Structural Analysis & Design

DRBirt Solutions

1300 28th St. Rd
Greeley, CO 80631

Water Tank Fence

Colorado – Various Locations

October 19, 2011

Prepared By:
Kim Gazdik, E.I.
Behrent Engineering Company
11455 I-70 North Frontage Road
Wheat Ridge, CO 80033
303.940.6868 (P)
303.940.0041 (F)

Behrent Engineering Job # 11178

Reviewed By: Pete Sopher, P.E. 10/19/11

10/19/11

COLORADO REGISTERED
PETER SOPHER
31899
PROFESSIONAL ENGINEER

Overview

Objective:

Perform a structural analysis and design to determine the member sizes required for the 20' water tank fence sections (20 sections per unit). The tank will be designed assuming it is completely full of water. Because the tank is open and water is free to flow over the top, no additional lateral load has been applied to the structure due to sloshing from seismic activity or otherwise. We expect expansion of water due to freeze not to impact the structure. Expansion and contraction due to temperature will be mitigated at the pin connections with up to 1/2" of space per section.

References:

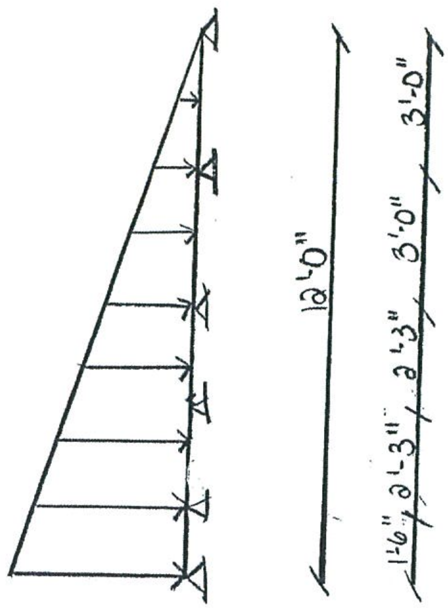
1. AISC 13th Edition
2. ASCE 7 – 05

BEHRENT ENGINEERING COMPANY • CALCULATION SHEET

Customer	DRBirt Solutions	Job No.	11281
Project	Water Tank Fence	Date	10/19/11
Subject	Structural	Page	2
By	KG	Checked By	PS 10/19/11

Check Plate

Water = 62.4 psf/ft



$w(0) = 0$ psf

$w(3) = 187$ psf

$w(6) = 375$ psf

$w(8.25) = 515$ psf

$w(10.5) = 655$ psf

$w(12) = 750$ psf

see Pg 3

$M_{max} = 0.24$ k-ft $= 2.88$ k-in

try 1/4" steel plate ($F_y = 36$ ksi)

$S = (12" \times 0.25 in^2)/6 = 0.125 in^3$

$f_b = M/S = 23.04$ ksi

$F_b = 0.75 F_y = 27.0$ ksi

$f_b / F_b = 0.85 < 1.0 \rightarrow$ 1/4" plate ok!

3

Title :
Dsgnr:
Description :

Job #
Date: 3:51PM, 12 MAY 11

Scope :

Rev: 560100
User: KW-0602014, Ver 5.6.1, 25-Oct-2002
(c)1983-2002 ENERCALC Engineering Software

Multi-Span Steel Beam

Page 1
p:\2011-beco\11111 - drbirt solutions - water

Description Plate

General Information

Calculations are designed to AISC 9th Edition ASD and 1997 UBC Requirements

Fy - Yield Stress 36.00 ksi
Load Duration Factor 1.00
Spans Considered Continuous Over Supports

Span Information

Description						
Span	ft	1.50	2.25	2.25	3.00	3.00
Steel Section						
End Fixity		Pin-Pin	Pin-Pin	Pin-Pin	Pin-Pin	Pin-Pin
Unbraced Length	ft	1.50	2.25	2.25	3.00	3.00

Loads

Live Load Used This Span ?		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
DL @ Left	k/ft					
DL @ Right	k/ft					
LL @ Left	k/ft	0.750	0.655	0.515	0.375	0.187
LL @ Right	k/ft	0.655	0.515	0.375	0.187	
Start	ft					
End	ft					

Results

Mmax @ Cntr	k-ft	0.10	0.14	0.07	0.13	0.03
@ X =	ft	0.52 worst case	1.12	1.09	1.48	1.86
Max @ Left End	k-ft	0.00	-0.24	-0.21	-0.21	-0.16
Max @ Right End	k-ft	-0.24 ✓	-0.21	-0.21	-0.16	0.00
fb : Actual	psi	0.0	0.0	0.0	0.0	0.0
Fb : Allowable	psi	0.0	0.0	0.0	0.0	0.0
		Bending OK	Bending OK	Bending OK	Bending OK	Bending OK
fv : Actual	psi	0.0	0.0	0.0	0.0	0.0
Fv : Allowable	psi	0.0	0.0	0.0	0.0	0.0
		Shear OK	Shear OK	Shear OK	Shear OK	Shear OK

