Tedds JSD Professional Services, Inc 161 Horizon Drive, Verona, WI 52593	Project Arboretum Pond #3 Storm Water Screen Treatment Structure				Job Ref.	
	Section Walls				Sheet no./rev. 1	
	Calc. by JJE	Date 11/12/2014	Chk'd by	Date	App'd by	Date

REINFORCEMENT SHOWN AS DESIGNED

RETAINING WALL ANALYSIS

In accordance with IBC 2009

Tedds calculation version 2.4.06

Retaining wall details

Stem type	Cantilever
Stem height	h_{stem} = **14.92** ft
Stem thickness	t_{stem} = **12** in
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **150** pcf
Toe length	l_{toe} = **30** ft
Base thickness	t_{base} = **12** in
Key position	p_{key} = **0** ft
Key depth	d_{key} = **6** ft
Key thickness	t_{key} = **12** in
Base density	γ_{base} = **150** pcf
Height of retained soil	h_{ret} = **14.67** ft
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **0.25** ft

Program is for Retaining Wall and does not have allowance for upturned walls. Key added to resolve Sliding.

Retained soil properties

Soil type	Medium dense well graded sand
Moist density	γ_{mr} = **135** pcf
Saturated density	γ_{sr} = **145** pcf
Effective angle of internal resistance	ϕ_r = **30** deg
Effective wall friction angle	δ_r = **0** deg

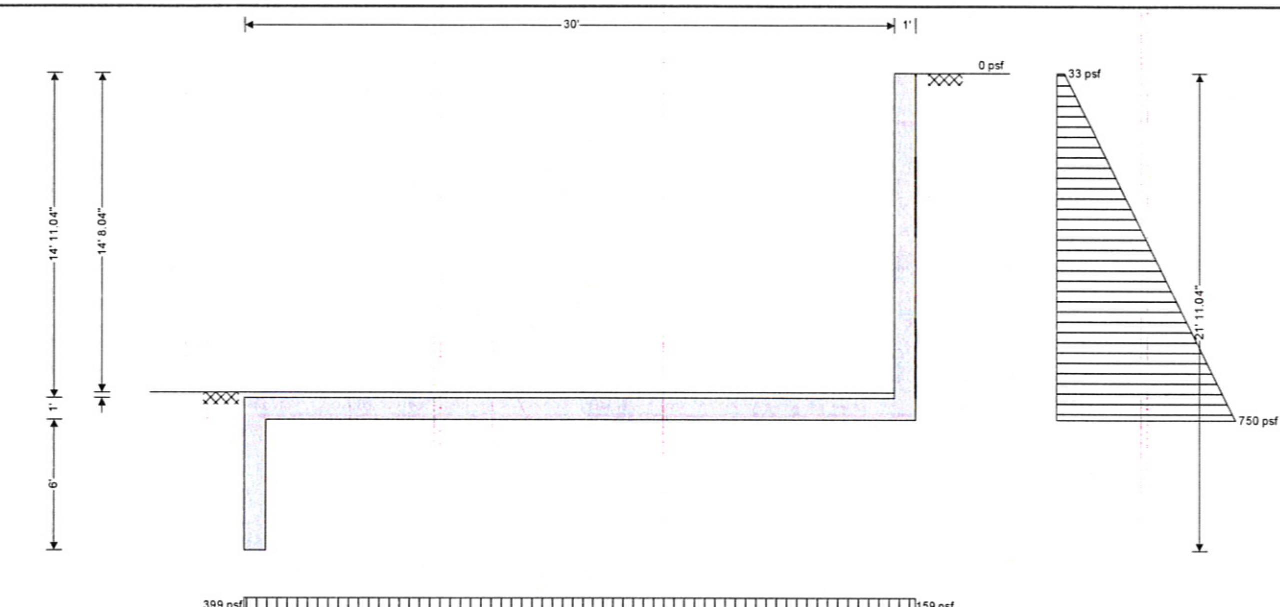
Base soil properties

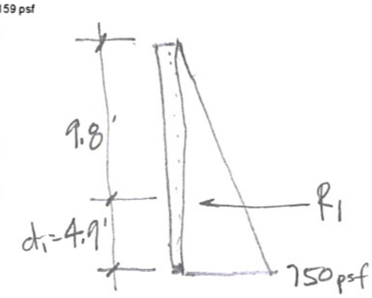
Soil type	Medium dense well graded sand
Moist density	γ_{mb} = **115** pcf
Cohesion	c_b = **0** psf
Effective angle of internal resistance	ϕ_b = **30** deg
Effective wall friction angle	δ_b = **15** deg
Effective base friction angle	δ_{bb} = **30** deg
Allowable bearing pressure	$P_{bearing}$ = **3000** psf

