

PREPARED FOR:



Neuvokas Corp.

13206 #6 Rd, PO BOX 220

Ahmeek, MI 49901

(906) 934-2661

DESIGN COMPUTATIONS FOR:

Standard Drainage or Electrical Vault

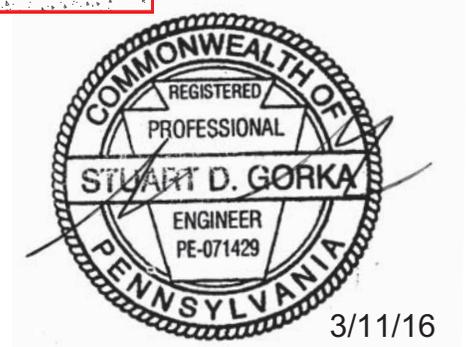
5'-0" Max. x 5'-0" Max. x 5'-0" Max. I.D.

AASHTO H-20 Loading

SPECIALTY ENGINEERING SERVICES PROVIDED BY:

Concrete Engineering Solutions, LLC

101 Pineview Estates
Mountain Top, PA 18707
Phone: 570-868-2081
Fax: 570-868-2082



CONCRETE ENGINEERING SOLUTIONS, LLC

101 PINEVIEW ESTATES
MOUNTAIN TOP, PA 18707
PHONE: 570-868-2081
FAX: 570-868-2082

Client: <u>Neuvokas</u>	Description: Vault Design
Project Name: <u>Standard Tank Design</u>	5' Max X 5' Max Vaults
Calculated By <u>SDG</u> Date: <u>3/11/2016</u>	Basalt Fiber Reinforced Polymer

Maximum Inside Dimensions

Length 5.00 ft
 Width 5.00 ft
 Height 5.00 ft

Member Thickness

Top Slab 8.00 in
 Walls 6.00 in
 Base Slab 6.00 in

Base Extension 0.00 in LS 0.00 in SS

AASHTO ASTM
 Design Live Load HS 20 A- 16

Wheel Load 16 kips
 Impact 1.3

Earth Fill For Design 2.00 ft Max
1.00 ft Min

Top of Cover Above Grade 0.00 ft

Lateral Earth Pressure, ka = 0.333

EP(h) 40 pcf (dry)
 82 pcf (saturated)

Surcharge 80 psf

Max Depth 8.00 ft

Water Table Elevation 3.00 ft below grade

Materials

Concrete Strength, f'c = 5000 psi
 Tensile Strength, fu* = 145000 psi
 Allowable ffu = 0.7 fu* = 101500 psi
 Concrete Density, Wc 150 pcf
 Soil Density, Ws 120 pcf
 Water Density, Ww 62.4 pcf

Load Factors

Live Load 1.6
 Dead Load 1.2
 Earth Load 1.6

Structure Watertight? Yes
 Minimum Floatation SF 1.1

Structure Components:

Mono Top Riser Height	0.00 ft
Riser #1 Height	0.00 ft
Riser #2 Height	0.00 ft
Riser #3 Height	0.00 ft
Mono Base Riser Height	5.00 ft
Total Inside Height	5.00 ft

Depth		Lateral Earth Pressure				Concrete	
t-o-w	b-o-w	Pe top	Pe bot	Surch	Avg	Vol	Wgt
(ft)	(ft)	(psf)	(psf)	(psf)	(psf)	(cy)	(Tons)
2.67	2.67	107	107	80	187	0.89	1.80
2.67	2.67	107	107	80	187	0.00	0.00
2.67	2.67	107	107	80	187	0.00	0.00
2.67	2.67	107	107	80	187	0.00	0.00
2.67	7.67	107	501	80	384	2.70	5.48
Totals						3.59	7.28

** Openings not subtracted

CONCRETE ENGINEERING SOLUTIONS, LLC

101 PINEVIEW ESTATES
MOUNTAIN TOP, PA 18707
PHONE: 570-868-2081
FAX: 570-868-2082

Client: <u>Neuvokas</u>	Description: Vault Design
Project Name: <u>Standard Tank Design</u>	5' Max X 5' Max Vaults
Calculated By <u>SDG</u> Date: <u>3/11/16</u>	References

- (1) AASHTO Standard Specifications for Highway Bridges, 17th Edition
- (2) ASTM C857 "Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
- (3) ACI318 & ACI440
- (4) "Moments and Reactions for Rectangular Plates" Engineering Monograph 27, U.S. Bureau of Reclamation

http://www.usbr.gov/pmts/hydraulics_lab/pubs/EM/EM27.pdf

$E_c = 57000 \sqrt{f'_c} = 4031 \text{ ksi} \quad (1) 8.7.1$

$E_f = 6000 \text{ ksi} \quad (1) 8.7.2$

$n = E_f / E_c = 1.49 \quad (1) 8.15.3.4$

$M_{cr} = f_r \cdot b \cdot T^2 / 6 \quad T = \text{Member Thickness} \quad (1) 8.13.3$

