

SnailPlus 2018: Report Output

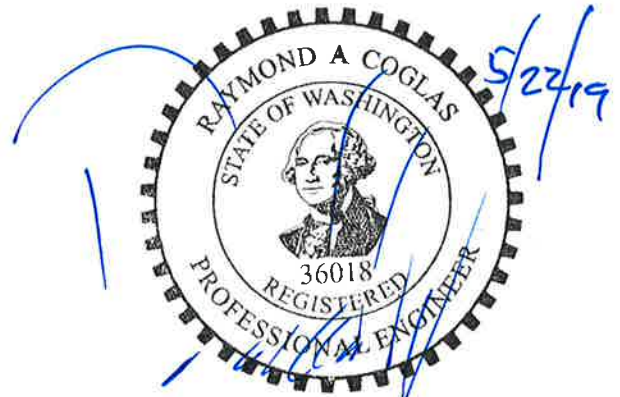
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Project: Boyle Residence



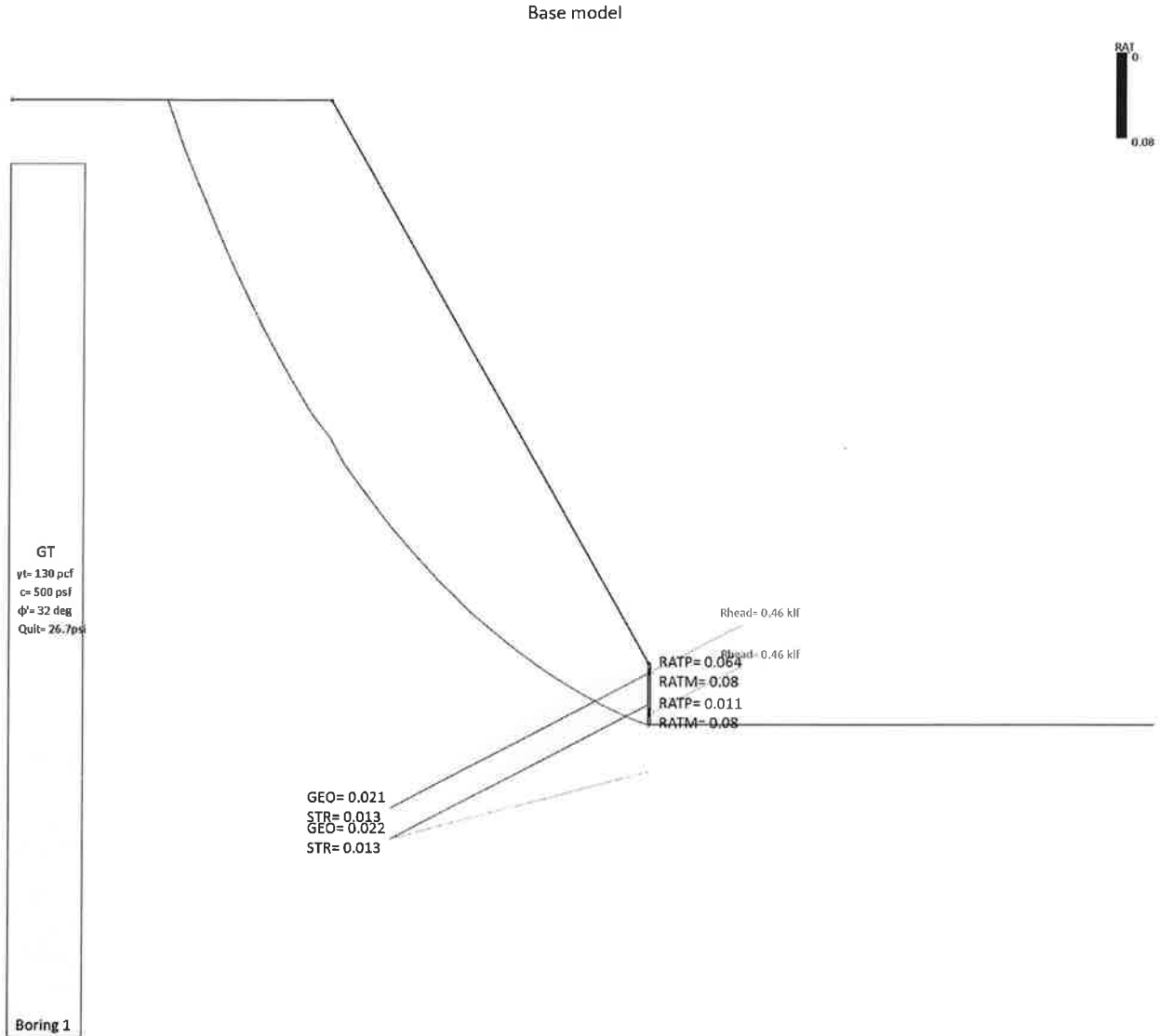
Company: ESNW
Prepared by engineer: HTW
File number: 1
Time: 5/21/2019 9:05:04 AM