Loading details

Live surcharge load	$Surcharge_L$ = **100** psf

Tedds JSD Professional Services, Inc 161 Horizon Drive, Verona, WI 52593	Project Arboretum Pond #3 Storm Water Screen Treatment Structure				Job Ref.	
	Section Walls				Sheet no./rev. 2	
	Calc. by JJE	Date 11/12/2014	Chk'd by	Date	App'd by	Date





$q_1 = (1.2)(1.6)(750) = 1440$ psf

$R_1 = 1440(14.67)/2 = 10{,}560$ lb/ft

$M = R_1 d_1 = 51{,}744$ ft-lb/ft

Calculate retaining wall geometry

Base length $l_{base} = l_{toe} + t_{stem} = \mathbf{31}$ ft

Base height $h_{base} = t_{base} + d_{key} = \mathbf{7}$ ft

Moist soil height $h_{moist} = h_{soil} = \mathbf{14.92}$ ft

Length of surcharge load $l_{sur} = l_{heel} = \mathbf{0}$ ft

- Distance to vertical component $x_{sur\_v} = l_{base} - l_{heel} / 2 = \mathbf{31}$ ft

Effective height of wall $h_{eff} = h_{base} + d_{cover} + h_{ret} = \mathbf{21.92}$ ft

- Distance to horizontal component $x_{sur\_h} = h_{eff} / 2 - d_{key} = \mathbf{4.96}$ ft
- Distance to horizontal component above key $x_{sur\_h\_a} = (h_{eff} - d_{key}) / 2 = \mathbf{7.96}$ ft

Area of wall stem $A_{stem} = h_{stem} \times t_{stem} = \mathbf{14.92}$ ft^2

- Distance to vertical component $x_{stem} = l_{toe} + t_{stem} / 2 = \mathbf{30.5}$ ft

Area of wall base $A_{base} = l_{base} \times t_{base} + d_{key} \times t_{key} = \mathbf{37}$ ft^2

- Distance to vertical component $x_{base} = (l_{base}^2 \times t_{base} / 2 + d_{key} \times t_{key} \times (p_{key} + t_{key} / 2)) / A_{base} = \mathbf{13.068}$ ft

Area of base soil $A_{pass} = d_{cover} \times l_{toe} = \mathbf{7.5}$ ft^2

- Distance to vertical component $x_{pass\_v} = l_{base} - (d_{cover} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{pass} = \mathbf{15}$ ft
- Distance to horizontal component $x_{pass\_h} = (d_{cover} + h_{base}) / 3 - d_{key} = \mathbf{-3.583}$ ft

Area of excavated base soil $A_{exc} = h_{pass} \times l_{toe} = \mathbf{7.5}$ ft^2

- Distance to vertical component $x_{exc\_v} = l_{base} - (h_{pass} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{exc} = \mathbf{15}$ ft
- Distance to horizontal component $x_{exc\_h} = (h_{pass} + h_{base}) / 3 - d_{key} = \mathbf{-3.583}$ ft

Using Coulomb theory

Active pressure coefficient $K_A = \sin(\alpha + \phi_r)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_r) \times [1 + \sqrt{[\sin(\phi_r + \delta_r) \times \sin(\phi_r - \beta) / (\sin(\alpha - \delta_r) \times \sin(\alpha + \beta))]}]^2) = \mathbf{0.333}$

Passive pressure coefficient $K_P = \sin(90 - \phi_b)^2 / (\sin(90 + \delta_b) \times [1 - \sqrt{[\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(90 + \delta_b))]}]^2) = \mathbf{4.977}$

From IBC 2009 cl.1807.2.3 Safety factor

Load combination 1 — 1.0 × Dead + 1.0 × Live + 1.0 × Lateral earth

Sliding check

Vertical forces on wall

Wall stem — $F_{stem} = A_{stem} \times \gamma_{stem} = \mathbf{2238}$ plf

Wall base — $F_{base} = A_{base} \times \gamma_{base} = \mathbf{5550}$ plf

Base soil — $F_{exc\_v} = A_{exc} \times \gamma_{mb} = \mathbf{863}$ plf

Total — $F_{total\_v} = F_{stem} + F_{base} + F_{exc\_v} = \mathbf{8651}$ plf

Horizontal forces on wall

Surcharge load — $F_{sur\_h} = K_A \times Surcharge_L \times h_{eff} = \mathbf{731}$ plf

