	-0.068	in	9.745	ft
+0.60D+W	-0.0273	in	9.634	ft	-0.027	in	9.634	ft
+0.60D+0.70E	-0.0327	in	9.634	ft	-0.025	in	10.077	ft
D Only	-0.0456	in	9.634	ft	-0.046	in	9.634	ft
Lr Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
L Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
S Only	-0.0326	in	9.634	ft	-0.033	in	9.634	ft

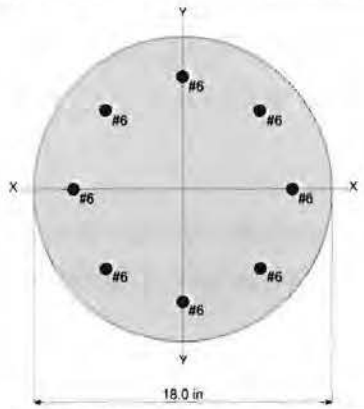
Concrete Column

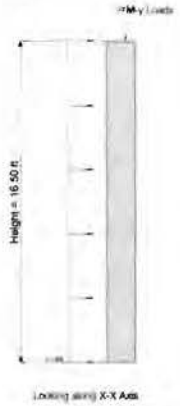
Description : Typical Center Column

Maximum Deflections for Load Combinations

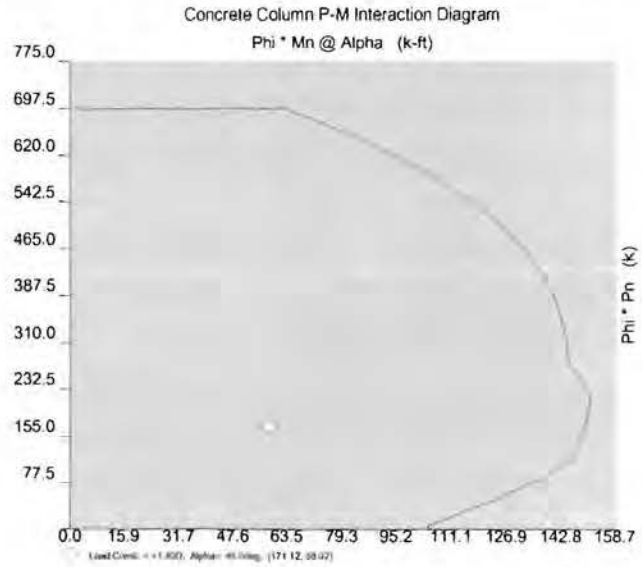
Load Combination	Max. X-X Deflection		Distance		Max. Y-Y Deflection		Distance	
W Only	0.0000	in	0.000	ft	0.000	in	0.000	ft
E Only	-0.0076	in	9.634	ft	0.005	in	6.866	ft
H Only	0.0000	in	0.000	ft	0.000	in	0.000	ft

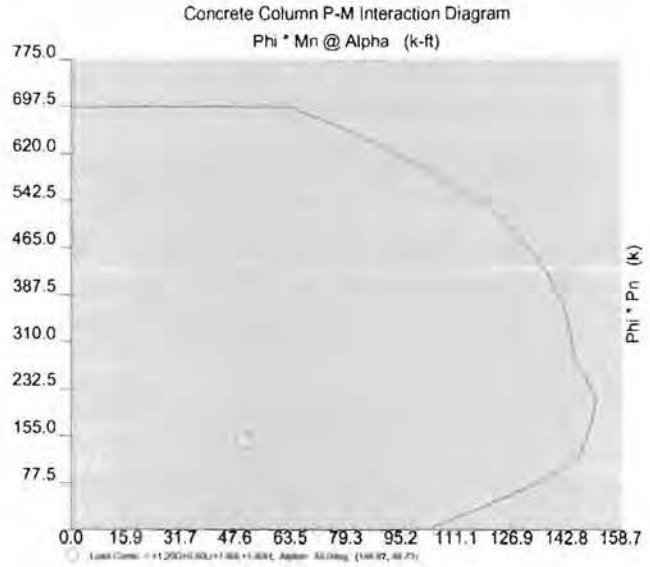
Sketches





Interaction Diagrams





Title Block Line 1
You can changes this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project Descr:

Project ID:

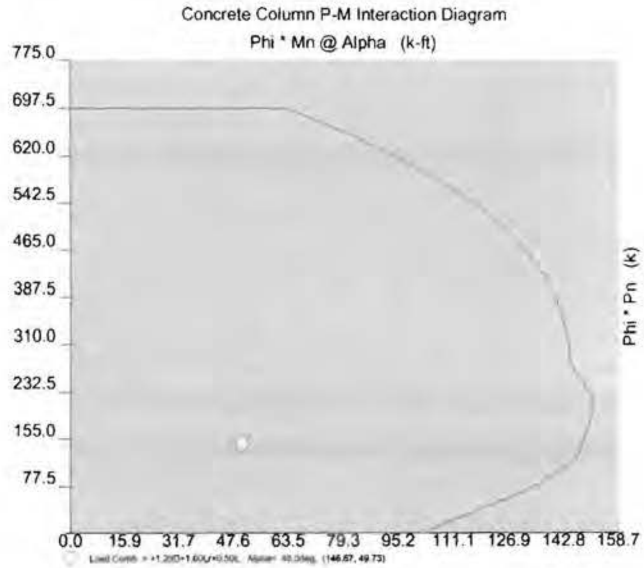
Printed: 9 MAR 2015, 9:35AM

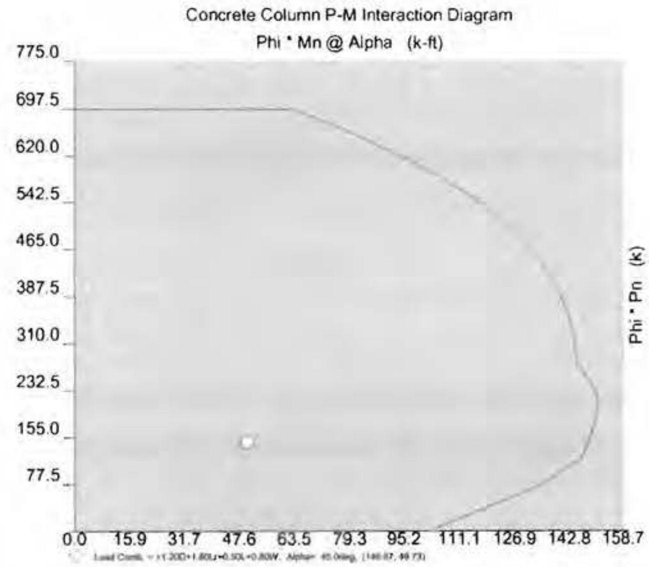
Concrete Column

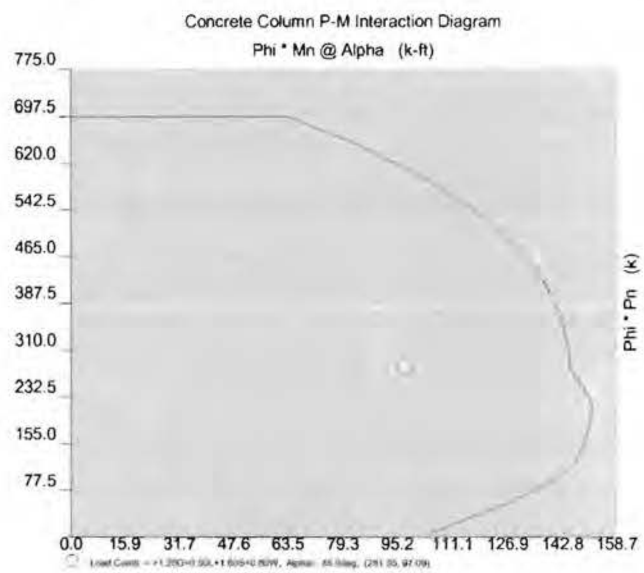
ojects 2015\15068 - Uintah 200K Gal Reservoir #3 Rebuild\Engineering\Calculations\Other\15068 uintah res#3.ec6
ENERCALC, INC. 1983-2015, Build:6.15.2.17, Ver:6.15.2.17