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File: C:\Users\henry.wright\Documents\Snail\6690.SNLP



Seismic

Quick analysis summary for design section: Base model



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Stage 0	Calculated	1.244	2.84	1.83	0.022	0.08	0.047	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
 Fmax Nail@head = Maximum axial nail force at facing.
 STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
 STR Plates= Stress check for nail plates (punching and bending).
 STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Stage 0	Yes	1.244	1.2	Circle	26.83	168.58	141.153	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
N/A	N/A	N/A		Service Facto	123.96	0.022	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Extreme event, flood or seismic
Min required FS	1.2
Method	Morgenstern-Price
Nail methods	Available shear
Earthquake	ax= 0.29g, az= 0g
Seismic pressures	Semirigid B= 0.75
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FSO	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.35
FS on nail pullout	1.5
FS on facing bending	1.2
FS on facing punching	1.2
FS on bolts	1.3
FS on bearing	2.3

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N0	0: N1	15	0	35	50	0	4	0.457	1.83
N1	0: N1	15	0	32	50	0	4	0.456	1.82

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-120	90.12
2	-59.74	90.08
3	0	36
4	0	30
5	100	30

Soil type property data

Name	γ_{tot}	γ_{dry}	Φ'	c'	S_u	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
GT	130	120	32	500	N/A	26.7	

γ_{tot} = Total unit weight below water table

γ_{dry} = Bulk unit weight above water table

c' = Effective cohesion (in drained state for clays)

Φ' = Effective friction (in drained state for clays)

S_u = Undrained shear strength (for clays in undrained condition)

q_{Bond} = Ultimate bond resistance for soil nails

Name: Boring 1, pos: (-50, 90)

Top elev.	Soil type	OCR	Ko
84	GT	1	0.5

Slope stability assumptions: Stage 0

Table: Basic analysis assumptions last stage

Stage conditions	Extreme event, flood or seismic
Min required FS	1.2
Method	Morgenstern-Price
Nail methods	Available shear
Earthquake	$a_x = 0.29g$, $a_z = 0g$
Seismic pressures	Semirigid $B = 0.75$
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FSO	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.35
FS on nail pullout	1.5
FS on facing bending	1.2
FS on facing punching	1.2
FS on bolts	1.3
FS on bearing	2.3

Maximum number of iterations = 100, Tolerance = 0.01%

Maximum slice width = 3 ft

Circular search method applied

Search Limits from top left corner of wall

Left = 26.83 ft, Right = 73.16 ft, Horizontal intervals = 6

Top = 168.58 ft, Bottom = 133.71 ft, Vertical intervals = 6

Radii search starts from point $x = 0\text{ft}$, $z = 30\text{ft}$

Radii search ends at point $x = 0\text{ft}$, $z = 15\text{ft}$

5 radii intervals are used

Active angle limit is not used.

Passive angle limit is not used.

Service Support Capacities are included in slope stability.

Wall shear capacity is included for stability surfaces intersecting the wall (note: soldier pile wall = 0)

Shear and lateral force on vertical start and end faces is based on at-rest conditions

Number of intervals on vertical start and end faces = 30

Mobilized soil nail axial force distribution calculated with back analysis for $FS = 1.0$

Soil nail mobilization interaction factor $I_{mob} = 0.25$

$I_{mob} = 0$ means that $F_{X,mobilized} = F_{X,nail}$ for $FS = 1.0$, $I_{mob} = 1$ means that $F_{X,mobilized} = F_{X,nail}$ ultimate

Minimum soil nail mobilization factor $SN_{min,mob} = 0$

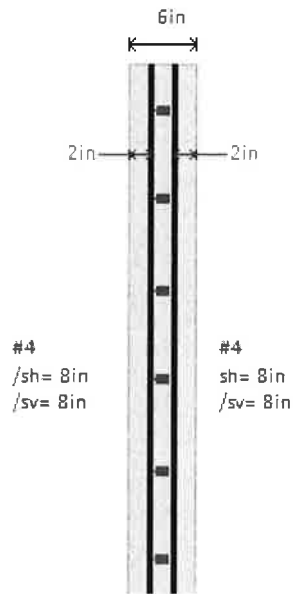
$F_{x,mob} = F_x(FS = 1.0) + I_{mob} \times (F_{x,ULT} - F_x(FS = 1.0)) \geq SN_{min,mob} \times F_{x,ULT}$

Global mode parameters applied for slope stability analysis.

Soil nail stability considers both external and internal stability (punching through facing).

Soil nail shear is ignored in the analysis.

