



Structural Calculations For:

Boyle Shoring

3603 West Mercer Way

Mercer Island, WA



11/15/2018

Prepared for: Max Corp

Job #: 02087-2018-01

Date: November 15, 2018

Soil Nail Shoring Wall Design:

Soil nail design has been conducted with the soil criteria provided in the geotechnical reports provided by GeoResources LLC, dated 8/26/2018 and 3/3/2016.

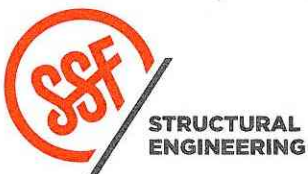
The relevant soil criteria utilized for the soil nail wall design are as follows:

Unit Weight [lbs/ft ³]	130
Cohesion [psf]	1000
Friction Angle [deg]	33
Water Surface	None

(from GeoResources 3/3/2016 report, page 28 of 41)

Soil nail design follows the guidance of the US Department of Transportation Federal Highway Administration Publication No. FHWA-NHI-14-007

Stability analysis has been conducted utilizing SNAP 2.0 software. An analysis report is included on the following pages.



Boyle Shoring
PROJECT _____

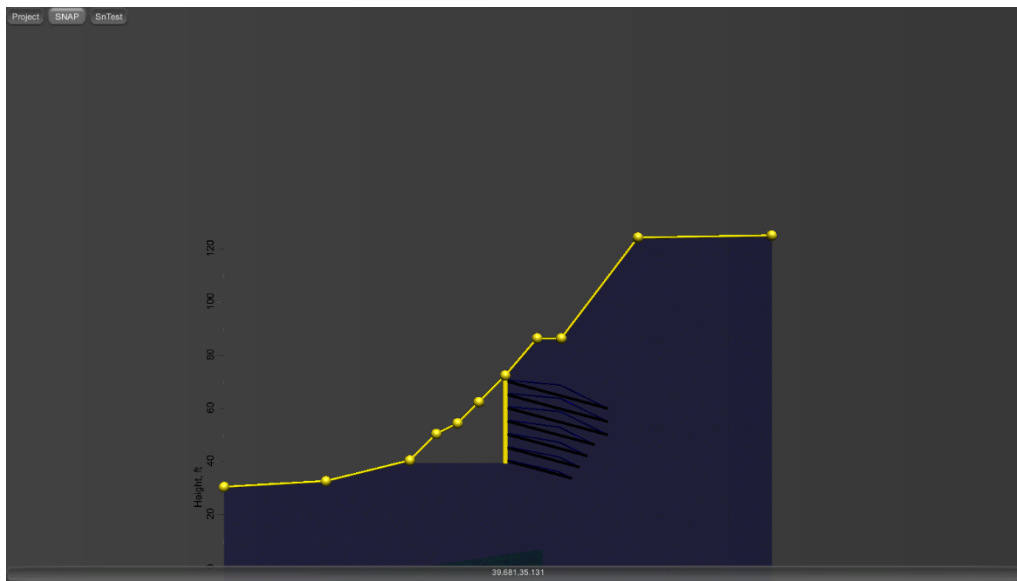
11/15/2018
DATE _____
PROJ. # **EBG**
DESIGN 1 of 21
SHEET _____

SNAP_2 Report_ Soil Nail Wall Analysis

Name	Company	Designer	Reviewer
Boyle Shoring	SSF	EBG	ABB

Name: Name of project.
Company: Name of company
Designer: Name of person performing design.
Reviewer: Name of person performing project review.

Existing Slope



Existing Slope Points

#	X, ft	Y, ft
1	-70.0	30.0
2	-31.6	32.2
3	0.0	40.0
4	10.0	50.0
5	18.0	54.0
6	26.0	62.0
7	36.0	72.0
8	48.0	86.0
9	57.1	86.0

10	86.0	124.0
11	136.4	124.8

X: Horizontal coordinates
Y: Vertical coordinates

Soils Soil Properties

Name	Texture	Color	γ'_s , pcf	ϕ' , °	δ_s , °	c', psf	q_u , psi	N_c	N_q	N_γ
Soil 1	clay	blue	130	33	22	1000.0	16.0	38.6	26.1	35.2