Moist retained soil — $F_{moist\_h} = K_A \times \gamma_{mr} \times h_{eff}^2 / 2 = \mathbf{10811}$ plf

Total — $F_{total\_h} = F_{moist\_h} + F_{sur\_h} = \mathbf{11542}$ plf

Check stability against sliding

Base soil resistance — $F_{exc\_h} = K_P \times \cos(\delta_b) \times \gamma_{mb} \times (h_{pass} + h_{base})^2 / 2 = \mathbf{14528}$ plf

Base friction — $F_{friction} = F_{total\_v} \times \tan(\delta_{bb}) = \mathbf{4994}$ plf

Resistance to sliding — $F_{rest} = F_{exc\_h} + F_{friction} = \mathbf{19523}$ plf

Factor of safety — $FoS_{sl} = F_{rest} / F_{total\_h} = \mathbf{1.691} > 1.5$

PASS - Factor of safety against sliding is adequate

Overturning check

Vertical forces on wall

Wall stem — $F_{stem} = A_{stem} \times \gamma_{stem} = \mathbf{2238}$ plf

Wall base — $F_{base} = A_{base} \times \gamma_{base} = \mathbf{5550}$ plf

Base soil — $F_{exc\_v} = A_{exc} \times \gamma_{mb} = \mathbf{863}$ plf

Total — $F_{total\_v} = F_{stem} + F_{base} + F_{exc\_v} = \mathbf{8651}$ plf

Horizontal forces on wall

Surcharge load — $F_{sur\_h} = K_A \times Surcharge_L \times (h_{eff} - d_{key}) = \mathbf{531}$ plf

Moist retained soil — $F_{moist\_h} = K_A \times \gamma_{mr} \times (h_{eff} - d_{key})^2 / 2 = \mathbf{5703}$ plf

Base soil — $F_{exc\_h} = \max(-K_P \times \cos(\delta_b) \times \gamma_{mb} \times (h_{pass} + h_{base})^2 / 2, \min(-F_{moist\_h} - F_{sur\_h}, 0 \text{ plf})) = \mathbf{-6233}$ plf

Total — $F_{total\_h} = F_{moist\_h} + F_{exc\_h} + F_{sur\_h} = \mathbf{0}$ plf

Overturning moments on wall

Surcharge load — $M_{sur\_OT} = F_{sur\_h} \times x_{sur\_h\_a} = \mathbf{4224}$ lb_ft/ft

Moist retained soil — $M_{moist\_OT} = F_{moist\_h} \times x_{moist\_h\_a} = \mathbf{30262}$ lb_ft/ft

Base soil — $M_{exc\_OT} = F_{exc\_v} \times x_{exc\_v} = \mathbf{12937}$ lb_ft/ft

Total — $M_{total\_OT} = M_{moist\_OT} + M_{exc\_OT} + M_{sur\_OT} = \mathbf{47423}$ lb_ft/ft

Restoring moments on wall

Wall stem — $M_{stem\_R} = F_{stem} \times x_{stem} = \mathbf{68259}$ lb_ft/ft

Wall base — $M_{base\_R} = F_{base} \times x_{base} = \mathbf{72525}$ lb_ft/ft

Base soil — $M_{exc\_R} = F_{exc\_v} \times x_{exc\_v} = \mathbf{12937}$ lb_ft/ft

Total $M_{total\_R} = M_{stem\_R} + M_{base\_R} + M_{exc\_R} =$ **153721** lb_ft/ft

Check stability against overturning

Factor of safety $FoS_{ot} = M_{total\_R} / M_{total\_OT} =$ **3.241** > 1.5

PASS - Factor of safety against overturning is adequate

Bearing pressure check

Vertical forces on wall

Wall stem $F_{stem} = A_{stem} \times \gamma_{stem} =$ **2238** plf

Wall base $F_{base} = A_{base} \times \gamma_{base} =$ **5550** plf

Base soil $F_{pass\_v} = A_{pass} \times \gamma_{mb} =$ **863** plf

Total $F_{total\_v} = F_{stem} + F_{base} + F_{pass\_v} =$ **8651** plf

Horizontal forces on wall

Surcharge load $F_{sur\_h} = K_A \times Surcharge_L \times (h_{eff} - d_{key}) =$ **531** plf

