PLAN ADDENDUM

3/30/2023

STARR HOMES

RE: MILLIGAN RESIDENCE
512 NE PROMISED VIEW DR
LEE'S SUMMIT, MO.

Our firm has been asked to address a foundation design change for the garage tall foundation.

The footing width of the foundation for the sports court area has been reduced based the support provided by the pier supported foundation. The footing width has been reduced to 40" per the attached calculations.
The footing in place is approximately 36" wide. The current footing will be extended inward 12" with two rows of #4 pins at 12" on center and two continuous #4 bars top and bottom.
The footing reduction requires that the floor slab and precast slab be in place prior to backfill. The foundation for the garage will require 1/2" clean rock backfill full height.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted engineering practices. No warranties, either express or implied, are intended or made.

We appreciate the opportunity to be of service to you on this project. If you have any questions regarding this report, please contact us.

Very truly yours,
HD ENGINEERING & DESIGN, INC.

John Hulse, Principal

STATE OF MISSOURI
CHRIS SAATHOFF
NUMBER 2008001865
03/30/2023
REGISTERED PROFESSIONAL ENGINEER

STRUCTURAL REVIEW
HD ENGINEERING & DESIGN
HD: 42639 DATE: 3/30/2023

STATE OF MISSOURI
CHRIS SAATHOFF
NUMBER 2008001865
03/28/2023
REGISTERED PROFESSIONAL ENGINEER

RETAINING WALL ANALYSIS

In accordance with International Building Code 2018

Tedds calculation version 2.9.18

Retaining wall details

Stem type	Propped cantilever pinned at the base
Stem height	h_{stem} = **20** ft
Prop height	h_{prop} = **19** ft
Stem thickness	t_{stem} = **16** in
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **150** pcf
Toe length	l_{toe} = **1** ft
Heel length	l_{heel} = **1** ft
Base thickness	t_{base} = **16** in
Base density	γ_{base} = **150** pcf
Height of retained soil	h_{ret} = **18.5** ft
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **0** ft

Retained soil properties

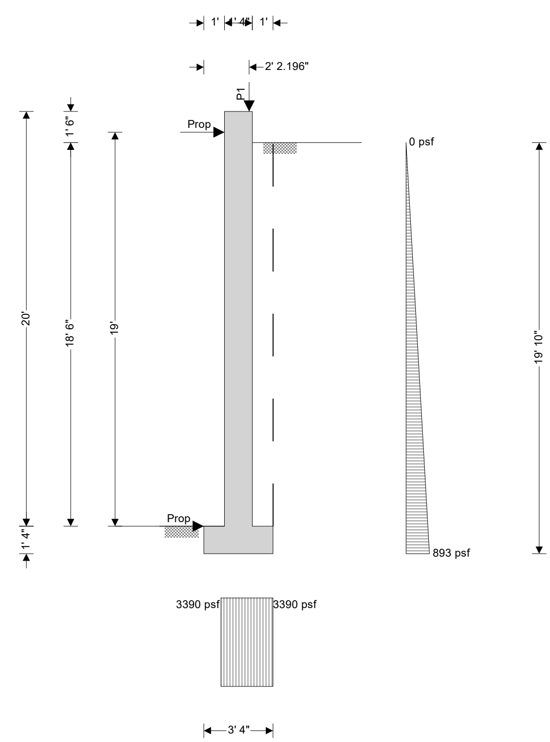
Soil type	Dense well graded sand and gravel
Moist density	γ_{mr} = **131** pcf
Saturated density	γ_{sr} = **143** pcf
Prescribed at rest lateral soil pressure	p_{0r} = **45** psf/ft

Base soil properties

Soil type	Very Dense rock fill
Soil density	γ_b = **110** pcf
Prescribed passive lateral soil pressure	p_{0b} = **60** psf/ft
Allowable bearing pressure	$P_{bearing}$ = **3500** psf