Reactions & Deflections

Shear @ Left	k	0.38	0.70	0.53	0.49	0.24
Shear @ Right	k	0.67	0.62	0.47	0.36	0.04
Reactions...						
DL @ Left	k	0.00	0.00	0.00	0.00	0.00
LL @ Left	k	0.38	1.37	1.15	0.96	0.60
Total @ Left	k	0.38	1.37	1.15	0.96	0.60
DL @ Right	k	0.00	0.00	0.00	0.00	0.00
LL @ Right	k	1.37	1.15	0.96	0.60	0.04
Total @ Right	k	1.37	1.15	0.96	0.60	0.04
Max. Deflection	in	0.000	0.000	0.000	0.000	0.000
@ X =	ft	0.00	0.00	0.00	0.00	0.00
Span/Deflection Ratio		0.0	0.0	0.0	0.0	0.0

Query Values

Location	ft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shear	k	0.38	0.70	0.53	0.49	0.24	0.00	0.00	0.00
Moment	k-ft	0.00	-0.24	-0.21	-0.21	-0.16	0.00	0.00	0.00
Max. Deflection	in	538.75	684.37	526.87	468.50	187.00	0.00	0.00	0.00

BEHRENT ENGINEERING COMPANY • CALCULATION SHEET

Customer	DR Birt Solutions	Job No.	11281
Project	Water Tank Fence	Date	10/19/11
Subject	Structural	Page	4
By	KG	Checked By	PS 10/19/11

Check Horizontal members

hoop stress:

@ 11.63ft - 725 psf (0.75')(120') / 2 = 32.6k ✓

@ 10.5ft - 655 psf (1.875)(120') / 2 = 73.7k ⟸ worst case

@ 8.25ft - 515 psf (2.25) (120') / 2 = 69.5k ✓

@ 6 ft - 375 psf (2.625') (120') / 2 = 59.0k ✓

@ 3 ft - 187 psf (3') (120') / 2 = 33.7k ✓

@ 0 ft 47 psf (1.5')(120') / 2 = 4.23k ✓

try HSS 4x4x 5/16
A = 4.10
Capacity = 4.10in² (0.6)(46ksi) = 113.2k > 73.7k — HSS4x4x 5/16 ok!

Try HSS4x4x ___
Capacity (1/4") = 93.0k < 73.7k — HSS4x4x1/4 ok!