Member Design Width, $b = 12 \text{ in}$

Moment Equations

Plate Fixed on 3 sides, $M = W_{avg} \times H^2 \times C_m$

$C_m / C_v =$ Moment or Shear Coefficient from Ref (4)

interpolated to the nearest 0.1

L/H Ratio of 4 or greater considered a cantilever

Simple Span Moments = $W \times S^2 / 8$ (Uniform)

$= P \times S / 4$ (Concentrated)

Fixed End Moments = $W \times L^2 / 12$

$p = A_s / b d$

$k = \sqrt{(r n^2 \cdot 2m)} - r n$

$j = 1 - k / 3$

$F_s = M / (A_s \cdot j \cdot d)$

Shear Equations

Plate Fixed on 3 sides, $V = W_{avg} \times H \times C_v$

Shear Capacity, $V_n = 2 \sqrt{f'_c} \cdot b d \quad (1) 8.16.6.1$

Minimum Flexural Reinforcing

$\mu > 1.2 M_{cr} =$; Waived if $A_s \text{ Prov} > 4/3 A_s \text{ Req}$

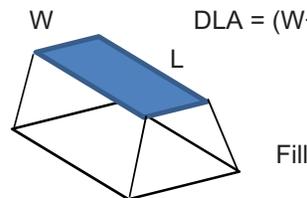
(1) 8.17.7.1.1 and 8.17.7.1.2

For Concentrated Wheel Load

Distribution Width, $e = 4 + .06S \quad (1) 3.24.3$

For Wheel Load Distributed Through Fill (2) and (3)

$DLA = (W + 1.75 \text{ Fill}) \cdot (L + 1.75 \text{ Fill})$

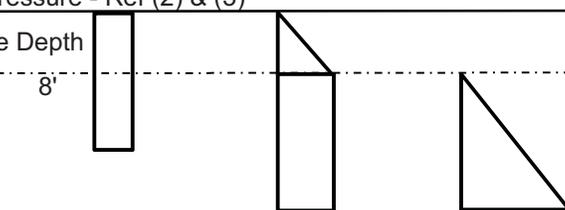


Lateral Soil Pressure - Ref (2) & (3)

Surcharge Depth
8'

Finished Grade

Water Table Elevation



LL Surcharge

EP(h) Dry

EP(h) Saturated

0.5% Wheel Load

$K_a \cdot W_s \cdot H$

$(W_w + K_a \cdot (W_s - W_w)) \cdot H$

CONCRETE ENGINEERING SOLUTIONS, LLC

101 PINEVIEW ESTATES
MOUNTAIN TOP, PA 18707
PHONE: 570-868-2081
FAX: 570-868-2082

Client: <u>Neuvokas</u>	Description: Vault Design
Project Name: <u>Standard Tank Design</u>	5' Max X 5' Max Vaults
Calculated By <u>SDG</u> Date: <u>3/11/16</u>	Top Slab Design - Concentrated Load, Min Fill

Span 5.50 ft Short Dir 5.5 ft Long Dir

Design As a 1-Way Slab?

Single Layer of Reinforcing?

Dead Load

Earth Fill	120 psf
Concrete	100 psf
Other	psf
Total	220 psf

Live Load

Wheel Load, Pw =	16 kips/ft
Impact, I	1.3
Distribution Width, e	4.33 ft
Strip Load =P+I/e	4.80 kips/ft

Bar Cover in

Moments Short Dir. B.F. Long Dir. B.F.

Portion Of Uniform Load 0.500 0.500

Dead Load Moment, Mdl 0.42 kip-ft 0.42 kip-ft

Portion Of Concentrated Loa 0.500 Short 0.500 Long

Live Load Moment, Mll 3.303 kip-ft 3.30 kip-ft

Mu = 5.783 kip-ft 5.78 kip-ft

Vu = 4.57 kips (DL*Span/2*DLF + P/2-Ways*LLF)

*See Following Sheet For Capacity & FRP Reinforcing.