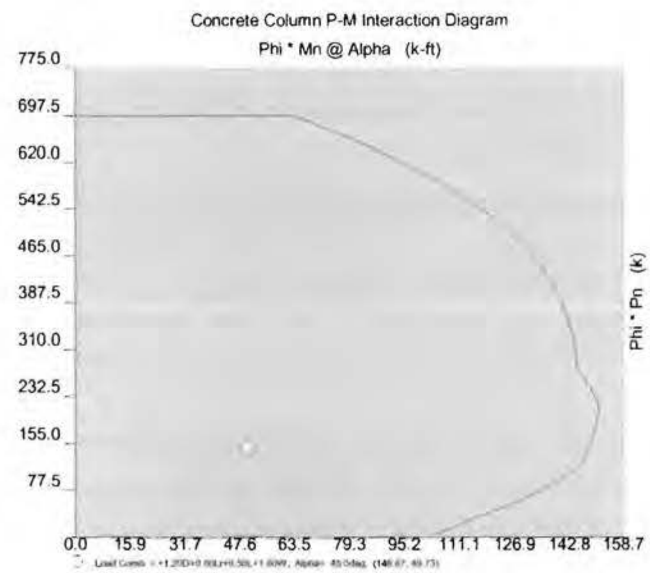
Lic. # : KW-06002489 **Licensee : ARW ENGINEERS**

Description : Typical Center Column









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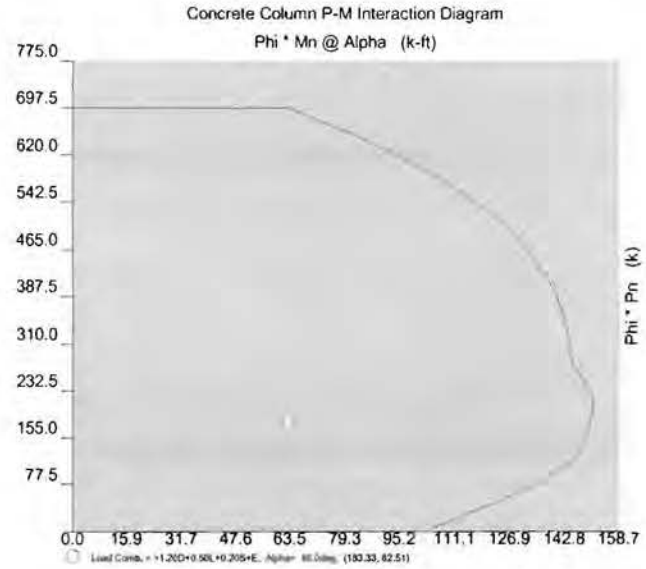
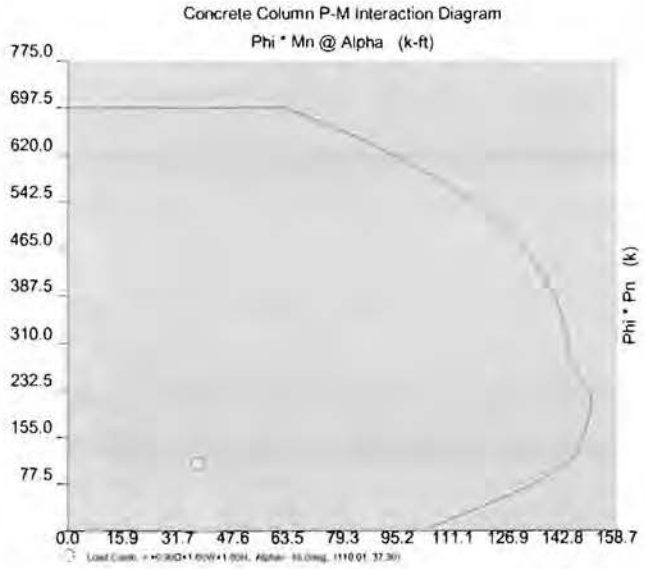
Concrete Column

ojects 2015\15068 - Uintah 200K Gal Reservoir #3 Rebuild\Engineering\Calculations\Other\15068 uintah res#3.ec6
ENERCALC, INC. 1983-2015, Build:6.15.2.17, Ver:6.15.2.17

Lic. # : KW-06002489 **Licensee : ARW ENGINEERS**

Description : Typical Center Column





Title Block Line 1
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Title Block Line 6

Project Title:
Engineer:
Project Descr:

Project ID:

General Footing

Lic. # : KW-06002489 — Licensee : ARW ENGINEERS

Description : Center Column Footing

Code References

Calculations per ACI 318-05, IBC 2006, CBC 2007, ASCE 7-05
Load Combinations Used : ASCE 7-10

General Information

Material Properties

f'c : Concrete 28 day strength	=	4,500.0 ksi
fy : Rebar Yield	=	60.0 ksi
Ec : Concrete Elastic Modulus	=	3,122.0 ksi
Concrete Density	=	145.0 pcf
φ Values Flexure	=	0.90
Shear	=	0.750

Analysis Settings

Min Steel % Bending Reinf.	=	
Min Allow % Temp Reinf.	=	0.00180
Min. Overturning Safety Factor	=	1.0 : 1
Min. Sliding Safety Factor	=	1.0 : 1
Add Ftg Wt for Soil Pressure	:	Yes
Use ftg wt for stability, moments & shears	:	Yes
Add Pedestal Wt for Soil Pressure	:	No
Use Pedestal wt for stability, mom & shear	:	No

Soil Design Values

Allowable Soil Bearing	=	4.0 ksf
Increase Bearing By Footing Weight	=	No
Soil Passive Resistance (for Sliding)	=	250.0 pcf
Soil/Concrete Friction Coeff.	=	0.30

Increases based on footing Depth

Footing base depth below soil surface	=	0.0 ft
Allowable pressure increase per foot of deptl	=	0.0 ksf
when footing base is below	=	0.0 ft

Increases based on footing plan dimension

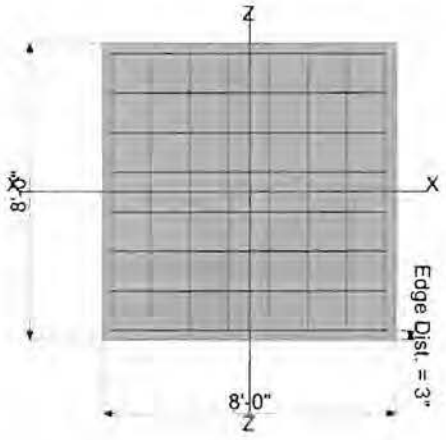
Allowable pressure increase per foot of depl	=	0.0 ksf
when maximum length or width is greater	=	0.0 ft

Dimensions

Width parallel to X-X Axis	=	8.0 ft
Length parallel to Z-Z Axis	=	8.0 ft
Footing Thicknes	=	18.0 in

Pedestal dimensions...

px : parallel to X-X Axis	=	0.0 in
pz : parallel to Z-Z Axis	=	0.0 in
Height		0.0 in
Rebar Centerline to Edge of Concrete.. at Bottom of footing	=	3.0 in



Reinforcing

Bars parallel to X-X Axis		
Number of Bars	=	8
Reinforcing Bar Size	=	# 8
Bars parallel to Z-Z Axis		
Number of Bars	=	8
Reinforcing Bar Size	=	# 8

Bandwidth Distribution Check (ACI 15.4.4.2)

Direction Requiring Closer Separation	n/a
# Bars required within zone	n/a
# Bars required on each side of zone	n/a

Applied Loads

		D	Lr	L	S	W	E	H
P : Column Load	=	123.0	0.0	0.0	84.30	0.0	19.80	0.0 k
OB : Overburden	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0 ksf
M-xx	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0 k-ft
M-zz	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0 k-ft
V-x	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0 k
V-z	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0 k