* add 5" width of 1/4" plate
A = 3.37in² + 0.25" (5") = 4.62in²

Capacity = 4.62in² (0.6)(46ksi) = 127.5k > 73.7k ∴ OK

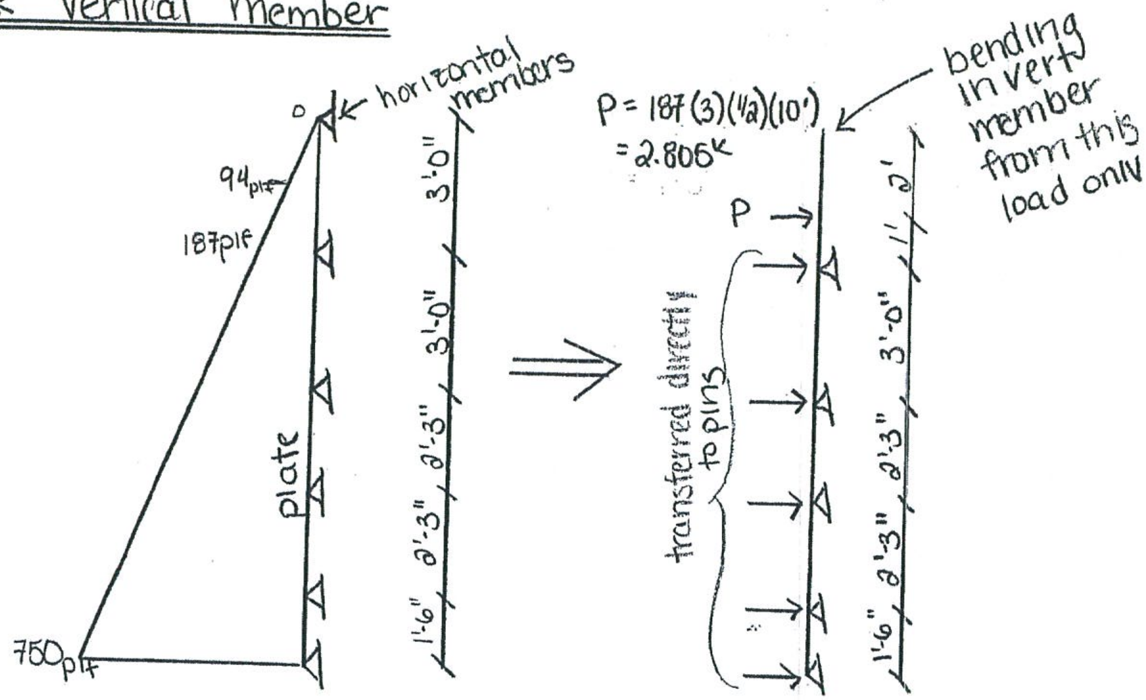
Use: HSS 4x4x1/4

BEHRENT ENGINEERING COMPANY • CALCULATION SHEET

Customer DR Birt Solutions
Project Water Tank Fence
Subject structural
By KG

Job No. 11281
Date 10/19/11
Page 5
Checked By PS 10/19/11

Check Vertical member



$M_{max} = 2.805^k (1') = 2.805^{k\text{-}ft} = 33.66^{k\text{-}in}$

$F_b = 0.6 F_y = 27.6$ ksi

$f_b = M/S = 33.66^{k\text{-}in} / 3.9 in^3 = 8.63\ k/in^2$

$f_b / F_b = 0.31 < 1.0$

HSS4x4x1/4 (Vert) OK

BEHRENT ENGINEERING COMPANY • CALCULATION SHEET

Customer DR Birt Solutions
Project Water Tank Fence
Subject Structural
By KG

Job No. 11281
Date 10/19/11
Page 6
Checked By PS 10/19/11

Check Welds:

Worst Case -

$V = 105^k$

load/plate = 105^k / 5 plates = 21.0^k/plate

weld = 1/4" x 14"

capacity = $(4)(0.928)(14) = 51.97^k$

$51.97^k > 21.0^k$ ∴ welds ok

Check Pins by Hoop stress

$V(10.5')_1 = 665\,psf\,(2.625')(120')/2 = 104.7^k$

$V(8.25')_2 = 515\,psf\,(2.25')(120')/2 = 69.5^k$

$V(6.0')_3 = 363\,psf\,(2.625')(120')/2 = 57.2^k$

$V(3.0') = 140\,psf\,(4.5')(120')/2 = 37.8^k$

$F_v = 0.4(60\,ksi)(2) = 48\,ksi$

double shear

BEHRENT ENGINEERING COMPANY • CALCULATION SHEET

Customer	DRBirt Solutions	Job No.	11281
Project	Water Tank Fence	Date	10/19/11
Subject	Structural	Page	7
By	KG	Checked By	PS 10/19/11