Moist retained soil $F_{moist\_h} = K_A \times \gamma_{mr} \times (h_{eff} - d_{key})^2 / 2 =$ **5703** plf

Base soil $F_{pass\_h} = \max(-K_P \times \cos(\delta_b) \times \gamma_{mb} \times (d_{cover} + h_{base})^2 / 2, \min(- F_{moist\_h} - F_{sur\_h} + F_{total\_v} \times \tan(\delta_{bb}), 0 \text{ plf})) =$ **-1239** plf

Total $F_{total\_h} = F_{moist\_h} + F_{pass\_h} + F_{sur\_h} - F_{total\_v} \times \tan(\delta_{bb}) =$ **0** plf

Moments on wall

Wall stem $M_{stem} = F_{stem} \times x_{stem} =$ **68259** lb_ft/ft

Wall base $M_{base} = F_{base} \times x_{base} =$ **72525** lb_ft/ft

Surcharge load $M_{sur} = -F_{sur\_h} \times x_{sur\_h\_a} =$ **-4224** lb_ft/ft

Moist retained soil $M_{moist} = -F_{moist\_h} \times x_{moist\_h\_a} =$ **-30262** lb_ft/ft

Base soil $M_{pass} = F_{pass\_v} \times x_{pass\_v} - F_{pass\_h} \times x_{pass\_h} =$ **8498** lb_ft/ft

Total $M_{total} = M_{stem} + M_{base} + M_{moist} + M_{pass} + M_{sur} =$ **114797** lb_ft/ft

Check bearing pressure

Distance to reaction $\bar{x} = M_{total} / F_{total\_v} =$ **13.271** ft

Eccentricity of reaction $e = \bar{x} - l_{base} / 2 =$ **-2.229** ft

Loaded length of base $l_{load} = l_{base} =$ **31** ft

Bearing pressure at toe $q_{toe} = F_{total\_v} / l_{base} \times (1 - 6 \times e / l_{base}) =$ **399** psf

Bearing pressure at heel $q_{heel} = F_{total\_v} / l_{base} \times (1 + 6 \times e / l_{base}) =$ **159** psf

Factor of safety $FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) =$ **7.51**

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

RETAINING WALL DESIGN

In accordance with ACI 318-08

Tedds calculation version 2.4.06

Concrete details

Compressive strength of concrete $f'_c =$ **4000** psi

Concrete type Normal weight

Reinforcement details

Yield strength of reinforcement $f_y =$ **60000** psi

Modulus of elasticity or reinforcement $E_s =$ **29000000** psi

Cover to reinforcement

No steel in front face

Note that drawings show rebar in center of wall. This makes it more ineffective for Tension reinforcement.

Front face of stem	c_{sf} = **1.5** in
Rear face of stem	c_{sr} = **2** in
Top face of base	c_{bt} = **2** in
Bottom face of base	c_{bb} = **3** in

From IBC 2009 cl.1605.2.1 Basic load combinations

Load combination no.1	1.4 × Dead
Load combination no.2	1.2 × Dead + 1.6 × Live + 1.6 × Lateral earth
Load combination no.3	1.2 × Dead + 1.0 × Earthquake + 1.0 × Live
Load combination no.4	0.9 × Dead + 1.0 × Earthquake + 1.6 × Lateral earth

Check stem design at base of stem

Depth of section — h = **12** in

Rectangular section in flexure - Chapter 10

Factored bending moment combination 2	M = **45792** lb_ft/ft
Depth of tension reinforcement	$d = h - c_{sr} - \phi_{sr} / 2$ = **9.688** in
Tension reinforcement provided	No.5 bars @ 12" c/c ← From drawings
Area of tension reinforcement provided	$A_{sr.prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr})$ = **0.307** in²/ft
Maximum reinforcement spacing - cl.14.3.5	s_{max} = min(18 in, 3 × h) = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block	$a = A_{sr.prov} \times f_y / (0.85 \times f'_c)$ = **0.451** in
Neutral axis factor - cl.10.2.7.3	β_1 = min(max(0.85 - 0.05 × (f'c - 4 ksi) / 1 ksi, 0.65), 0.85) = **0.85**
Depth to neutral axis	$c = a / \beta_1$ = **0.531** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c$ = **0.051753**