General Footing

Description : Center Column Footing

DESIGN SUMMARY

Design OK

	Min. Ratio	Item	Applied	Capacity	Governing Load Combination
PASS	0.8643	Soil Bearing	3.457 ksf	4.0 ksf	+D+S+H about Z-Z axis
PASS	n/a	Overturning - X-X	0.0 k-ft	0.0 k-ft	No Overturning
PASS	n/a	Overturning - Z-Z	0.0 k-ft	0.0 k-ft	No Overturning
PASS	n/a	Sliding - X-X	0.0 k	0.0 k	No Sliding
PASS	n/a	Sliding - Z-Z	0.0 k	0.0 k	No Sliding
PASS	n/a	Uplift	0.0 k	0.0 k	No Uplift
PASS	0.6622	Z Flexure (+X)	35.310 k-ft	53.323 k-ft	+1.20D+0.50L+1.60S+1.60H
PASS	0.6622	Z Flexure (-X)	35.310 k-ft	53.323 k-ft	+1.20D+0.50L+1.60S+1.60H
PASS	0.6622	X Flexure (+Z)	35.310 k-ft	53.323 k-ft	+1.20D+0.50L+1.60S+1.60H
PASS	0.6622	X Flexure (-Z)	35.310 k-ft	53.323 k-ft	+1.20D+0.50L+1.60S+1.60H
PASS	0.02158	1-way Shear (+X)	68.658 psi	3,181.98 psi	+1.20D+0.50L+1.60S+1.60H
PASS	0.02158	1-way Shear (-X)	68.658 psi	3,181.98 psi	+1.20D+0.50L+1.60S+1.60H
PASS	0.02158	1-way Shear (+Z)	68.658 psi	3,181.98 psi	+1.20D+0.50L+1.60S+1.60H
PASS	0.02158	1-way Shear (-Z)	68.658 psi	3,181.98 psi	+1.20D+0.50L+1.60S+1.60H
PASS	0.04795	2-way Punching	305.148 psi	6,363.96 psi	+1.20D+0.50L+1.60S+1.60H

Detailed Results

Soil Bearing

Rotation Axis & Load Combination...	Gross Allowable	Xecc	Zecc	Actual Soil Bearing Stress Bottom, -Z	Top, +Z	Left, -X	Right, +X	Actual / Allowable Ratio
X-X, +D+H	4.0	n/a	0.0	2.139	2.139	n/a	n/a	0.535
X-X, +D+L+H	4.0	n/a	0.0	2.139	2.139	n/a	n/a	0.535
X-X, +D+Lr+H	4.0	n/a	0.0	2.139	2.139	n/a	n/a	0.535
X-X, +D+S+H	4.0	n/a	0.0	3.457	3.457	n/a	n/a	0.864
X-X, +D+0.750Lr+0.750L+H	4.0	n/a	0.0	2.139	2.139	n/a	n/a	0.535
X-X, +D+0.750L+0.750S+H	4.0	n/a	0.0	3.127	3.127	n/a	n/a	0.782
X-X, +D+0.60W+H	4.0	n/a	0.0	2.139	2.139	n/a	n/a	0.535
X-X, +D+0.70E+H	4.0	n/a	0.0	2.356	2.356	n/a	n/a	0.589
X-X, +D+0.750Lr+0.750L+0.450W+H	4.0	n/a	0.0	2.139	2.139	n/a	n/a	0.535
X-X, +D+0.750L+0.750S+0.450W+H	4.0	n/a	0.0	3.127	3.127	n/a	n/a	0.782
X-X, +D+0.750L+0.750S+0.5250E+H	4.0	n/a	0.0	3.290	3.290	n/a	n/a	0.823
X-X, +0.60D+0.60W+0.60H	4.0	n/a	0.0	1.284	1.284	n/a	n/a	0.321
X-X, +0.60D+0.70E+0.60H	4.0	n/a	0.0	1.50	1.50	n/a	n/a	0.375
Z-Z, +D+H	4.0	0.0	n/a	n/a	n/a	2.139	2.139	0.535
Z-Z, +D+L+H	4.0	0.0	n/a	n/a	n/a	2.139	2.139	0.535
Z-Z, +D+Lr+H	4.0	0.0	n/a	n/a	n/a	2.139	2.139	0.535
Z-Z, +D+S+H	4.0	0.0	n/a	n/a	n/a	3.457	3.457	0.864
Z-Z, +D+0.750Lr+0.750L+H	4.0	0.0	n/a	n/a	n/a	2.139	2.139	0.535
Z-Z, +D+0.750L+0.750S+H	4.0	0.0	n/a	n/a	n/a	3.127	3.127	0.782
Z-Z, +D+0.60W+H	4.0	0.0	n/a	n/a	n/a	2.139	2.139	0.535
Z-Z, +D+0.70E+H	4.0	0.0	n/a	n/a	n/a	2.356	2.356	0.589
Z-Z, +D+0.750Lr+0.750L+0.450W+H	4.0	0.0	n/a	n/a	n/a	2.139	2.139	0.535
Z-Z, +D+0.750L+0.750S+0.450W+H	4.0	0.0	n/a	n/a	n/a	3.127	3.127	0.782
Z-Z, +D+0.750L+0.750S+0.5250E+H	4.0	0.0	n/a	n/a	n/a	3.290	3.290	0.823
Z-Z, +0.60D+0.60W+0.60H	4.0	0.0	n/a	n/a	n/a	1.284	1.284	0.321
Z-Z, +0.60D+0.70E+0.60H	4.0	0.0	n/a	n/a	n/a	1.50	1.50	0.375

Overturning Stability

Rotation Axis & Load Combination...	Overturning Moment	Resisting Moment	Stability Ratio	Status
Footing Has NO Overturning				

Sliding Stability

All units k

Force Application Axis Load Combination...	Sliding Force	Resisting Force	Sliding SafetyRatio	Status
Footing Has NO Sliding				

General Footing

Description : Center Column Footing

Footing Flexure

Flexure Axis & Load Combination	Mu k-ft	Which Side ?	Tension @ Bot or Top ?	As Req'd in^2	Gvrn. As in^2	Actual As in^2	Phi*Mn k-ft	Status
X-X, +1.40D+1.60H	21.525	+Z	Bottom	0.4251910932713	Min ACI 10.5	0.790	53.323	OK
X-X, +1.40D+1.60H	21.525	-Z	Bottom	0.4251910932713	Min ACI 10.5	0.790	53.323	OK