Name: Name of soil
Texture: Soil/rock Type
Color: Soil color
 γ'_s : Effective unit weight of soil
 ϕ' : Effective soil friction angle / angle of internal friction
 δ_s : Wall-soil interface friction angle, $\delta = 2/3\phi$
c': Effective cohesion of soil
 q_u : Ultimate bond strength
 N_c : N_c bearing capacity factor
 N_q : N_q bearing capacity factor
 N_γ : N_γ bearing capacity factor

Nails Default Factors of Safety

U	F_y FoS	F_{ys} FoS	F_p FoS	F_{ps} FoS
true	1.80	1.35	2.00	1.50

U: Use same factors of safety for each bar
 F_y FoS: Factor of safety for yield strength
 F_{ys} FoS: Seismic factor of safety for yield strength
 F_p FoS: Factor of safety for pullout
 F_{ps} FoS: Seismic factor of safety for pullout

Bar Properties

Name	D, in	D_{out} , in	D_{in} , in	Bar No, Bar #	F_y , ksi
Bar 1	6.0	1.102	0.000	9.0	75.0

Name: Name of bar set
D: Drill hole diameter
 D_{out} : Outside diameter of bar
 D_{in} : Inside diameter of bar
Bar No: Nail size 3-18
 F_y : Steel yield strength of bar

Wall types

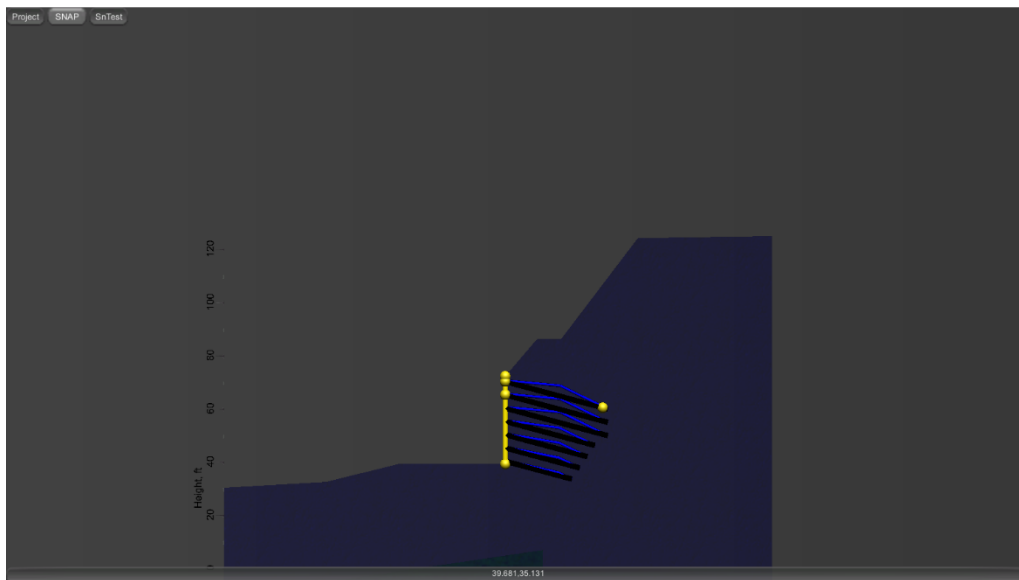
Name	Description
SN Wall 1	Temp Wall

Name: Name of wall
Description: Wall Description

SN Wall 1:

Static Case

Wall: Soil nail wall geometry



Wall: Soil nail wall size and location

Facing	Base, ft	Top, ft	H, ft	θ , °	Emb, ft	Width, ft
Temp SNW 1	36.0,39.0	36.0,72.0	33.0	0.0	0.0	10