Loading details

Vertical line load at 2.183 ft	P_{D1} = **1200** plf
	P_{L1} = **170** plf



General arrangement

Calculate retaining wall geometry

Base length	$l_{base} = l_{toe} + t_{stem} + l_{heel} = \mathbf{3.333}$ ft
Moist soil height	$h_{moist} = h_{soil} = \mathbf{18.5}$ ft
Retained surface length	$l_{sur} = l_{heel} = \mathbf{1}$ ft
Effective height of wall	$h_{eff} = h_{base} + d_{cover} + h_{ret} = \mathbf{19.833}$ ft
Area of wall stem	$A_{stem} = h_{stem} * t_{stem} = \mathbf{26.667}$ ft^2
- Distance to vertical component	$x_{stem} = l_{toe} + t_{stem} / 2 = \mathbf{1.667}$ ft
Area of wall base	$A_{base} = l_{base} * t_{base} = \mathbf{4.444}$ ft^2
- Distance to vertical component	$x_{base} = l_{base} / 2 = \mathbf{1.667}$ ft
Area of moist soil	$A_{moist} = h_{moist} * l_{heel} = \mathbf{18.5}$ ft^2
- Distance to vertical component	$x_{moist\_v} = l_{base} - (h_{moist} * l_{heel}^2 / 2) / A_{moist} = \mathbf{2.833}$ ft
- Distance to horizontal component	$x_{moist\_h} = h_{eff} / 3 = \mathbf{6.611}$ ft

Soil coefficients

Coefficient of friction to back of wall	$K_{fr} = \mathbf{0.325}$
Coefficient of friction to front of wall	$K_{fb} = \mathbf{0.325}$
Coefficient of friction beneath base	$K_{fbb} = \mathbf{0.325}$

From IBC 2018 cl.1807.2.3 Safety factor

Load combination 1	1.0 * Dead + 1.0 * Live + 1.0 * Lateral earth

Bearing pressure check

Vertical forces on wall

Wall stem $F_{stem} = A_{stem} * \gamma_{stem} = \mathbf{4000}$ plf

Wall base $F_{base} = A_{base} * \gamma_{base} = \mathbf{667}$ plf

Line loads $F_{P\_v} = P_{D1} + P_{L1} = \mathbf{1370}$ plf

Moist retained soil $F_{moist\_v} = A_{moist} * \gamma_{mr} = \mathbf{2428}$ plf

Total $F_{total\_v} = F_{stem} + F_{base} + F_{P\_v} + F_{moist\_v} = \mathbf{8465}$ plf

Horizontal forces on wall

Moist retained soil $F_{moist\_h} = p_{0r} * h_{eff}^2 / 2 = \mathbf{8851}$ plf

Base soil $F_{pass\_h} = -p_{0b} * (d_{cover} + h_{base})^2 / 2 = \mathbf{-53}$ plf

Total $F_{total\_h} = F_{moist\_h} + F_{pass\_h} = \mathbf{8797}$ plf

Moments on wall

Wall stem $M_{stem} = F_{stem} * x_{stem} = \mathbf{6667}$ lb_ft/ft

Wall base $M_{base} = F_{base} * x_{base} = \mathbf{1111}$ lb_ft/ft

Line loads $M_P = ((P_{D1} + P_{L1})) * p_1 = \mathbf{2991}$ lb_ft/ft

Moist retained soil $M_{moist} = F_{moist\_v} * x_{moist\_v} = \mathbf{6880}$ lb_ft/ft

Total $M_{total} = M_{stem} + M_{base} + M_P + M_{moist} = \mathbf{17648}$ lb_ft/ft

Check bearing pressure

Distance to reaction $\bar{x} = M_{total} / F_{total\_v} = \mathbf{2.085}$ ft

Eccentricity of reaction $e = \bar{x} - l_{base} / 2 = \mathbf{0.418}$ ft

Loaded length of base $l_{load} = 2 * (l_{base} - \bar{x}) = \mathbf{2.497}$ ft

Bearing pressure at toe $q_{toe} = \mathbf{0}$ psf

Bearing pressure at heel $q_{heel} = F_{total\_v} / l_{load} = \mathbf{3390}$ psf

Factor of safety $FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) = \mathbf{1.032}$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