General Footing

Description : Center Column Footing

Footing Flexure

Flexure Axis & Load Combination	Mu k-ft	Which Side ?	Tension @ Bot or Top ?	As Req'd in^2	Gvrn. As in^2	Actual As in^2	Phi*Mn k-ft	Status
X-X, +1.20D+0.50Lr+1.60L+1.60H	18.450	+Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +1.20D+0.50Lr+1.60L+1.60H	18.450	-Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +1.20D+1.60L+0.50S+1.60H	23.719	+Z	Bottom	0.4685256922545	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+1.60L+0.50S+1.60H	23.719	-Z	Bottom	0.4685256922545	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+1.60Lr+0.50L+1.60H	18.450	+Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +1.20D+1.60Lr+0.50L+1.60H	18.450	-Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +1.20D+1.60Lr+0.50W+1.60H	18.450	+Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +1.20D+1.60Lr+0.50W+1.60H	18.450	-Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +1.20D+0.50L+1.60S+1.60H	35.310	+Z	Bottom	0.6974973802601	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+0.50L+1.60S+1.60H	35.310	-Z	Bottom	0.6974973802601	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+1.60S+0.50W+1.60H	35.310	+Z	Bottom	0.6974973802601	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+1.60S+0.50W+1.60H	35.310	-Z	Bottom	0.6974973802601	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+0.50Lr+0.50L+W+1.60H	18.450	+Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +1.20D+0.50Lr+0.50L+W+1.60H	18.450	-Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +1.20D+0.50L+0.50S+W+1.60H	23.719	+Z	Bottom	0.4685256922545	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+0.50L+0.50S+W+1.60H	23.719	-Z	Bottom	0.4685256922545	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+0.50L+0.20S+E+1.60H	23.033	+Z	Bottom	0.4549697275861	Min ACI 10.5	0.790	53.323	OK
X-X, +1.20D+0.50L+0.20S+E+1.60H	23.033	-Z	Bottom	0.4549697275861	Min ACI 10.5	0.790	53.323	OK
X-X, +0.90D+W+0.90H	13.838	+Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +0.90D+W+0.90H	13.838	-Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +0.90D+E+0.90H	16.313	+Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
X-X, +0.90D+E+0.90H	16.313	-Z	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.40D+1.60H	21.525	-X	Bottom	0.4251910932713	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.40D+1.60H	21.525	+X	Bottom	0.4251910932713	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+0.50Lr+1.60L+1.60H	18.450	-X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.20D+0.50Lr+1.60L+1.60H	18.450	+X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.20D+1.60L+0.50S+1.60H	23.719	-X	Bottom	0.4685256922545	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+1.60L+0.50S+1.60H	23.719	+X	Bottom	0.4685256922545	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+1.60Lr+0.50L+1.60H	18.450	-X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.20D+1.60Lr+0.50L+1.60H	18.450	+X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.20D+1.60Lr+0.50W+1.60H	18.450	-X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.20D+1.60Lr+0.50W+1.60H	18.450	+X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.20D+0.50L+1.60S+1.60H	35.310	-X	Bottom	0.6974973802601	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+0.50L+1.60S+1.60H	35.310	+X	Bottom	0.6974973802601	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+1.60S+0.50W+1.60H	35.310	-X	Bottom	0.6974973802601	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+1.60S+0.50W+1.60H	35.310	+X	Bottom	0.6974973802601	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+0.50Lr+0.50L+W+1.60H	18.450	-X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.20D+0.50Lr+0.50L+W+1.60H	18.450	+X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +1.20D+0.50L+0.50S+W+1.60H	23.719	-X	Bottom	0.4685256922545	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+0.50L+0.50S+W+1.60H	23.719	+X	Bottom	0.4685256922545	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+0.50L+0.20S+E+1.60H	23.033	-X	Bottom	0.4549697275861	Min ACI 10.5	0.790	53.323	OK
Z-Z, +1.20D+0.50L+0.20S+E+1.60H	23.033	+X	Bottom	0.4549697275861	Min ACI 10.5	0.790	53.323	OK
Z-Z, +0.90D+W+0.90H	13.838	-X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +0.90D+W+0.90H	13.838	+X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +0.90D+E+0.90H	16.313	-X	Bottom	0.3888	Min Temp %	0.790	53.323	OK
Z-Z, +0.90D+E+0.90H	16.313	+X	Bottom	0.3888	Min Temp %	0.790	53.323	OK

One Way Shear

Load Combination...	Vu @ -X	Vu @ +X	Vu @ -Z	Vu @ +Z	Vu:Max	Phi Vn	Vu / Phi*Vn	Status
+1.40D+1.60H	41.854 psi	41.854 psi	41.854 psi	41.854 psi	41.854 psi	3 psi	0.01315	OK
+1.20D+0.50Lr+1.60L+1.60H	35.875 psi	35.875 psi	35.875 psi	35.875 psi	35.875 psi	3 psi	0.01127	OK
+1.20D+1.60L+0.50S+1.60H	46.12 psi	46.12 psi	46.12 psi	46.12 psi	46.12 psi	3 psi	0.01449	OK
+1.20D+1.60Lr+0.50L+1.60H	35.875 psi	35.875 psi	35.875 psi	35.875 psi	35.875 psi	3 psi	0.01127	OK
+1.20D+1.60Lr+0.50W+1.60H	35.875 psi	35.875 psi	35.875 psi	35.875 psi	35.875 psi	3 psi	0.01127	OK
+1.20D+0.50L+1.60S+1.60H	68.658 psi	68.658 psi	68.658 psi	68.658 psi	68.658 psi	3 psi	0.02158	OK
+1.20D+1.60S+0.50W+1.60H	68.658 psi	68.658 psi	68.658 psi	68.658 psi	68.658 psi	3 psi	0.02158	OK
+1.20D+0.50Lr+0.50L+W+1.60H	35.875 psi	35.875 psi	35.875 psi	35.875 psi	35.875 psi	3 psi	0.01127	OK
+1.20D+0.50L+0.50S+W+1.60H	46.12 psi	46.12 psi	46.12 psi	46.12 psi	46.12 psi	3 psi	0.01449	OK
+1.20D+0.50L+0.20S+E+1.60H	44.785 psi	44.785 psi	44.785 psi	44.785 psi	44.785 psi	3 psi	0.01408	OK
+0.90D+W+0.90H	26.906 psi	26.906 psi	26.906 psi	26.906 psi	26.906 psi	3 psi	0.008456	OK
+0.90D+E+0.90H	31.719 psi	31.719 psi	31.719 psi	31.719 psi	31.719 psi	3 psi	0.009968	OK

General Footing

Description : Center Column Footing

Punching Shear

All units k

Load Combination...	Vu	Phi*Vn	Vu / Phi*Vn	Status
+1.40D+1.60H	186.019 psi	6 psi	0.02923	OK
+1.20D+0.50Lr+1.60L+1.60H	159.444 psi	6 psi	0.02505	OK
+1.20D+1.60L+0.50S+1.60H	204.977 psi	6 psi	0.03221	OK
+1.20D+1.60Lr+0.50L+1.60H	159.444 psi	6 psi	0.02505	OK
+1.20D+1.60Lr+0.50W+1.60H	159.444 psi	6 psi	0.02505	OK
+1.20D+0.50L+1.60S+1.60H	305.148 psi	6 psi	0.04795	OK
+1.20D+1.60S+0.50W+1.60H	305.148 psi	6 psi	0.04795	OK
+1.20D+0.50Lr+0.50L+W+1.60H	159.444 psi	6 psi	0.02505	OK
+1.20D+0.50L+0.50S+W+1.60H	204.977 psi	6 psi	0.03221	OK
+1.20D+0.50L+0.20S+E+1.60H	199.046 psi	6 psi	0.03128	OK
+0.90D+W+0.90H	119.583 psi	6 psi	0.01879	OK
+0.90D+E+0.90H	140.972 psi	6 psi	0.02215	OK

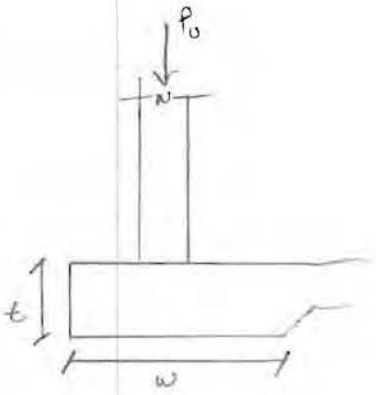
ARW ENGINEERS

Project No. 15068 Sheet No. _____

Project UINTAH HIGHLANDS RES #3

Prepared By ZCH Date 3/9/15

CONTINUOUS WALL FOOTING



LIVE LOADS => DL = 140 psf (25')(½) = 1,750 plf

SL = 100 psf (25')(½) = 1,250 plf

WALL WEIGHT => DL = 150 psf (16.83') = 2,525 plf

TOTAL LOADS => DL = 1,750 + 2,525 = 4,275 plf

SL = 1,250 plf

USE 3'-0" x 16" FOOTING W/ #6 BARS @ 12" o.c. EA. WAY

Title Block Line 1
You can changes this area
using the "Settings" menu item
and then using the "Printing &
Title Block" selection.
Title Block Line 6

Project Title:
Engineer:
Project Descr:

Project ID:

Wall Footing

Lic. # : KW-06002489 — Licensee : ARW ENGINEERS

Description : Typical Wall Footing

Code References

Calculations per ACI 318-05, IBC 2006, CBC 2007, ASCE 7-05
Load Combinations Used : ASCE 7-10

General Information

Material Properties

f'c : Concrete 28 day strength	=	4,500.0 ksi
fy : Rebar Yield	=	60.0 ksi
Ec : Concrete Elastic Modulus	=	3,122.0 ksi
Concrete Density	=	145.0 pcf
φ Values Flexure	=	0.90
Shear	=	0.750

Analysis Settings

Min Steel % Bending Reinf.	=	
Min Allow % Temp Reinf.	=	0.00180
Min. Overturning Safety Factor	=	1.0 : 1
Min. Sliding Safety Factor	=	1.0 : 1
AutoCalc Footing Weight as DL	:	No

Soil Design Values

Allowable Soil Bearing	=	4.0 ksf
Increase Bearing By Footing Weight	=	No
Soil Passive Resistance (for Sliding)	=	250.0 pcf
Soil/Concrete Friction Coeff.	=	0.30