Client: Neuvokas
Project Name: Standard Tank Design
Structure Name: 5' Max X 5' Max Vaults

Member: Top Slab

Member Thickness:	8.0"
Bar Cover:	1.0"
Concrete Strength, f _c :	5000 PSI
Beam Width, b:	12.0"

Factored Moment, Mu:	5.78 K-FT
Service Moment, Ms:	3.72 K-FT

Calculate Flexural Capacity:

Bar Size/Spacing: #3 @ 5.0" o.c. (A_f Provided =0.27 sq.in./ft.)

M_n=A_f*f_{fu}(d-β₁*c_b/2): 14.35 k-ft c_b=ε_{cu}/(ε_{cu}+ε_{fu})*d= 1.03"
 Where, β₁=[0.85-.05*(f_c-4ksi)]= 0.80
 d=Thickness-Cover-1/2Bar Dia.= 6.81"

Check Min A_s Provided:

Minimum Reinforcement, ρ_{f,ts} =0.0015 ≤ 0.0051 ≤ 0.0036
 Note, If Middle Value > 0.0036, Use 0.0036.
 A_{f,min}= 0.35 Sq.in./ft. **NG** , **4/3 A_s Provided, OK**

Check Max Bar Spacing & Serviceability:

ρ_f = A_f / b * d = 0.00324 E_f= 6000 psi
 ρ_{fb}=β₁*f_c/f_{tu}*E_f*ε_{cu}/(E_f*ε_{cu}+f_{fu}) = 0.00490 f_{fu}= 101500 psi
 Check if Tension-Controlled: ρ_f/ρ_{fb} = 0.661 (If Greater than 1.0, compression-controlled)
 φM_n= **7.89 k-ft** φ= 0.55 (0.55 if tension controlled,
 Mu= **5.78 k-ft** **OK** 0.65 if compression)

s_{max}=1.15E_fw/(f_{fs}*k_b)-2.5c_c ≤ 0.92*E_f*w/(f_{fs}*k_b) k_b=0.7
 7.85 < 8.65 w=0.028
OK n_f=1.49
 k=SQRT(2ρ_f*n_f+(ρ_f*n_f)²)- 0.094
 l_{cr}=bd³/3*k³+n_f*A_f*d² / 16.083
 c_c= 1.188
 f_{fs}=M_s*n_f*d(1-k)/l_{cr}= 25.52 ksi

Check Creep Rupture: f_{fs} Max = 0.5f_{fu}= 50.75 ksi **OK**
 (Under Sustained Loading)

Check Shear:

Factored Shear, Vu: **4.57 KIPS**
Shear Capacity, φV_n: **5.43 KIPS** **OK** (Based Upon Unreinforced Concrete)
 (φV_n=0.6(4/3*√f_c*b*h/1000))

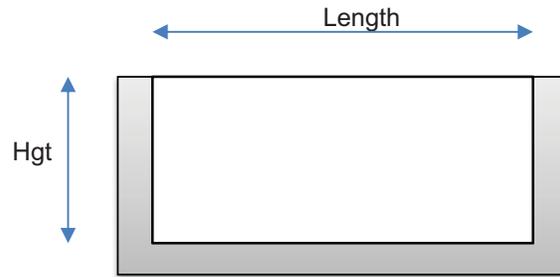
CONCRETE ENGINEERING SOLUTIONS, LLC

101 PINEVIEW ESTATES
MOUNTAIN TOP, PA 18707
PHONE: 570-868-2081
FAX: 570-868-2082

Client: <u>Neuvokas</u>	Description: Vault Design
Project Name: <u>Standard Tank Design</u>	5' Max X 5' Max Vaults
Calculated By <u>SDG</u> Date: <u>3/11/16</u>	Base Riser Wall Design

Wall considered fixed on 3 sides and free at the joint

Wall Length, L 5.00 ft
 Wall Height, H 5.00 ft
 Wall Thickness 6.00 in
 Design as Cantilever?
 Ratio L/H 1
 Single Layer of Reinforcing
 Average Lat Earth Pressure 384 psf
 Cracking Moment, M_{cr} 0.00 kip-ft



	(-) Horiz	(-) Vert	(+) Horiz	(+) Vert
Moment Coefficient, C _m	.085	.053	.043	.014
Unfactored Moment, M _a	0.82 k-ft	0.51 k-ft	0.41 k-ft	0.13 k-ft
Ultimate Moment, M _u	1.31 k-ft	0.82 k-ft	0.66 k-ft	0.21 k-ft
Shear Coefficient, C _v	.533	.457		
Factored Shear, V _u	1.64 kips	1.40 kips		

*See Following Sheet For Capacity & FRP Reinforcing.