Shotcrete facing data design section Base model



Facing Thickness $D=6\text{in}$

Concrete strength $F_c'=3\text{ksi}$

Rebar and mesh yield strength $F_y=60\text{ksi}$

Back face hor. reinforcement (or mesh) #4@8in area $a_{bh}=0.3\text{ in}^2/\text{ft}$

Back face vertical reinforcement (or mesh) #4@8in area $a_{bv}=0.3\text{ in}^2/\text{ft}$

Front face reinforcement (if used in permanent section)

Front face hor. reinforcement (or mesh) #4@8in area $a_{fh}=0.3\text{ in}^2/\text{ft}$

Front face vertical reinforcement (or mesh) #4@8in area $a_{fv}=0.3\text{ in}^2/\text{ft}$

Stage	Active	Top El.	Bottom El.	Two stage facing	Thickness
Name	Yes/No	(ft)	(ft)	-	(in)
Stage 0	Yes	36	30	N/A	6

Soil nail input data for design section Base model

Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in ²)	(in)	(ksi)
N0	0: N1	15	0	35	50	0	4	1.13	4	270
N1	0: N1	15	0	32	50	0	4	1.13	4	270

Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
N0	35	8	1	36	1	N/A	N/A	N/A
N1	32	8	1	36	1	N/A	N/A	N/A

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: Base model

Soil nail results Stage: 0

Soil nail results available for this stage.

Critical point at x= 26.83 z= 168.58 FS= 1.244

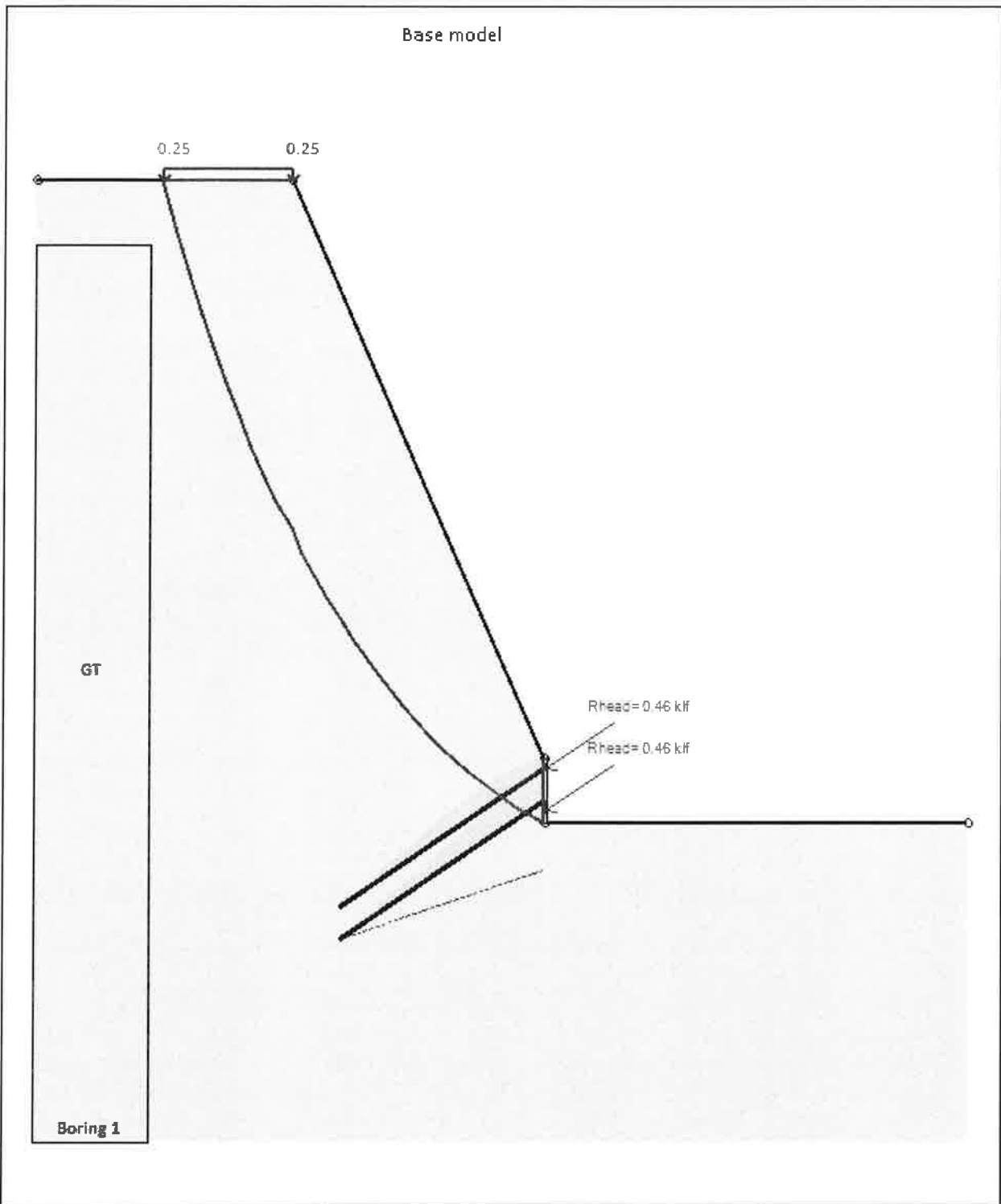
	F	Fmax	CAP S	CAP G	Tcap G	TC1 ST	TC2	TC3	TC4	TC4 C4	ks	Po	Pu	lo	IxxCalc	SxxCalc	t. loss	% STR	Mode
Nail/Uni	k	k	k	k	k	k	k	k	k	k	ksf	ksf	ksf	ft	in4	in3	in	%	Crit
0: NO	57.9	82.14	274.5	134.2	0	137.2	Not in	Not in	Not in	Not in	N/A	N/A	N/A	N/A	0.08	0.14	N/A	N/A	GEO
1: N1	120.9	123.9	274.5	126.7	0	137.2	Not in	Not in	Not in	Not in	N/A	N/A	N/A	N/A	0.08	0.14	N/A	N/A	GEO