Increases based on footing Depth

Reference Depth below Surface	=	0.0 ft
Allow. Pressure Increase per foot of depth	=	0.0 ksf
when base footing is below	=	0.0 ft

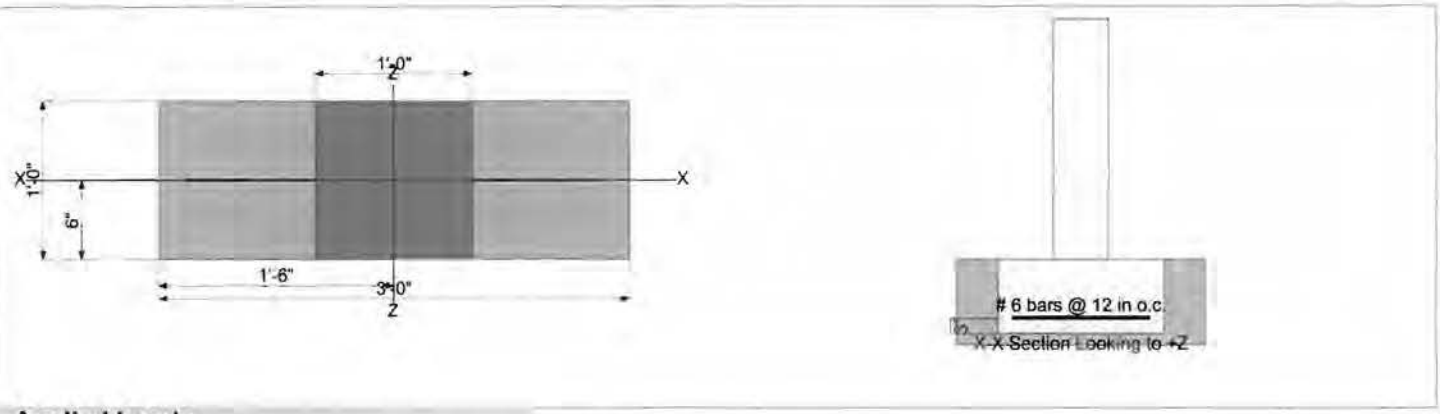
Increases based on footing Width

Allow. Pressure Increase per foot of width	=	0.0 ksf
when footing is wider than	=	0.0 ft

Dimensions

Footing Widt	=	3.0 ft	Footing Thicknes	=	16.0 in	Bars along X-X Axis	
Wall Thickness	=	12.0 in	Rebar Centerline to Edge of Concrete..			Bar spacing	= 12.00
Wall center offset from center of footing	=	0 in	at Bottom of footing	=	3.0 in	Reinforcing Bar Size	= # 6

Reinforcing



Applied Loads

		D	Lr	L	S	W	E	H
P : Column Load	=	4.280	0.0	0.0	1.250	0.0	0.0	0.0 k
OB : Overburden	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0 ksf
V-x	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0 k
M-zz	=	0.0	0.0	0.0	0.0	0.0	0.0	0.0 k-ft

Vx applied = 0.0 in above top of footing

DESIGN SUMMARY

Design OK

	Min. Ratio	Item	Applied	Capacity	Governing Load Combination
PASS	0.4608	Soil Bearing	1.843 ksf	4.0 ksf	+D+S+H
PASS	n/a	Overturning - Z-Z	0.0 k-ft	0.0 k-ft	No Overturning
PASS	n/a	Sliding - X-X	0.0 k	0.0 k	No Sliding
PASS	n/a	Uplift	0.0 k	0.0 k	No Uplift
PASS	0.04621	Z Flexure (+X)	1.189 k-ft	25.739 k-ft	+1.20D+0.50L+1.60S+1
PASS	0.02494	Z Flexure (-X)	0.6420 k-ft	25.739 k-ft	+0.90D+E+0.90H
PASS	n/a	1-way Shear (+X)	0.0 psi	3,181.98 psi	n/a
PASS	0.0	1-way Shear (-X)	0.0 psi	0.0 psi	n/a

Wall Footing

Description : Typical Wall Footing

Detailed Results

Soil Bearing

Rotation Axis & Load Combination...	Gross Allowable	Xecc	Zecc	+Z	Actual Soil Bearing Stress +Z	-X	-X	Actual / Allowable Ratio
, +D+H	4.0 ksf	0.0 in				1.427 ksf	1.427 ksf	0.357
, +D+L+H	4.0 ksf	0.0 in				1.427 ksf	1.427 ksf	0.357
, +D+Lr+H	4.0 ksf	0.0 in				1.427 ksf	1.427 ksf	0.357
, +D+S+H	4.0 ksf	0.0 in				1.843 ksf	1.843 ksf	0.461
, +D+0.750Lr+0.750L+H	4.0 ksf	0.0 in				1.427 ksf	1.427 ksf	0.357
, +D+0.750L+0.750S+H	4.0 ksf	0.0 in				1.739 ksf	1.739 ksf	0.435
, +D+0.60W+H	4.0 ksf	0.0 in				1.427 ksf	1.427 ksf	0.357
, +D+0.70E+H	4.0 ksf	0.0 in				1.427 ksf	1.427 ksf	0.357
, +D+0.750Lr+0.750L+0.450W+H	4.0 ksf	0.0 in				1.427 ksf	1.427 ksf	0.357
, +D+0.750L+0.750S+0.450W+H	4.0 ksf	0.0 in				1.739 ksf	1.739 ksf	0.435
, +D+0.750L+0.750S+0.5250E+H	4.0 ksf	0.0 in				1.739 ksf	1.739 ksf	0.435
, +0.60D+0.60W+0.60H	4.0 ksf	0.0 in				0.8560 ksf	0.8560 ksf	0.214
, +0.60D+0.70E+0.60H	4.0 ksf	0.0 in				0.8560 ksf	0.8560 ksf	0.214

Overturning Stability

Units : k-ft

Rotation Axis & Load Combination...	Overturning Moment	Resisting Moment	Stability Ratio	Status

Footing Has NO Overturning

Sliding Stability

Force Application Axis Load Combination...	Sliding Force	Resisting Force	Sliding SafetyRatio	Status

Footing Has NO Sliding

Footing Flexure

Flexure Axis & Load Combination	Mu k-ft	Which Side ?	Tension @ Bot. or Top ?	As Req'd in^2	Gvrn. As in^2	Actual As in^2	Phi*Mn k-ft	Status
, +1.40D+1.60H	0.9987	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.40D+1.60H	0.9987	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50Lr+1.60L+1.60H	0.856	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50Lr+1.60L+1.60H	0.856	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+1.60L+0.50S+1.60H	0.9602	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+1.60L+0.50S+1.60H	0.9602	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+1.60Lr+0.50L+1.60H	0.856	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+1.60Lr+0.50L+1.60H	0.856	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+1.60Lr+0.50W+1.60H	0.856	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+1.60Lr+0.50W+1.60H	0.856	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50L+1.60S+1.60H	1.189	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50L+1.60S+1.60H	1.189	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+1.60S+0.50W+1.60H	1.189	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+1.60S+0.50W+1.60H	1.189	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50Lr+0.50L+W+1.60H	0.856	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50Lr+0.50L+W+1.60H	0.856	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50L+0.50S+W+1.60H	0.9602	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50L+0.50S+W+1.60H	0.9602	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50L+0.20S+E+1.60H	0.8977	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +1.20D+0.50L+0.20S+E+1.60H	0.8977	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +0.90D+W+0.90H	0.642	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +0.90D+W+0.90H	0.642	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +0.90D+E+0.90H	0.642	-X	Bottom	0.3456	Min Temp %	0.44	25.739	OK
, +0.90D+E+0.90H	0.642	+X	Bottom	0.3456	Min Temp %	0.44	25.739	OK

One Way Shear

Units : k

Load Combination...	Vu @ -X	Vu @ +X	Vu:Max	Phi Vn	Vu / Phi*Vn	Status
+1.40D+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK
+1.20D+0.50Lr+1.60L+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK
+1.20D+1.60L+0.50S+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK
+1.20D+1.60Lr+0.50L+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK
+1.20D+1.60Lr+0.50W+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK
+1.20D+0.50L+1.60S+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK
+1.20D+1.60S+0.50W+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK

Wall Footing

Description : Typical Wall Footing

+1.20D+0.50Lr+0.50L+W+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK
+1.20D+0.50L+0.50S+W+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK
+1.20D+0.50L+0.20S+E+1.60H	0 psi	0 psi	0 psi	3 psi	0	OK

Wall Footing

Description : Typical Wall Footing

One Way Shear

Units : k

Load Combination...	Vu @ -X	Vu @ +X	Vu:Max	Phi Vn	Vu / Phi*Vn	Status
+0.90D+W+0.90H	0 psi	0 psi	0 psi	3 psi	0	OK
+0.90D+E+0.90H	0 psi	0 psi	0 psi	3 psi	0	OK

ARW ENGINEERS

Project No. 15068 Sheet No. _____

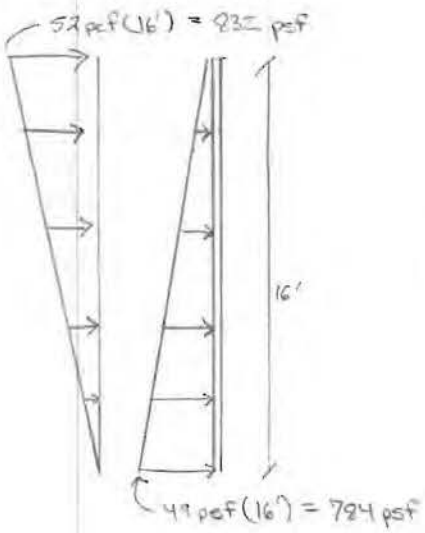
Project UINTAH HIGHLANDS RES #3

Prepared By ZCH Date 3/11/15

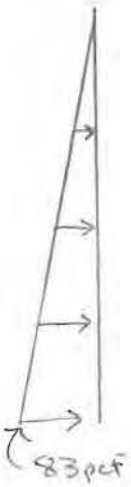
CHECK SEISMIC FORCES ON EMPTY TANK

* SEE ATTACHED SPREADSHEET FOR ADDITIONAL INFORMATION.

SOIL FORCES ON WALL



EQUIVALENT TO
(FOR INPUT IN SEISMIC SPREADSHEET)



M_{MAX} = 21.875 K-FT @ 8.160'

EQUIV. ω

$21.875 \text{ K-ft} = 0.128(W)(16') \Rightarrow W = 10.68 \text{ K}$ $\quad W = \omega L (1/2)$

$$\omega = \frac{10.68 \text{K}(2)}{16} = 1{,}335 \text{ psf}$$

$$\text{EQUIV. SOIL PRESSURE} = \frac{1{,}335 \text{ psf}}{16'} = 83 \text{ pcf}$$

SEE SPREADSHEET: $\Rightarrow$ RING FORCES ARE GOOD

CHECK MAX MOMENT IN WALL = 9 K-FT (WALL HAS #6 @ 12" OC.)

$\phi M_n \Rightarrow \quad a = \frac{0.44(60 \text{ ksi})}{0.85(4.5)(12)} = 0.575 \text{ in}$ $\quad \phi M_n = 0.9(0.44)(60)\left(9.5 - \frac{0.575}{2}\right) = 218.9 \text{ K-in}$

$18.2 \text{ K-ft} > 9 \text{ K-ft}$

$\therefore$ WALL IS GOOD. ✓

Project Name Uintah Highlands Reservoir #3
Project # 15068
Prepared By ZCH
Date 3/11/2015

Program Authors: TAB & DOC
Last Revised 10/20/2010
Reviewed By: TAB

ENGINEERS

Circular Concrete Tanks without Prestressing

(Based on the 1993 PCA Document)

Design Criteria

$f'c$	4500	psi
D_{tank}	48	ft
H_{tank}	10	ft
t_{wall}	12	in
Fluid Pressure	62.4	pcf
Soil Pressure	63	pcf
E_s	29000000	psi
E_c	3823676.24	psi
n	7.6	
Surcharge	100	pcf
Soil on Lid	1	ft
Load Factor		
$F_{liquid\ pressure}$	1.4	
$F_{Soil\ pressure}$	1.6	
Environmental		
Durability Factor		
Flexure (liquid)	1.00	
Tension (liquid)	1.00	
Flexure (soil)	1.00	
Compression (soil)	1	
H^2/Dt	5.33	

Estimation of Tank Wall Thickness

Limit Ring Tension Stress in Concrete Wall from 7% to 12% of f'c

For given t and H^2/Dt, with a hinged base/free top (Table A-5)

Max Coefficient= 0.624 (Table A-5)

w_u	169	pcf
T_{max}	40422	lbs
$T_{unfactored}$	14960	lbs
$A_{s(req'd)}$	0.75	in^2
$A_{s(used)}$	0.88	in^2
	OK	
$F_{f(conc)}$	150	psi

Compression Check	
F'c	482
0.33f'c	1485
OK	

This equates to 3.34 % of f'c
Wall thickness is OK

The Following Load Cases were used in Analysis:

Load Case #1: Full of Water, No Lid, No Backfill
Load Case #2: Empty, No Lid, w/Backfill
Load Case #3: Empty, w/Lid, w/Backfill
Load Case #4: Full of Water, w/Lid, Ignore Backfill

Load Case #1-Full of Water, No Lid, No Backfill

Assume Free Top/Hinged Base (Tables A-5 and A-7)
Effects of Possible outward movement will be handled by designing the entire portion of the wall for the maximum Ring Tension and Moment

Ring Force=(A-5 Coef.)w_uHR w_uHR= 64744.2432

Moment =(A-7 Coef.)$w_u H^3$ $w_u H^3$= 690605.2608

	A-5 Coef.	RF (#)	A-7 Coef.	Moment (#-ft/ft)
Top	-0.009	-583	0	0
0.1H	0.110	7143	0.0000	0
0.2H	0.231	14956	0.0001	46
0.3H	0.352	22768	0.0005	322
0.4H	0.467	30236	0.0013	921
0.5H	0.563	36473	0.0029	2003
0.6H	0.624	40422	0.0051	3522
0.7H	0.618	40034	0.0074	5110
0.8H	0.518	33516	0.0089	6123
0.9H	0.305	19747	0.0075	5157
Bottom	0.000	0	0	0

Project Name Uintah Highlands Reservoir #3
Project # 15068
Prepared By ZCH
Date 3/11/2015

Program Authors: TAB & DOC
Last Revised 1/19/2006
Reviewed By: TMD

ENGINEERS

Load Case #2-Empty, No Lid, w/ Backfill

Use Durability Coefficients as Noted Previous

Soil Over Lid= 1 ft
p 100

Ring Force=(A-5 Coef.)w_sHR+(A-6 Coef.)pR

w_sHR= -98421
pR= -7411.2

Moment=(A-7 Coef.)($w_s h^3$+ph^2)

$w_s h^3$+ph^2= -988496

	A-5 Coef	RF (#)	A-6 Coef.	RF (#)	Total RF (#)	A-7 Coef.	Moment (#-ft/ft)
Top	-0.009	886	0.991	-7344.4992	-6459	0	0
0.1H	0.110	-10859	1.010	-7487.7824	-18347	0.0000	0
0.2H	0.231	-22735	1.031	-7640.9472	-30376	0.0001	-66
0.3H	0.352	-34611	1.052	-7794.112	-42405	0.0005	-461
0.4H	0.467	-45962	1.067	-7907.7504	-53870	0.0013	-1318
0.5H	0.563	-55444	1.063	-7880.576	-63324	0.0029	-2867
0.6H	0.624	-61447	1.024	-7591.5392	-69039	0.0051	-5041
0.7H	0.618	-60857	0.918	-6805.952	-67663	0.0074	-7315
0.8H	0.518	-50949	0.718	-5318.7712	-56268	0.0089	-8765
0.9H	0.305	-30018	0.405	-3001.536	-33020	0.0075	-7381
Bottom	0.000	0	0.000	0	0	0	0

Load Case #3-Empty, w/Lid, w/Backfill

Apply a shear force (V) @ top of wall to make Ring Tension = 0 @ top of Wall

When top of tank is free, Ring Force (LC#2) = -6459 #

At top of wall (0.0H) from table A-8, Coefficient= -8.49 #

Therefore, the shear force (V) required to produce zero ring force at the top of the tank=
(Coef. A-8 @ 0.0H)(VR/H)=(Ring Force from LC#2)

Therefore

V= -507 #
VR/H= -761 #

$Delta_{RF}$=Change in Ring Force Due to V applied @ the top of wall

$Delta_{RF}$=(A-8 Coef.)(VR/H)

Find the change in moment ($Delta_{mom}$) due to the V applied @ top.