Client: Neuvokas
Project Name: Standard Tank Design
Structure Name: 5' Max X 5' Max Vaults

Member: Walls (Outside Face)

Member Thickness: 6.0"
 Bar Cover: 2.0"
 Concrete Strength, f_c: 5000 PSI
 Beam Width, b: 12.0"

Factored Moment, Mu: 1.31 K-FT
Service Moment, Ms: 0.82 K-FT

Calculate Flexural Capacity:

Bar Size/Spacing: #3 @ 7.0" o.c. (Af Provided =0.19 sq.in./ft.)

Mn=Af*ffu(d-β1*cb/2): 3.09 k-ft cb=εcu/(εcu+εfu)*d= 0.92"
 Where, β1=[0.85-.05*(f_c-4ksi)]= 0.80
 d=Thickness-Cover-1/2Bar Dia.= 3.81"

Check Min A_s Provided:

Minimum Reinforcement, ρ_{f,ts} =0.0015 ≤ 0.0092 ≤ 0.0036
 Note, If Middle Value > 0.0036, Use 0.0036.
 Af,min= 0.26 Sq.in./ft. **NG** , 4/3 As Provided, Therefore OK

Check Max Bar Spacing & Serviceability:

ρ_f = Af / b * d = 0.00414 Ef= 6000 psi
 ρ_{fb}=β1*f_c/ftu*Ef*εcu/(Ef*εcu+ffu) = 0.00875 ffu(Bends)= 56840 psi
 (0.56*ffu)
 Check if Tension-Controlled: ρ_f/ρ_{fb} = 0.473 (If Greater than 1.0, compression-controlled)
 φMn= 1.70 k-ft φ= 0.55 (0.55 if tension controlled,
 Mu= 1.31 k-ft **OK** 0.65 if compression)

smax=1.15E_fw/(f_{fs}*k_b)-2.5c_c ≤ 0.92*Ef*w/(f_{fs}*k_b) kb=0.7
 14.07 < 15.63 w=0.028
OK nf=1.49
 k=SQRT(2ρ_f*nf+(ρ_f*nf)²)- 0.105
 lcr=bd³/3*k³+nf*Af*d²(3.538
 cc= 2.188
 ffs=Ms*nf*d(1-k)/lcf= 14.13 ksi

Check Creep Rupture: ffs Max = 0.5ffu= 28.42 ksi **OK**
 (Under Sustained Loading)

Check Shear:

Factored Shear, Vu: 1.64 KIPS
Shear Capacity, φVn: 4.07 KIPS **OK** (Based Upon Unreinforced Concrete)
 (φVn=0.6(4/3*√f_c*b*h/1000)

Client: Neuvokas
Project Name: Standard Tank Design
Structure Name: 5' Max X 5' Max Vaults

Member: Walls (Inside Face)

Member Thickness:	6.0"
Bar Cover:	3.6"
Concrete Strength, f _c :	5000 PSI
Beam Width, b:	12.0"

Factored Moment, Mu:	0.66 K-FT
Service Moment, Ms:	0.41 K-FT

Calculate Flexural Capacity:

Bar Size/Spacing: #3 @ 7.0" o.c. (Af Provided =0.19 sq.in./ft.)

Mn=Af*ffu(d-β1*cb/2): **3.28 k-ft** cb=εcu/(εcu+εfu)*d= 0.33"
 Where, β1=[0.85-.05*(f_c-4ksi)]= 0.80
 d=Thickness-Cover-1/2Bar Dia.= 2.18"

Check Min A_s Provided:

Minimum Reinforcement, ρ_{f,ts} =0.0015 ≤ 0.0051 ≤ 0.0036
 Note, If Middle Value > 0.0036, Use 0.0036.
 Af,min= 0.26 Sq.in./ft. **NG** ,4/3 As Provided, Therefore OK

Check Max Bar Spacing & Serviceability:

ρ_f = Af / b * d = 0.00723 Ef= 6000 psi
 ρ_{fb}=β1*f_c/ftu*Ef*εcu/(Ef*εcu+ffu) = 0.00490 ffu= 101500 psi
 Check if Tension-Controlled: ρ_f/ρ_{fb} = 1.475
 φMn= **2.14 k-ft** φ= 0.65 (0.55 if tension controlled,
 Mu= **0.66 k-ft** **OK** 0.65 if compression)

smax=1.15E_fw/(f_{fs}*k_b)-2.5c_c ≤ 0.92*Ef*w/(f_{fs}*k_b) kb=0.7
12.58 < **17.70** w=0.028
OK nf=1.49
 k=SQRT(2ρ_f*nf+(ρ_f*nf)²)- 0.136
 lcr=bd³/3*k³+nf*Af*d²(1.107
 cc= 3.818
 ffs=Ms*nf*d(1-k)/lcf= 12.47 ksi