Section is in the tension controlled zone

Strength reduction factor	ϕ_f = min(max(0.65 + (ε_t - 0.002) × (250 / 3), 0.65), 0.9) = **0.9**
Nominal flexural strength	$M_n = A_{sr.prov} \times f_y \times (d - a / 2)$ = **14514** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n$ = **13063** lb_ft/ft
	$M / \phi M_n$ = **3.505**

FAIL - Design flexural strength is less than factored bending moment

By iteration, reinforcement required by analysis	$A_{sr.des}$ = **1.151** in²/ft
Minimum area of tension reinforcement - exp.10-3	$A_{sr.min}$ = max(3 × √(f'c × 1 psi), 200 psi) × d / f_y = **0.388** in²/ft

FAIL - Area of reinforcement provided is less than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Factored shear force	V = **8810** lb/ft
Concrete modification factor - cl.8.6.1	λ = **1**
Nominal concrete shear strength - exp.11-3	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1 psi)} \times d$ = **14705** lb/ft
Strength reduction factor	ϕ_s = **0.75**
Design concrete shear strength - cl.11.4.6.1	$\phi V_c = \phi_s \times V_c$ = **11028** lb/ft
	$V / \phi V_c$ = **0.799**

PASS - No shear reinforcement is required

Horizontal reinforcement parallel to face of stem

Minimum area of reinforcement - cl.14.3.3 — $A_{sx.req} = 0.002 \times t_{stem}$ = **0.288** in²/ft

Transverse reinforcement provided — No.5 bars @ 12" c/c

Area of transverse reinforcement provided — $A_{sx.prov} = \pi \times \phi_{sx}^2 / (4 \times s_{sx}) = \mathbf{0.307}$ in²/ft

PASS - Area of reinforcement provided is greater than area of reinforcement required

Check base design at toe

BASE NOT CONSIDERED

Depth of section — h = **12** in

Rectangular section in flexure - Chapter 10

Factored bending moment combination 2 — M = **53815** lb_ft/ft

Depth of tension reinforcement — $d = h - c_{bb} - \phi_{bb} / 2 = \mathbf{8.688}$ in

Tension reinforcement provided — No.5 bars @ 12" c/c

Area of tension reinforcement provided — $A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb}) = \mathbf{0.307}$ in²/ft

Maximum reinforcement spacing - cl.15.10.4 — s_{max} = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block — $a = A_{bb.prov} \times f_y / (0.85 \times f'_c) = \mathbf{0.451}$ in

Neutral axis factor - cl.10.2.7.3 — $\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4 \text{ ksi}) / 1 \text{ ksi}, 0.65), 0.85) = \mathbf{0.85}$

Depth to neutral axis — $c = a / \beta_1 = \mathbf{0.531}$ in

Strain in reinforcement — $\varepsilon_t = 0.003 \times (d - c) / c = \mathbf{0.046101}$

Section is in the tension controlled zone

Strength reduction factor — $\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) = \mathbf{0.9}$

Nominal flexural strength — $M_n = A_{bb.prov} \times f_y \times (d - a / 2) = \mathbf{12980}$ lb_ft/ft

Design flexural strength — $\phi M_n = \phi_f \times M_n = \mathbf{11682}$ lb_ft/ft

$M / \phi M_n = \mathbf{4.607}$

FAIL - Design flexural strength is less than factored bending moment

By iteration, reinforcement required by analysis — $A_{bb.des} = \mathbf{1.591}$ in²/ft

Minimum area of tension reinforcement - cl.7.12.2.1 — $A_{bb.min} = 0.0018 \times h = \mathbf{0.259}$ in²/ft

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Factored shear force — V = **2786** lb/ft

Concrete modification factor - cl.8.6.1 — $\lambda = \mathbf{1}$

Nominal concrete shear strength - exp.11-3 — $V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1 \text{ psi})} \times d = \mathbf{13187}$ lb/ft

Strength reduction factor — $\phi_s = \mathbf{0.75}$

Design concrete shear strength - cl.11.4.6.1 — $\phi V_c = \phi_s \times V_c = \mathbf{9890}$ lb/ft

$V / \phi V_c = \mathbf{0.282}$

PASS - No shear reinforcement is required

Rectangular section in flexure - Chapter 10

Factored bending moment combination 1 — M = **1392** lb_ft/ft

Depth of tension reinforcement — $d = h - c_{bt} - \phi_{bt} / 2 = \mathbf{9.75}$ in