If S_D for moment is less than S_D for compression, then V is reduced by (S_{DM}/S_{DC})

$Delta_{mom}$=(A-9 Coef.)VH

VH= -8118

	A-8 Coef.	$Delta_{RF}$ (#)	LC#2 RF (#)	Total RF (#)	A-9 Coef.	$Delta_{mom}$ (#-ft/ft)	LC #2 Moment (#-ft/ft)	Total Moment (#-ft/ft)
Top	-8.487	6459	-6459	0	0	0	0	0
0.1H	-5.050	3843	-18347	-14504	0.0633	-514	0	-514
0.2H	-2.390	1819	-30376	-28557	0.0753	-612	-66	-677
0.3H	-0.693	528	-42405	-41878	0.0633	-514	-461	-975
0.4H	0.187	-142	-53870	-54012	0.0433	-352	-1318	-1670
0.5H	0.510	-388	-63324	-63712	0.0247	-200	-2867	-3067
0.6H	0.510	-388	-69039	-69427	0.0107	-87	-5041	-5128
0.7H	0.363	-277	-67663	-67939	0.0020	-16	-7315	-7331
0.8H	0.190	-145	-56268	-56413	-0.0030	24	-8765	-8740
0.9H	0.043	-33	-33020	-33053	-0.0063	51	-7381	-7329
Bottom	0.000	0	0	0	-0.0093	76	0	76

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Load Case #4-Full of Water, w/Lid, ignore Backfill

Add the effects of shear @ the top of the tank to LC #1

At the top of the wall - Coefficient from Table A-8= -8.49 #

(Coef. A-8 @ 0.0H)(VR/H) = (Ring Force from LC#1)

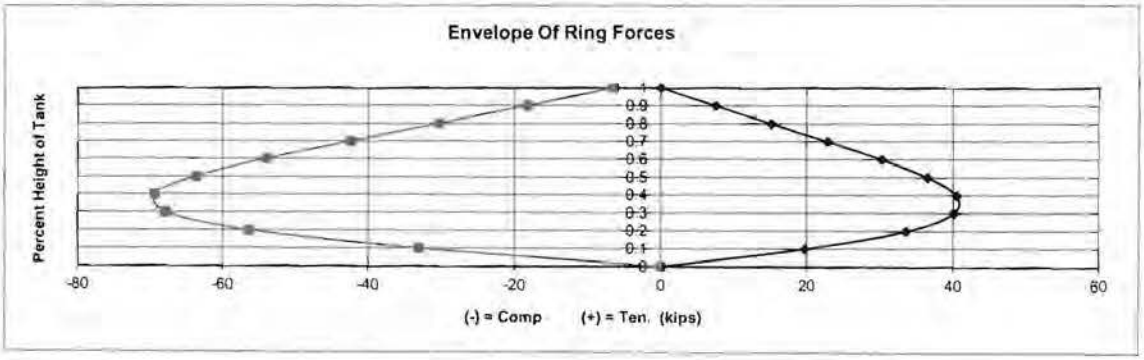
V= -46 #
VR/H= -69 # (For Ring Force)
VH= -732 # (For Moment)

	A-8 Coef.	$Delta_{RF}$ (#)	LC#1 RF (#)	Total RF (#)	A-9 Coef.	$Delta_{mom}$ (#-ft/ft)	LC#1 Moment (#-ft/ft)	Total Moment (#-ft/ft)
Top	-8.49	583	-583	0	0	0	0	0
0.1H	-5.05	347	7143	7490	0.063	-46	0	-46
0.2H	-2.39	164	14956	15120	0.075	-55	46	-9
0.3H	-0.69	48	22768	22816	0.063	-46	322	276
0.4H	0.19	-13	30236	30223	0.043	-32	921	889
0.5H	0.51	-35	36473	36438	0.025	-18	2003	1985
0.6H	0.51	-35	40422	40387	0.011	-8	3522	3514
0.7H	0.36	-25	40034	40009	0.002	-1	5110	5109
0.8H	0.19	-13	33516	33503	-0.003	2	6123	6126
0.9H	0.04	-3	19747	19744	-0.006	5	5157	5161
Bottom	0	0	0	0	-0.009	7	0	7

Envelope of Ring Forces

	LC#1	LC#2	LC#3	LC#4	Max	Min
Top	-583	-6459	0	0	0	-6459
0.1H	7143	-18347	-14504	7490	7490	-18347
0.2H	14956	-30376	-28557	15120	15120	-30376
0.3H	22768	-42405	-41878	22816	22816	-42405
0.4H	30236	-53870	-54012	30223	30236	-54012
0.5H	36473	-63324	-63712	36438	36473	-63712
0.6H	40422	-69039	-69427	40387	40422	-69427
0.7H	40034	-67663	-67939	40009	40034	-67939
0.8H	33516	-56268	-56413	33503	33516	-56413
0.9H	19747	-33020	-33053	19744	19747	-33053
Bottom	0	0	0	0	0	0

	Tension	Compression
Bottom	0	0
0.9H	20	-33
0.8H	34	-56
0.7H	40	-68
0.6H	40	-69
0.5H	36	-64
0.4H	30	-54
0.3H	23	-42
0.2H	15	-30
0.1H	7	-18
Top	0	-6



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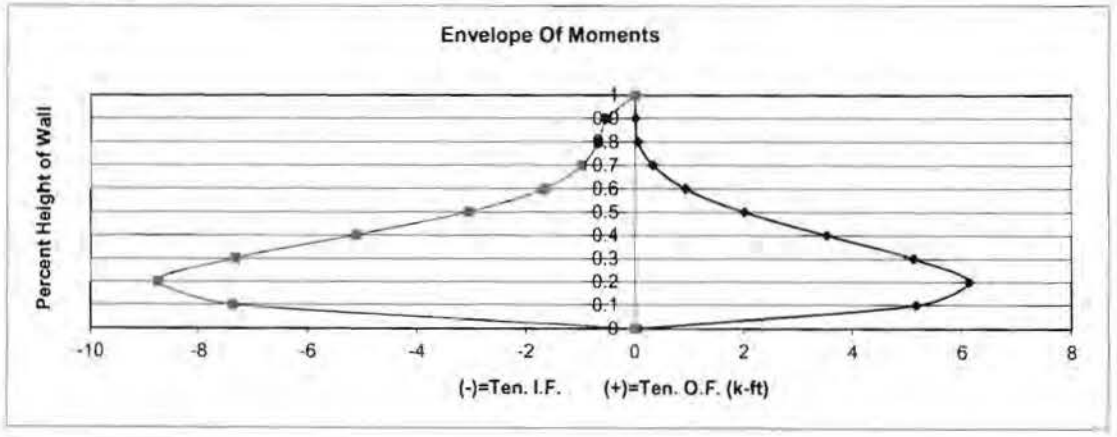
Envelope of Moments

	LC#1	LC#2	LC#3	LC#4	Max	Min
Top	0	0	0	0	0	0
0.1H	0	0	-514	-46	0	-514
0.2H	46	-66	-677	-9	46	-677
0.3H	322	-461	-975	276	322	-975
0.4H	921	-1318	-1670	889	921	-1670
0.5H	2003	-2867	-3067	1985	2003	-3067
0.6H	3522	-5041	-5128	3514	3522	-5128
0.7H	5110	-7315	-7331	5109	5110	-7331
0.8H	6123	-8765	-8740	6126	6126	-8765
0.9H	5157	-7381	-7329	5161	5161	-7381
Bottom	0	0	76	7	76	0