GENERAL SOIL NAIL DATA

Soil nails are considered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion for limit equilibrium approach
ks	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)



Company: ESNW Engineer: HTW	DS: 0, Stage 0	Deep Excavation LCC
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SnailPlus 2018: Report Output

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Project: Boyle Residence



Company: ESNW
Prepared by engineer: HTW
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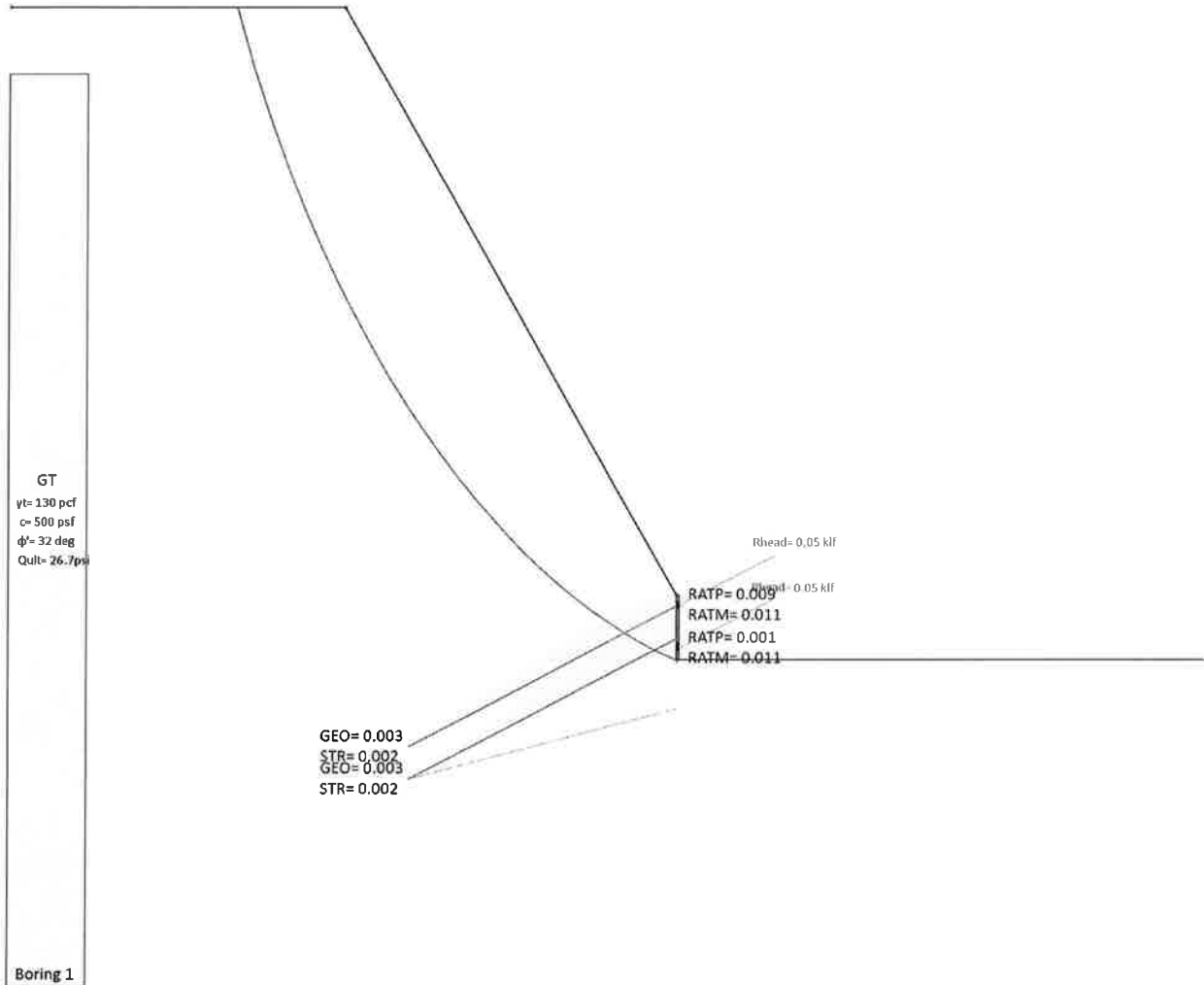