RETAINING WALL DESIGN

In accordance with ACI 318-14

Tedds calculation version 2.9.08

Concrete details

Compressive strength of concrete $f'_c = \mathbf{3500}$ psi

Concrete type Normal weight

Reinforcement details

Yield strength of reinforcement $f_y = \mathbf{60000}$ psi

Modulus of elasticity or reinforcement $E_s = \mathbf{29000000}$ psi

Compression-controlled strain limit $\varepsilon_{ty} = \mathbf{0.002}$

Cover to reinforcement

Front face of stem $c_{sf} = \mathbf{2.5}$ in

Rear face of stem $c_{sr} = \mathbf{2.5}$ in

Top face of base $c_{bt} = \mathbf{3}$ in

Bottom face of base $c_{bb} = \mathbf{1.5}$ in

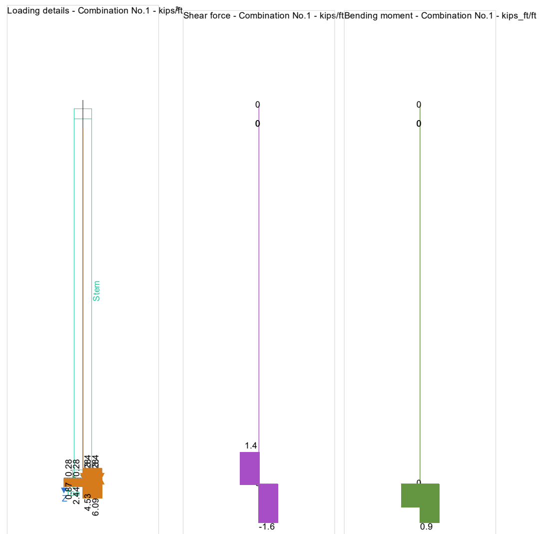
From IBC 2018 cl.1605.2 Basic load combinations

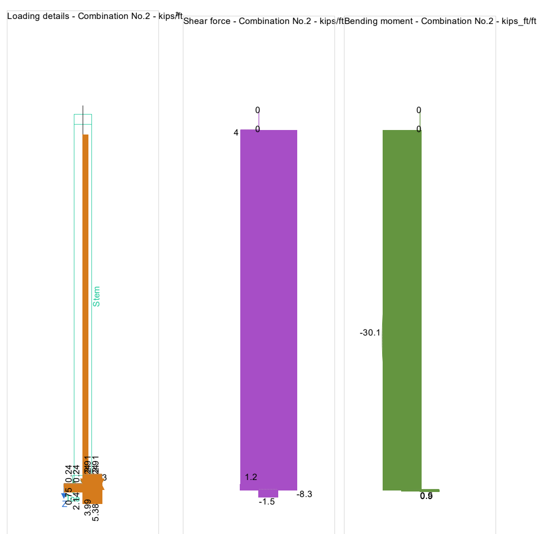
Load combination no.1 1.4 * Dead

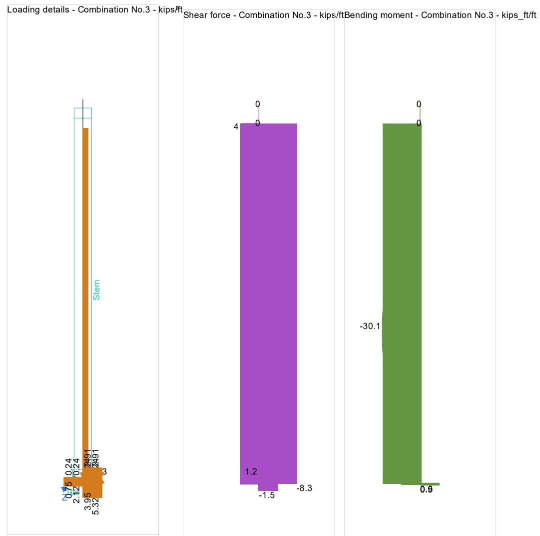
Load combination no.2 1.2 * Dead + 1.6 * Live + 1.6 * Lateral earth

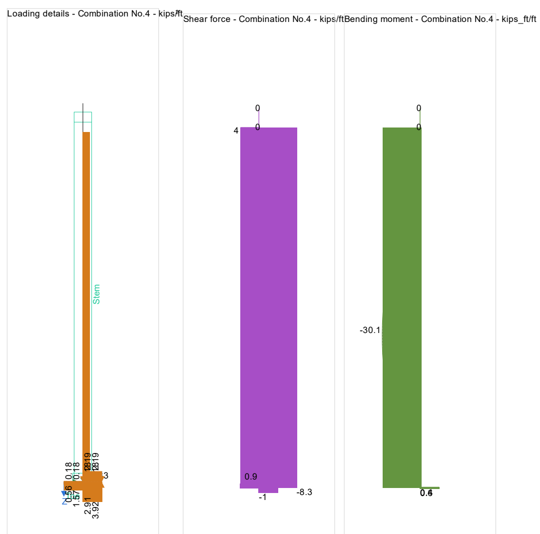
Load combination no.3 1.2 * Dead + 1.0 * Earthquake + 1.0 * Live + 1.6 * Lateral earth