Check Creep Rupture: ffs Max = 0.5ffu= 50.75 ksi **OK**
 (Under Sustained Loading)

CONCRETE ENGINEERING SOLUTIONS, LLC

101 PINEVIEW ESTATES
MOUNTAIN TOP, PA 18707
PHONE: 570-868-2081
FAX: 570-868-2082

Client: <u>Neuvokas</u>	Description: Vault Design
Project Name: <u>Standard Tank Design</u>	5' Max X 5' Max Vaults
Calculated By <u>SDG</u> Date: <u>3/11/16</u>	Base Slab Design

Span	5.50 ft Short Dir	5.5 ft Long Dir	
Design As 1-Way?	<input type="text" value="No"/>		
Single Layer of Reinforcing?	<input type="text" value="Yes"/>		
Dead Load		Live Load	
Earth Fill	240 psf	Wheel Load, Pw	16 kips/ft
Concrete	329 psf	Number Of Wheels	<input type="text" value="1"/>
Other	psf	Bearing Area	36 SF
Total	569 psf	Uniform Live Load	444 ksf
Hydrostatic	322 psf		
	<-Controls		
Bar Cover	<input type="text" value="1.00"/> in	<input type="text" value="1.5"/>	
Moments	Short Dir. T.F.	Long Dir. T.F.	
Portion of Uniform Load	0.500	0.500	
Dead Load Moment, Mdl	1.08 kip-ft	1.08 kip-ft	
Live Load Moment, Mll	0.84 kip-ft	0.84 kip-ft	
Mu =	2.64 kip-ft	2.64 kip-ft	
Factored Shear, Vu	1.92 kips	1.92 kips	

*See Following Sheet For Capacity & FRP Reinforcing.

Client: Neuvokas
Project Name: Standard Tank Design
Structure Name: 5' Max X 5' Max Vaults

Member: Base Slab

Member Thickness:	6.0"
Bar Cover:	1.0"
Concrete Strength, f _c :	5000 PSI
Beam Width, b:	12.0"

Factored Moment, Mu:	2.64 K-FT
Service Moment, Ms:	1.92 K-FT

Calculate Flexural Capacity:

Bar Size/Spacing: #3 @ 6.0" o.c. (A_f Provided =0.22 sq.in./ft.)

M_n=A_f*f_{fu}(d-β₁*c_b/2): 8.45 k-ft c_b=ε_{cu}/(ε_{cu}+ε_{fu})*d= 0.72"
 Where, β₁=[0.85-.05*(f_c-4ksi)]= 0.80
 d=Thickness-Cover-1/2Bar Dia.= 4.81"

Check Min A_s Provided:

Minimum Reinforcement, ρ_{f,ts} =0.0015 ≤ 0.0051 ≤ 0.0036
 Note, If Middle Value > 0.0036, Use 0.0036.
 A_{f,min}= 0.26 Sq.in./ft. **NG** , **4/3 A_s Provided, OK**

Check Max Bar Spacing & Serviceability:

ρ_f = A_f / b * d = 0.00382 E_f= 6000 psi
 ρ_{fb}=β₁*f_c/f_{tu}*E_f*ε_{cu}/(E_f*ε_{cu}+f_{fu}) = 0.00490 f_{fu}= 101500 psi
 Check if Tension-Controlled: ρ_f/ρ_{fb} = 0.780 (If Greater than 1.0, compression-controlled)
 φM_n= **4.65 k-ft** φ= 0.55 (0.55 if tension controlled,
 Mu= **2.64 k-ft** **OK** 0.65 if compression)

s_{max}=1.15E_fw/(f_{fs}*k_b)-2.5c_c ≤ 0.92*E_fw/(f_{fs}*k_b) k_b=0.7
 9.34 < 9.84 w=0.028
 (Say OK) **OK** n_f=1.49
 k=SQRT(2ρ_f*n_f+(ρ_f*n_f)²)- 0.101
 l_{cr}=bd^{3/3}*k³+n_f*A_f*d²(6.614
 c_c= 1.188
 f_{fs}=M_s*n_f*d(1-k)/l_{cf}= 22.43 ksi

Check Creep Rupture: f_{fs} Max = 0.5f_{fu}= 50.75 ksi **OK**
 (Under Sustained Loading)

Check Shear:

Factored Shear, Vu: **1.92 KIPS**
Shear Capacity, φV_n: **4.07 KIPS** **OK** (Based Upon Unreinforced Concrete)
 (φV_n=0.6(4/3*√f_c*b*h/1000)