2/9

Static

Quick analysis summary for design section: Base model

Base model



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Stage 0	Calculated	1.794	0.32	0.2	0.003	0.011	0.005	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.

Fmax Nail@head = Maximum axial nail force at facing.

STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).

STR Plates= Stress check for nail plates (punching and bending).

STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Stage 0	Yes	1.794	1.5	Circle	26.83	147.658	120.678	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k)	MEQ seismic
N/A	N/A	N/A		Service Facto	92.97	0.003	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Permanent structure long term
Min required FS	1.5
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FSO	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.5
FS on facing punching	1.5
FS on bolts	1.7
FS on bearing	3

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N0	0: N1	15	0	35	50	0	4	0.0511	0.2
N1	0: N1	15	0	32	50	0	4	0.05	0.2

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-120	90.12
2	-59.74	90.08
3	0	36
4	0	30
5	100	30

Soil type property data

Name	γ_{tot}	γ_{dry}	Φ'	c'	S_u	q_{Bond}	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
GT	130	120	32	500	N/A	26.7	

γ_{tot} = Total unit weight below water table

γ_{dry} = Bulk unit weight above water table

c' = Effective cohesion (in drained state for clays)

Φ' = Effective friction (in drained state for clays)

Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: Boring 1, pos: (-50, 90)

Top elev.	Soil type	OCR	Ko
84	GT	1	0.5

Slope stability assumptions: Stage 0

Table: Basic analysis assumptions last stage

Stage conditions	Permanent structure long term
Min required FS	1.5
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FSO	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.5
FS on facing punching	1.5
FS on bolts	1.7
FS on bearing	3

Maximum number of iterations = 100, Tolerance = 0.01%

Maximum slice width = 3 ft

Circular search method applied

Search Limits from top left corner of wall

Left = 26.83 ft, Right = 73.16 ft, Horizontal intervals = 6

Top = 168.58 ft, Bottom = 133.71 ft, Vertical intervals = 6

Radii search starts from point x= 0ft, z= 30ft

Radii search ends at point x= 0ft, z= 15ft

5 radii intervals are used

Active angle limit is not used.

Passive angle limit is not used.

Service Support Capacities are included in slope stability.

Wall shear capacity is included for stability surfaces intersecting the wall (note: soldier pile wall = 0)

Shear and lateral force on vertical start and end faces is based on at-rest conditions

Number of intervals on vertical start and end faces = 30

Mobilized soil nail axial force distribution calculated with back analysis for FS=1.0

Soil nail mobilization interaction factor $I_{mob} = 0.25$

$I_{mob} = 0$ means that $F_{X,mobilized} = F_{X,nail}$ for FS=1.0, $I_{mob} = 1$ means that $F_{X,mobilized} = F_{X,nail}$ ultimate

Minimum soil nail mobilization factor $SN_{min,mob} = 0$

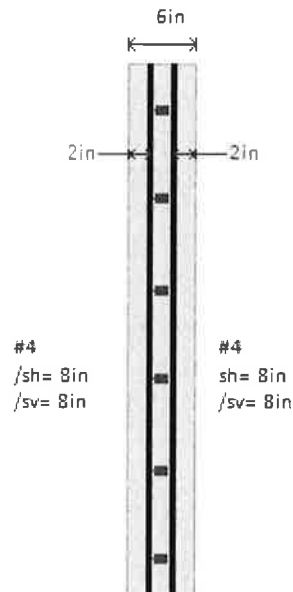
$F_{x,mob} = F_x(FS=1.0) + I_{mob} \times (F_{x,ULT} - F_x(FS=1.0)) \geq SN_{min,mob} \times F_{x,ULT}$

Global mode parameters applied for slope stability analysis.

Soil nail stability considers both external and internal stability (punching through facing).

Soil nail shear is ignored in the analysis.