Load combination no.4 0.9 * Dead + 1.0 * Earthquake + 1.6 * Lateral earth









Check stem design at 7.96 ft

Depth of section — h = **16** in

Rectangular section in flexure - Section 22.3

Design bending moment combination 4 — M = **30097** lb_ft/ft

Depth of tension reinforcement — $d = h - c_{sf} - \phi_{sx} - \phi_{sfM} / 2$ = **12.75** in

Compression reinforcement provided — No.4 bars @ 12" c/c

Area of compression reinforcement provided — $A_{srM.prov} = \pi * \phi_{srM}^2 / (4 * s_{srM})$ = **0.196** in^2/ft

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

Area of tension reinforcement provided — $A_{sfM.prov} = \pi * \phi_{sfM}^2 / (4 * s_{sfM})$ = **0.589** in^2/ft

Maximum reinforcement spacing - cl.11.7.2 — s_{max} = min(18 in, 3 * h) = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block — $a = A_{sfM.prov} * f_y / (0.85 * f'_c)$ = **0.99** in

Neutral axis factor - cl.22.2.2.4.3 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 / β_1 = **1.165** in

Strain in reinforcement ε_t = 0.003 × (d - c) / c = **0.029841**

Section is in the tension controlled zone

Strength reduction factor ϕ_f = min(max(0.65 + 0.25 *(ε_t - ε_{ty}) / 0.003, 0.65), 0.9) = **0.9**

Nominal flexural strength M_n = $A_{sfM.prov}$ * f_y * (d - a / 2) = **36094** lb_ft/ft

Design flexural strength ϕM_n = ϕ_f × M_n = **32485** lb_ft/ft

M / ϕM_n = **0.927**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis $A_{sfM.des}$ = **0.544** in^2/ft

Minimum area of reinforcement - cl.9.6.1.2 $A_{sfM.min}$ = max(3 * √(f'$_c$ * 1 psi), 200 psi) * d / f_y = **0.51** in^2/ft

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

Check stem design at base of stem

Depth of section h = **16** in

Rectangular section in shear - Section 22.5

Design shear force V = **8322** lb/ft

Concrete modification factor - cl.19.2.4 λ = **1**

Nominal concrete shear strength - eqn.22.5.5.1 V_c = 2 × λ × √(f'$_c$ × 1 psi) × d = **18103** lb/ft

Strength reduction factor ϕ_s = **0.75**

Design concrete shear strength - cl.11.5.1.1 ϕV_c = ϕ_s × V_c = **13577** lb/ft

V / ϕV_c = **0.613**

PASS - No shear reinforcement is required

Check stem design at prop

Depth of section h = **16** in

Rectangular section in shear - Section 22.5

Design shear force V = **3999** lb/ft

Concrete modification factor - cl.19.2.4 λ = **1**

Nominal concrete shear strength - eqn.22.5.5.1 V_c = 2 × λ × √(f'$_c$ × 1 psi) × d = **18103** lb/ft

Strength reduction factor ϕ_s = **0.75**

Design concrete shear strength - cl.11.5.1.1 ϕV_c = ϕ_s × V_c = **13577** lb/ft

V / ϕV_c = **0.295**

PASS - No shear reinforcement is required

Horizontal reinforcement parallel to face of stem

Minimum area of reinforcement - cl.11.6.1 $A_{sx.req}$ = 0.002 * t_{stem} = **0.384** in^2/ft

Transverse reinforcement provided No.4 bars @ 12" c/c each face

Area of transverse reinforcement provided $A_{sx.prov}$ = 2 * π * ϕ_{sx}^2 / (4 * s_{sx}) = **0.393** in^2/ft