Check Pins: Cont'd

Areq @ 10.5' = 105 k / 48 ksi = 2.19 in² ← worst case

Areq @ 8.25' = 69.5k / 48 ksi = 1.45 in²

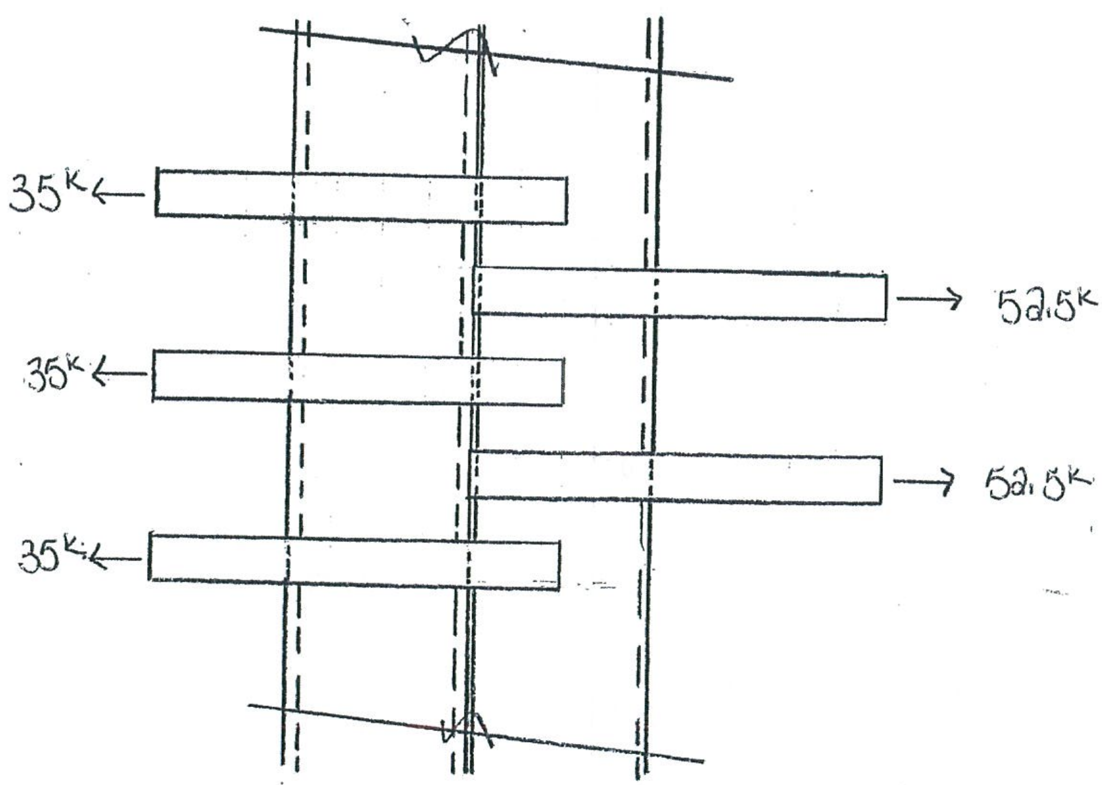
Areq @ 6.00' = 57.2k / 48 ksi = 1.19 in²

Areq @ 3.00' = 37.8k / 48 ksi = 0.79 in²

Use: 2" ϕ pin (A = 3.14 in²)

Check shear Plates

Vmax @ 10.5' = 105 k / 2 plates = 52.5k

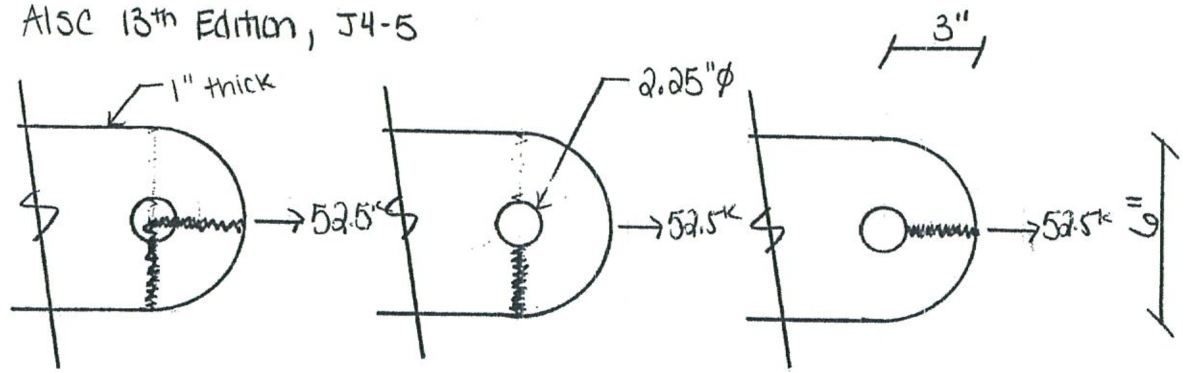


BEHRENT ENGINEERING COMPANY • CALCULATION SHEET

Customer	DR Birt Solutions	Job No.	11281
Project	Water tank Fence	Date	10/19/11
Subject	Connections	Page	8
By	KG	Checked By	PS 10/19/11

Check Plate for Block Shear Rupture ($F_u = 58\,ksi$, $F_y = 36\,ksi$)

Per AISC 13th Edition, J4-5



$A_{gv} = 1" \times 6" = 6\,in^2$ $\quad A_{nt} = (3" - \frac{2.25"}{2})1" = 1.875\,in^2$ $\quad A_{nv} = (3" - \frac{2.25"}{2})1" = 1.875\,in^2$

$$R_n = 0.6 F_u A_{nv} + U_{bs} F_u A_{nt} \le 0.6 F_y A_{gv} + U_{bs} F_u A_{nt}$$

$$= 0.6(58ksi)(1.875in^2) + (1.0)(58ksi)(1.875in^2) \le 0.6(36ksi)(6in^2) + (1.0)(58ksi)(1.875in^2)$$

$$= 174.0^k \le 238.4^k$$

$\Omega = 2$ (ASD)

$R_n = 174.0^k/2 = 87.0^k > 105^k/2$ plates $= 52.5^k$/plate

∴ <u>1" plate ok in block shear rupture</u>