Shotcrete facing data design section Base model



Facing Thickness $D=6\text{in}$

Concrete strength $F_c'=3\text{ksi}$

Rebar and mesh yield strength $F_y=60\text{ksi}$

Back face hor. reinforcement (or mesh) #4@8in area $a_{bh}=0.3\text{ in}^2/\text{ft}$

Back face vertical reinforcement (or mesh) #4@8in area $a_{bv}=0.3\text{ in}^2/\text{ft}$

Front face reinforcement (if used in permanent section)

Front face hor. reinforcement (or mesh) #4@8in area $a_{fh}=0.3\text{ in}^2/\text{ft}$

Front face vertical reinforcement (or mesh) #4@8in area $a_{fv}=0.3\text{ in}^2/\text{ft}$

Stage	Active	Top El.	Bottom El.	Two stage facing	Thickness
Name	Yes/No	(ft)	(ft)	-	(in)
Stage 0	Yes	36	30	N/A	6

Soil nail input data for design section Base model

Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in ²)	(in)	(ksi)
N0	0: N1	15	0	35	50	0	4	1.13	4	270
N1	0: N1	15	0	32	50	0	4	1.13	4	270

Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
N0	35	8	1	36	1	N/A	N/A	N/A
N1	32	8	1	36	1	N/A	N/A	N/A

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: Base model

Soil nail results Stage: 0

Soil nail results available for this stage.

Critical point at x= 26.83 z= 147.658 FS= 1.794

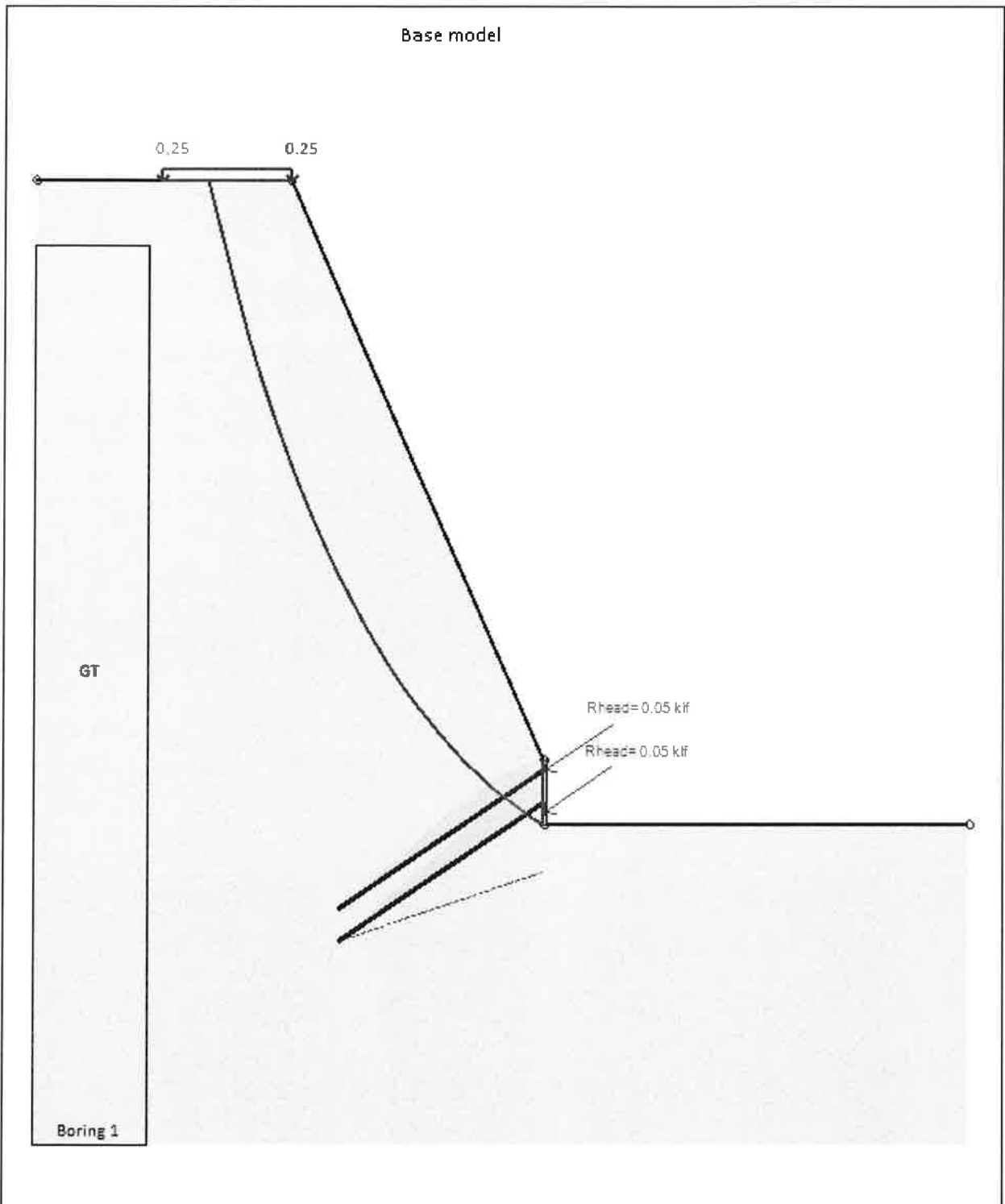
	F	Fmax	CAP S	CAP G	Tcap G	TC1 ST	TC2	TC3	TC4	TC4 C4	ks	Po	Pu	lo	IxxCalc	SxxCalc	t. loss	% STR	Mode
Nail/Uni	k	k	k	k	k	k	k	k	k	k	ksf	ksf	ksf	ft	in4	in3	in	%	Crit
0: NO	49.48	65.21	274.5	100.6	0	137.2	Not in	Not in	Not in	Not in	N/A	N/A	N/A	N/A	0.08	0.14	N/A	N/A	GEO
1: N1	91.02	92.97	274.5	95.06	0	137.2	Not in	Not in	Not in	Not in	N/A	N/A	N/A	N/A	0.08	0.14	N/A	N/A	GEO