Facing: Wall facing

Base: Base of wall

Top: Top of wall

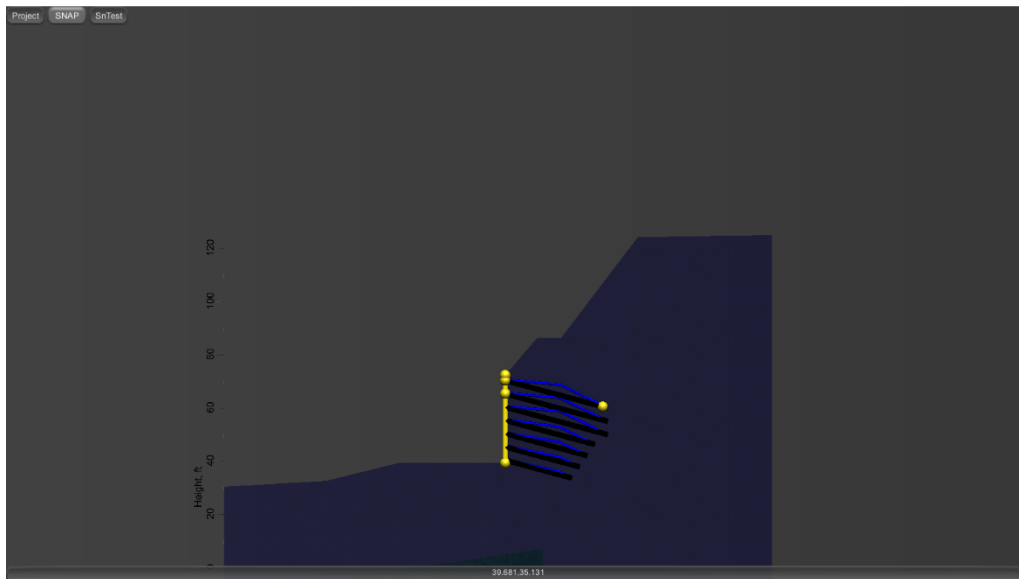
H: Wall height

θ : Wall batter angle, degrees from vertical

Emb: Embedment, depth below ground surface at toe

Width: Width of wall, extending along Z-Axis

Nails: Soil nail wall nail geometry



Shorten T_F

false

Shorten T_F: Shorten T-Forces on lower nails due to deformation during construction

Nails: Soil nail sizes and locations

Nail	L, ft	S _v , ft	S _H , ft	δ, °	C _d , ft	O	U
Bar 1	40.00	5.00	5.00	15.0	2.00	false	false

Nail: Bar used for this nail

L: Nail length

S_v: Vertical nail spacing

S_H: Horizontal nail spacing

δ: Nail inclination, degrees from horizontal

C_d: Cantilever distance, vertical distance from top of wall to top nail

O: Offset pattern, true if nails in even rows are offset to midspan, otherwise nails are in a square pattern

U: Use uniform nails

Nail List: Nail properties

Nail[1]

Head, ft	Tail, ft	Nail	L, ft	δ, °	C _{dH} , ft	Failure	L _{fail} , ft	T _{Force} , kip
36.00,70.00	74.64,59.65	Bar 1	40.00	15.0	2.00	Pullout from Soil 1	36.84	5.7

Head: Start location of nail

Tail: End location of nail

Nail: Bar used for this nail

L: Nail length

δ: Nail inclination, degrees from horizontal

C_{dH}: Cantilever distance, vertical distance from top of wall to this nail

Failure: Failure mode for wall slip surface

L_{fail}: Distance from nail head to failure surface

T_{Force}: Nail T-force

T-Forces: Nail T-forces

#	Dist, ft	T-Force, kip	Soil	Failure
1	0.00	3.2	Soil 1	Punching/Flexure Failure
2	20.40	35.4	Soil 1	Pullout
3	40.00	0.0	Soil 1	Pullout

Dist: Horizontal distance of T-force from nail head

T-Force: Nail T-force

Soil: Soil layer at T-force location

Failure: Failure mode at T-force location

Nail[2]

Head, ft	Tail, ft	Nail	L, ft	δ , °	C _{dH} , ft	Failure	L _{fail} , ft	T _{Force} , kip
36.00,65.00	74.64,54.65	Bar 1	40.00	15.0	7.00	Pullout from Soil 1	31.57	15.2