Tension reinforcement provided — No.4 bars @ 9" c/c

Area of tension reinforcement provided — $A_{bt.prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt}) = \mathbf{0.262}$ in²/ft

Maximum reinforcement spacing - cl.15.10.4 — s_{max} = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block — $a = A_{bt.prov} \times f_y / (0.85 \times f'_c) = \mathbf{0.385}$ in

Neutral axis factor - cl.10.2.7.3 — $\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4 \text{ ksi}) / 1 \text{ ksi}, 0.65), 0.85) = \mathbf{0.85}$

Depth to neutral axis — $c = a / \beta_1 = \mathbf{0.453}$ in

Strain in reinforcement $\varepsilon_t = 0.003 \times (d - c) / c =$ **0.061578**

Section is in the tension controlled zone

Strength reduction factor $\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) =$ **0.9**

Nominal flexural strength $M_n = A_{bt.prov} \times f_y \times (d - a / 2) =$ **12511** lb_ft/ft

Design flexural strength $\phi M_n = \phi_f \times M_n =$ **11260** lb_ft/ft

$M / \phi M_n =$ **0.124**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis $A_{bt.des} =$ **0.032** in²/ft

Minimum area of tension reinforcement - cl.7.12.2.1 $A_{bt.min} = 0.0018 \times h =$ **0.259** in²/ft

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Check key design

Depth of section h = **12** in

Rectangular section in flexure - Chapter 10

Factored bending moment combination 2 M = **21283** lb_ft/ft

Depth of tension reinforcement $d = h - c_{bb} - \phi_k / 2 =$ **8.688** in

Tension reinforcement provided No.5 bars @ 6" c/c

Area of tension reinforcement provided $A_{k.prov} = \pi \times \phi_k^2 / (4 \times s_k) =$ **0.614** in²/ft

Maximum reinforcement spacing - cl.15.10.4 $s_{max} =$ **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block $a = A_{k.prov} \times f_y / (0.85 \times f'_c) =$ **0.902** in

Neutral axis factor - cl.10.2.7.3 $\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 4\text{ ksi}) / 1\text{ ksi}, 0.65), 0.85) =$ **0.85**

Depth to neutral axis $c = a / \beta_1 =$ **1.062** in

Strain in reinforcement $\varepsilon_t = 0.003 \times (d - c) / c =$ **0.021551**

Section is in the tension controlled zone

Strength reduction factor $\phi_f = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9) =$ **0.9**

Nominal flexural strength $M_n = A_{k.prov} \times f_y \times (d - a / 2) =$ **25269** lb_ft/ft

Design flexural strength $\phi M_n = \phi_f \times M_n =$ **22742** lb_ft/ft

$M / \phi M_n =$ **0.936**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis $A_{k.des} =$ **0.572** in²/ft

Minimum area of tension reinforcement - cl.7.12.2.1 $A_{k.min} = 0.0018 \times h =$ **0.259** in²/ft

PASS - Area of reinforcement provided is greater than minimum area of reinforcement required

Rectangular section in shear - Chapter 11

Factored shear force V = **5045** lb/ft

Concrete modification factor - cl.8.6.1 $\lambda =$ **1**

Nominal concrete shear strength - exp.11-3 $V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\text{ psi})} \times d =$ **13187** lb/ft

Strength reduction factor $\phi_s =$ **0.75**

Design concrete shear strength - cl.11.4.6.1 $\phi V_c = \phi_s \times V_c =$ **9890** lb/ft

$V / \phi V_c =$ **0.510**

PASS - No shear reinforcement is required

Transverse reinforcement parallel to base

Minimum area of reinforcement - cl.7.12.2.1 $A_{bx.req} = 0.0018 \times t_{base} =$ **0.259** in²/ft

Transverse reinforcement provided No.5 bars @ 12" c/c each face

Tedds JSD Professional Services, Inc 161 Horizon Drive, Verona, WI 52593	Project Arboretum Pond #3 Storm Water Screen Treatment Structure			Job Ref.	
	Section Walls			Sheet no./rev. 8	
	Calc. by JJE	Date 11/12/2014	Chk'd by	Date	App'd by	Date

Area of transverse reinforcement provided $A_{bx.prov} = 2 \times \pi \times \phi_{bx}^2 / (4 \times s_{bx})$ = **0.614** in²/ft

PASS - Area of reinforcement provided is greater than area of reinforcement required