GENERAL SOIL NAIL DATA

Soil nails are considered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clousterre TC2 criterion
TC3	= Shear resistance according to Clousterre TC3 criterion
TC4	= Shear resistance according to Clousterre TC4 criterion
TC4 C4	= Shear resistance according to Clousterre TC4 criterion for limit equilibrium approach
ks	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)



Company: ESNW	DS: 0, Stage 0	Deep Excavation LCC
Engineer: HTW		SnailPlus 2019
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PSM

CONSULTING ENGINEERS

STRUCTURAL CALCULATIONS

Soil Nailed Wall Boyle Residence

By
PSM Engineers

May 15, 2019

PSM Project No # 19089

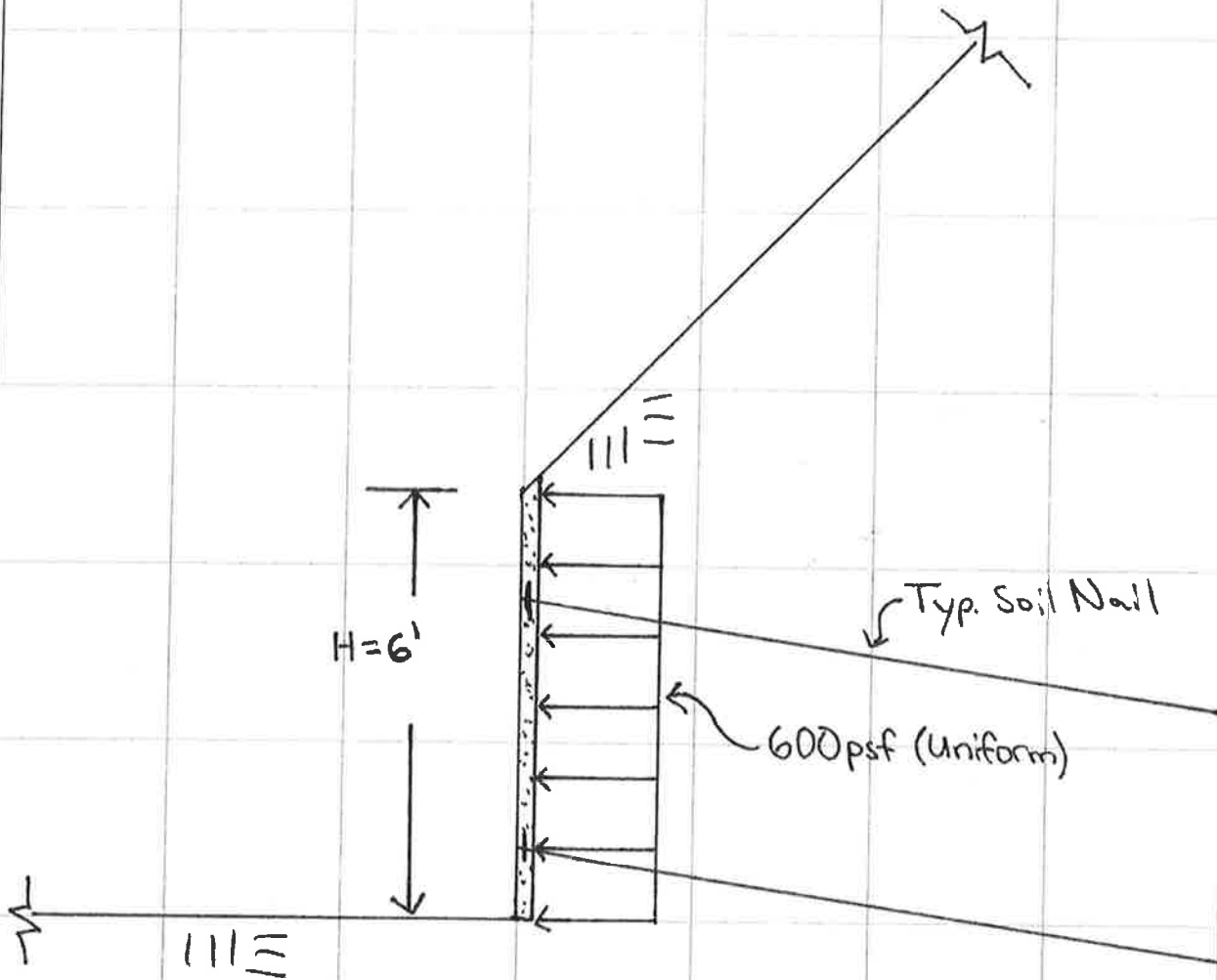




Earth Solutions NW LLC
CALCULATION SHEET

Name: HTW
Date: May 13, 2019
Project Number: ES-6690
Project Name: Boyle Residence

Permanent Wall Facing Criteria



Note: Soil nails will be on 4'0" x 4'0" grid

PSM Engineers

2200 6th Ave., #601, Seattle, WA 98121