Head: Start location of nail

Tail: End location of nail

Nail: Bar used for this nail

L: Nail length

δ : Nail inclination, degrees from horizontal

C_{dH}: Cantilever distance, vertical distance from top of wall to this nail

Failure: Failure mode for wall slip surface

L_{fail}: Distance from nail head to failure surface

T_{Force}: Nail T-force

T-Forces: Nail T-forces

#	Dist, ft	T-Force, kip	Soil	Failure
1	0.00	3.2	Soil 1	Punching/Flexure Failure
2	20.40	35.4	Soil 1	Pullout
3	40.00	0.0	Soil 1	Pullout

Dist: Horizontal distance of T-force from nail head

T-Force: Nail T-force

Soil: Soil layer at T-force location

Failure: Failure mode at T-force location

Nail[3]

Head, ft	Tail, ft	Nail	L, ft	δ , °	C _{dH} , ft	Failure	L _{fail} , ft	T _{Force} , kip
36.00,60.00	74.64,49.65	Bar 1	40.00	15.0	12.00	Pullout from Soil 1	25.96	25.4

Head: Start location of nail

Tail: End location of nail

Nail: Bar used for this nail

L: Nail length

δ : Nail inclination, degrees from horizontal

C_{dH}: Cantilever distance, vertical distance from top of wall to this nail

Failure: Failure mode for wall slip surface

L_{fail}: Distance from nail head to failure surface

T_{Force}: Nail T-force

T-Forces: Nail T-forces

#	Dist, ft	T-Force, kip	Soil	Failure
---	----------	--------------	------	---------

1	0.00	3.2	Soil 1	Punching/Flexure Failure
2	20.40	35.4	Soil 1	Pullout
3	40.00	0.0	Soil 1	Pullout

Dist: Horizontal distance of T-force from nail head
T-Force: Nail T-force
Soil: Soil layer at T-force location
Failure: Failure mode at T-force location

Nail[4]

Head, ft	Tail, ft	Nail	L, ft	δ , °	C _{dt} , ft	Failure	L _{fail} , ft	T _{Force} , kip
36.00,55.00	69.81,45.94	Bar 1	35.00	15.0	17.00	Punching/Flexure Failure	19.96	26.1

Head: Start location of nail
Tail: End location of nail
Nail: Bar used for this nail
L: Nail length
 δ : Nail inclination, degrees from horizontal
C_{dt}: Cantilever distance, vertical distance from top of wall to this nail
Failure: Failure mode for wall slip surface
L_{fail}: Distance from nail head to failure surface
T_{Force}: Nail T-force

T-Forces: Nail T-forces

#	Dist, ft	T-Force, kip	Soil	Failure
1	0.00	3.1	Soil 1	Punching/Flexure Failure
2	20.30	26.5	Soil 1	Pullout
3	35.00	0.0	Soil 1	Pullout

Dist: Horizontal distance of T-force from nail head
T-Force: Nail T-force
Soil: Soil layer at T-force location
Failure: Failure mode at T-force location

Nail[5]

Head, ft	Tail, ft	Nail	L, ft	δ , °	C _{dt} , ft	Failure	L _{fail} , ft	T _{Force} , kip
36.00,50.00	66.91,41.72	Bar 1	32.00	15.0	22.00	Punching/Flexure Failure	13.53	14.7

Head: Start location of nail
Tail: End location of nail
Nail: Bar used for this nail
L: Nail length

δ : Nail inclination, degrees from horizontal
 C_{dt} : Cantilever distance, vertical distance from top of wall to this nail
 Failure: Failure mode for wall slip surface
 L_{fail} : Distance from nail head to failure surface
 T_{Force} : Nail T-force

T-Forces: Nail T-forces

#	Dist, ft	T-Force, kip	Soil	Failure
1	0.00	3.1	Soil 1	Punching/Flexure Failure
2	20.48	20.7	Soil 1	Pullout
3	32.00	0.0	Soil 1	Pullout

Dist: Horizontal distance of T-force from nail head
 T-Force: Nail T-force
 Soil: Soil layer at T-force location
 Failure: Failure mode at T-force location

Nail[6]

Head, ft	Tail, ft	Nail	L, ft	δ , °	C_{dt} , ft	Failure	L_{fail} , ft	T_{Force} , kip
36.00,45.00	64.01,37.49	Bar 1	29.00	15.0	27.00	Punching/Flexure Failure	6.60	6.9