CHECK WALL FOR THIS MOMENT

	Tension O.F.	Tension I.F.
Bottom	0	0
0.9H	5	-7
0.8H	6	-9
0.7H	5	-7
0.6H	4	-5
0.5H	2	-3
0.4H	1	-2
0.3H	0	-1
0.2H	0	-1
0.1H	0	-1
Top	0	0



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D_{tank}	48	ft
H_L	16	ft
g	32.17	ft/s^2
λ	9.981706965	
T_C	4.361096243	s
S_{D1}	0.481	g
S_{DS}	0.841	g
T_S	0.571938169	s
C_C	0.106124558	
I	1.25	
d_{max}	3.183736748	ft

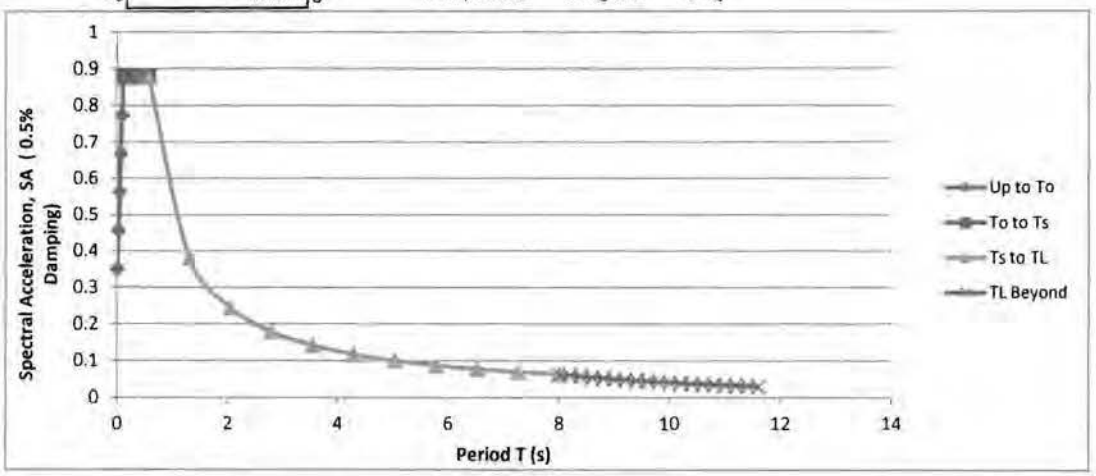
Required Freeboard

Tank Volume	203046	Gallons
Ht to Water	15	ft

New H_L	15	ft
New d_f	1	ft

Height to Liquid after Freeboard Check (IF desired to change from above)

h_n	16	ft	height above base to highest level of structure
T	0.16	s	Approximate Fundamental Period as Per ASCE 7 eqn 12.8-7
T_o	0.114387634	s	Per ASCE 7
T_L	8	s	Per ASCE 7 (fig 22-15)
S_a	0.59608	g	For periods less than T_o
S_a	0.841	g	For periods >= to T_o and <= to T_s



Find Pressure at Roof to Shell interface from insufficient freeboard depth.

SA (T_C)	0.11029337	g	Spectral Acceleration at Tc
Theta	6.293905847	degrees	Angle of free surface at sloshing load
h_r	0	ft	height from top of wall to underside of topmost point of lid
V_{EMPTY}	1809.557368	ft^3	Empty Volume of tank above water
d	2.647040872	ft	Vertical displacement of liquid surface
d_f/d	0.37778034		
h_r/d	0		
X_f/R	0.9		Fig 6 from "Earthquake Induced Sloshing in Tanks with insufficient Freeboard"
X_f	21.6	ft	
ρ	1.94	$slugs/ft^3$	mass density of liquid
P_{max}	4.62	psf	Weight of Roof is heavier, therefore ok
F_{max}	49.91	plf	#5 Radial Dowels @ 16" o.c. okay (Roof Slab to Wall)

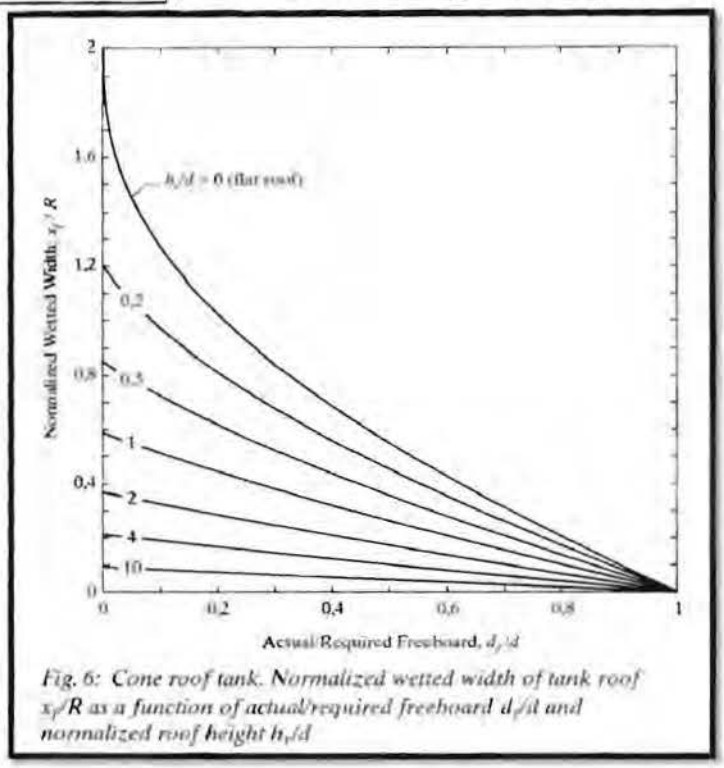


Fig. 6: Cone roof tank. Normalized wetted width of tank roof x_f/R as a function of actual/required freeboard d_f/d and normalized roof height h_r/d

Weight

D/H_L	3.2				
Wi/W_L	0.38	PCA EB219 fig 4-4 (b)			
Wc/W_L	0.6	PCA EB219 fig 4-4 (b)			
W_L	1764	kips	Weight Of Water		
Wi	670	kips	Impulsive Weight		
Wc	1059	kips	Convective Weight		
Tw	12	inches	Wall Thickness	D_{outer}	50.00 ft
Tr	10	inches	Roof Thickness		
W_W	369	kips	Weight of Walls		
W_R	245	kips	Weight of Roof		

Period

Cw	0.147	PCA EB219 fig 4-10	
C_L	0.30		
Ec	3823.676242	ksi	Elastic Modulus of Concrete
ρ_c	4.66	#-s/ft^4	Mass Density of Concrete
ω_i	217.4449364	rad/s	
T_i	0.03	s	

Base Shear

R	1.5	Response Modification Factor
C_{si}	0.70	
$C_{si\ (min)}$	13.87	
C_{sc}	0.70	
$C_{sc\ (min)}$	0.09	
Vi	1126 kips	Impulsive Base Shear
Vc	122 kips	Convective Base Shear
V_T	1133 kips	Total Base Shear

Overturning Moment

h_i/H_L	0.38	PCA EB219 fig 4-5 (b)	
h_c/H_L	0.54	PCA EB219 fig 4-5 (b)	
h_i	5.7 ft		
h_c	8.1 ft		
h_w	8 ft		
M_i	7502 kip ft		Impulsive
M_c	6009 kip ft		Convective (Per ACI 350)
M_T	9612 kip ft		Total

Overall Stability Check

Sliding (Neglecting Backfill)

Weight of tank w/out contents:

Walls	369	kips
Roof	245	kips
Columns	30	kips
Base Slab	189	kips
Water	1764	kips
Total Weight	2598	kips
Friction Coeff	0.49	
Base Shear	1133	
Safety Factor	1.12	ok

Overturning

OTM	9612	kip ft
RM	62351	kip ft
Safety Factor	6.5	ok

Design of Walls for In-Plane Loading

V_u	1133 kips	Base Shear	
V_c	12.0 kips/ft	Shear in wall	
α_c	3	See ACI 318 eqn 21-7	
ρ_t	0.006111	See ACI 318 eqn 21-7	#6 at 12" oc EF
φV_n	60.1 kips/ft	ok	

PER PCA EB219 for D>>H out of plane bending effects are small and can be neglected.