Soil Nailed Wall Design

Soil nailes / anchors

Nail spacing =	4 ft grid (per Geotech)
Soil pressure =	600 psf (per Geotech)
Pu =	15.36 k
Load factor =	1.6
pu =	960 psf

Concrete wall - flexure check

Wall thk =	6.0	
Rebar size =	4	
Rebar spacing =	10 in	
d =	2.5 in	
f'c =	3000 psi	
Mu =	1.54 ft-k/ft	
ϕMn =	2.45 ft-k/ft	OK

Concrete wall - punching shear check

Anchor bearing pl	8 in square	
ϕVn =	17.3 k	OK

Concrete wall - cracking check

Fr =	328.6 psi	
Ig =	216 in ⁴	
Sg =	72 in ³	
Mcr =	2.0 kft/ft	
Service moment Ms =	1.0 kft/ft	Wall will not crack under service load

Concrete wall - deflection check

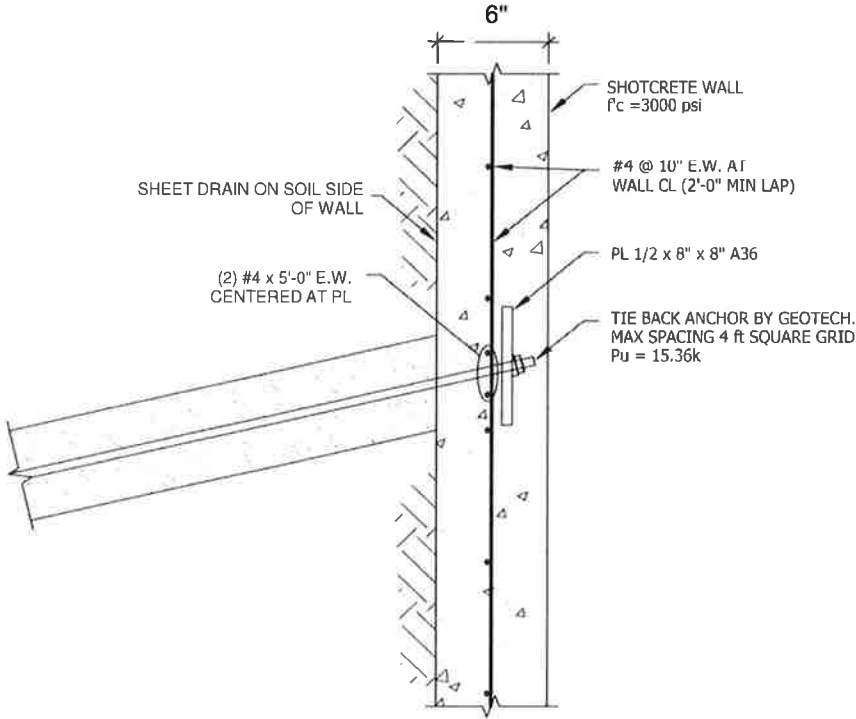
Ec =	3122 ksi
I =	216 in ⁴
Service soil pressure =	600 psf
Deflection =	0.004 in

Anchor bearing plate check

Ps =	9.600 k
Plate size =	8.000 in sq
Soil pressure =	0.150 ksi
Max lever arm =	2.0 in
M =	0.3 kin/in
tr =	0.26 in

PSM Engineers

2200 6th Ave., #601, Seattle, WA 98121



PERMANENT SOIL NAILED EXCAVATION SHORING WALL