Head: Start location of nail
 Tail: End location of nail
 Nail: Bar used for this nail
 L: Nail length
 δ : Nail inclination, degrees from horizontal
 C_{dt} : Cantilever distance, vertical distance from top of wall to this nail
 Failure: Failure mode for wall slip surface
 L_{fail} : Distance from nail head to failure surface
 T_{Force} : Nail T-force

T-Forces: Nail T-forces

#	Dist, ft	T-Force, kip	Soil	Failure
1	0.00	3.0	Soil 1	Punching/Flexure Failure
2	20.59	15.2	Soil 1	Pullout
3	29.00	0.0	Soil 1	Pullout

Dist: Horizontal distance of T-force from nail head
 T-Force: Nail T-force
 Soil: Soil layer at T-force location
 Failure: Failure mode at T-force location

Nail[7]

Head, ft	Tail, ft	Nail	L, ft	δ , °	C _{dt} , ft	Failure	L _{fail} , ft	T _{Force} , kip
36.00,40.00	61.11,33.27	Bar 1	26.00	15.0	32.00	-	0.00	0.0

Head: Start location of nail

Tail: End location of nail

Nail: Bar used for this nail

L: Nail length

δ : Nail inclination, degrees from horizontal

C_{dt}: Cantilever distance, vertical distance from top of wall to this nail

Failure: Failure mode for wall slip surface

L_{fail}: Distance from nail head to failure surface

T_{Force}: Nail T-force

T-Forces: Nail T-forces

#	Dist, ft	T-Force, kip	Soil	Failure
1	0.00	2.9	Soil 1	Punching/Flexure Failure
2	20.54	9.8	Soil 1	Pullout
3	26.00	0.0	Soil 1	Pullout

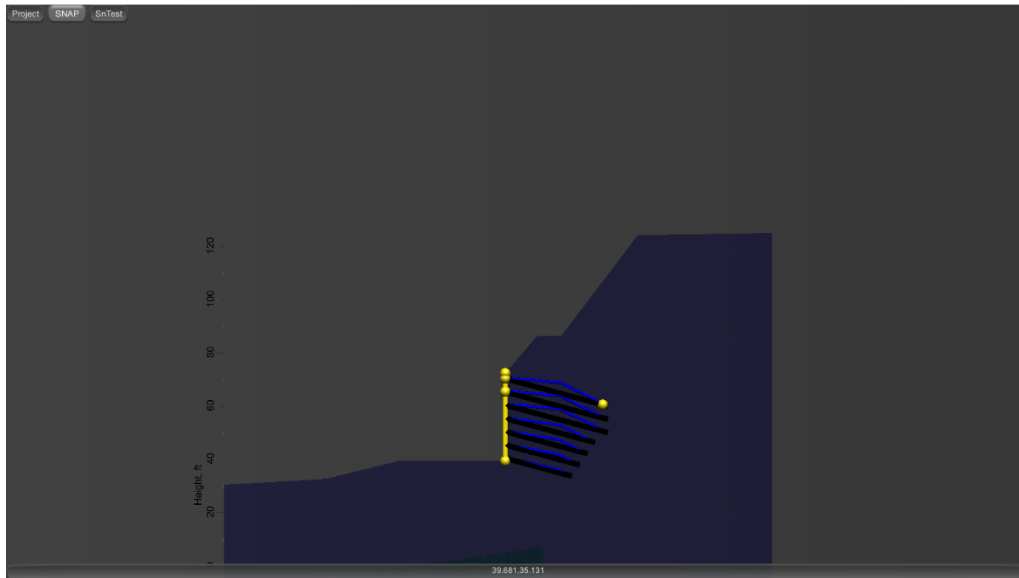
Dist: Horizontal distance of T-force from nail head