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

Check base design at heel

Depth of section h = **16** in

Rectangular section in flexure - Section 22.3

Design bending moment combination 1 M = **946** lb_ft/ft

Depth of tension reinforcement d = h - c_{bb} - ϕ_{bb} / 2 = **14.25** in

Compression reinforcement provided	No.4 bars @ 16" c/c
Area of compression reinforcement provided	$A_{bt.prov} = \pi * \phi_{bt}^2 / (4 * s_{bt})$ = **0.147** in^2/ft
Tension reinforcement provided	No.4 bars @ 6" c/c
Area of tension reinforcement provided	$A_{bb.prov} = \pi * \phi_{bb}^2 / (4 * s_{bb})$ = **0.393** in^2/ft
Maximum reinforcement spacing - cl.7.7.2.3	s_{max} = min(18 in, 3 * h) = **18** in

PASS - Reinforcement is adequately spaced

Depth of compression block	$a = A_{bb.prov} * f_y / (0.85 * f'_c)$ = **0.66** in
Neutral axis factor - cl.22.2.2.4.3	β_1 = min(max(0.85 - 0.05 × (f'$_c$ - 4 ksi) / 1 ksi, 0.65), 0.85) = **0.85**
Depth to neutral axis	$c = a / \beta_1$ = **0.776** in
Strain in reinforcement	$\varepsilon_t = 0.003 \times (d - c) / c$ = **0.052057**

Section is in the tension controlled zone

Strength reduction factor	ϕ_f = min(max(0.65 + 0.25 *($\varepsilon_t - \varepsilon_{ty}$) / 0.003, 0.65), 0.9) = **0.9**
Nominal flexural strength	$M_n = A_{bb.prov} * f_y * (d - a / 2)$ = **27332** lb_ft/ft
Design flexural strength	$\phi M_n = \phi_f \times M_n$ = **24599** lb_ft/ft
	$M / \phi M_n$ = **0.038**

PASS - Design flexural strength exceeds factored bending moment

By iteration, reinforcement required by analysis	$A_{bb.des}$ = **0.015** in^2/ft
Minimum area of reinforcement - cl.7.6.1.1	$A_{bb.min}$ = 0.0018 * h = **0.346** in^2/ft

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

Rectangular section in shear - Section 22.5

Design shear force	V = **1377** lb/ft
Concrete modification factor - cl.19.2.4	λ = **1**
Nominal concrete shear strength - eqn.22.5.5.1	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\ psi)} \times d$ = **20233** lb/ft
Strength reduction factor	ϕ_s = **0.75**
Design concrete shear strength - cl.7.6.3.1	$\phi V_c = \phi_s \times V_c$ = **15175** lb/ft
	$V / \phi V_c$ = **0.091**

PASS - No shear reinforcement is required

Check base design at heel

Depth of section	h = **16** in

Rectangular section in shear - Section 22.5

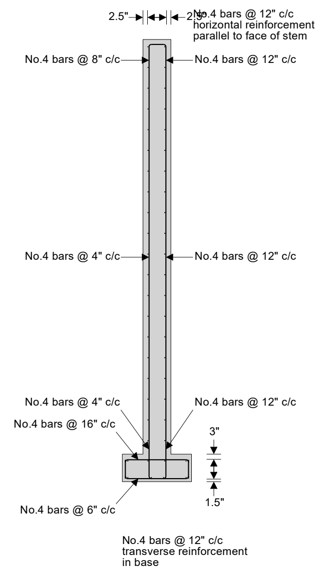
Design shear force	V = **1631** lb/ft
Concrete modification factor - cl.19.2.4	λ = **1**
Nominal concrete shear strength - eqn.22.5.5.1	$V_c = 2 \times \lambda \times \sqrt{(f'_c \times 1\ psi)} \times d$ = **20233** lb/ft
Strength reduction factor	ϕ_s = **0.75**
Design concrete shear strength - cl.7.6.3.1	$\phi V_c = \phi_s \times V_c$ = **15175** lb/ft
	$V / \phi V_c$ = **0.108**

PASS - No shear reinforcement is required

Transverse reinforcement parallel to base

Minimum area of reinforcement - cl.7.6.1.1	$A_{bx.req} = 0.0018 * t_{base}$ = **0.346** in^2/ft
Transverse reinforcement provided	No.4 bars @ 12" c/c each face
Area of transverse reinforcement provided	$A_{bx.prov} = 2 * \pi * \phi_{bx}^2 / (4 * s_{bx})$ = **0.393** in^2/ft

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



Reinforcement details