T-Force: Nail T-force

Soil: Soil layer at T-force location

Failure: Failure mode at T-force location

Checks: Soil nail wall design checks



Displacement: Long-term wall deformation and displacement parameters

δ_h / H	κ	δ , in	λ , ft
0.003	1.50	1.2	49.5

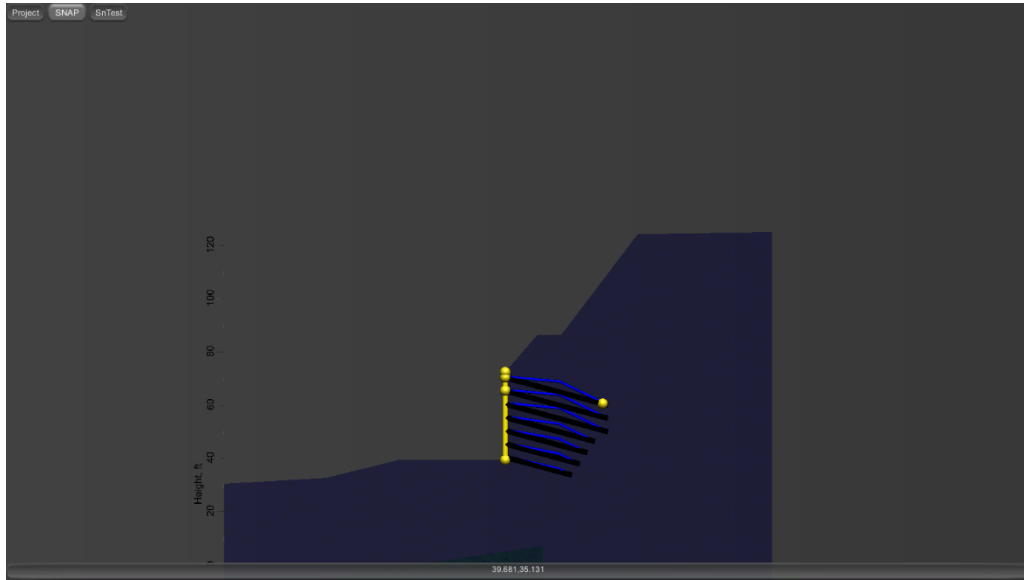
δ_h / H : Displacement ratio: (weathered rock/stiff soil: 0.001) (sandy soil: 0.002) (fine-grained soil: 0.003)

κ : Damping coefficient used to estimate wall displacement: (weathered rock/stiff soil: 0.8) (sandy soil: 1.25) (fine-grained soil: 1.5)

δ : Estimated displacement at the top of soil nail wall, L/H ratio outside 0.7 - 1.0, Estimation may not be accurate

λ : Horizontal distance behind soil nail wall where ground deformation can be significant

Vars: Soil nail internal variables



Ex Vars: External stability intermediate variables

θ , °	β , °	q_s , psf	ϕ , °	ϕ_f , °	γ_1 , pcf	γ_2 , pcf	c , psf	δ , °
0.0	38.4	0	33.0	33.0	130.0	130.0	1000.0	22.0

- θ : Inclination of back wall measured CCW from vertical plane
- β : Inclination of ground slope behind wall measured CCW from horiz. plane
- q_s : Surcharge load behind wall
- ϕ : Internal friction angle of weakest retained soil
- ϕ_f : Internal friction angle of weakest foundation soil
- γ_1 : Unit weight of weakest retained soil
- γ_2 : Unit weight of weakest foundation soil
- c : Cohesion - weakest foundation soil
- δ : Wall/soil interface friction angle

Ex Vars 2: More external stability intermediate variables

B , ft	h , ft	$N\gamma$	N_c	N_q	H_2 , ft	K_a	S , °
33.4	59.4	35.2	38.6	26.1	54.6	0.759	7.116

- B : Effective width of wall at the base
- h : Effective total height of soil at back of reinforced soil mass
- $N\gamma$: See Fig 4.4.7.1.1.4B and Table 4.4.7.1A AASHTO
- N_c : Bearing capacity coefficient - weakest foundation soil
- N_q : Bearing capacity coefficient - weakest foundation soil
- H_2 : A height near the back of wall for calculating PIR and PAE
- K_a : Active earth pressure coefficient - no seismic forces
- S : Angle relating the horizontal and vertical seismic coefficients

Ex Vars 3: More external stability intermediate variables

F_T, lbf/ft	F_H, lbf/ft	F_V, lbf/ft	V₂, lbf/ft	V₁, lbf/ft	F₂, lbf/ft
174206.5	136581.9	108135.5	57386.5	143257.4	0.0

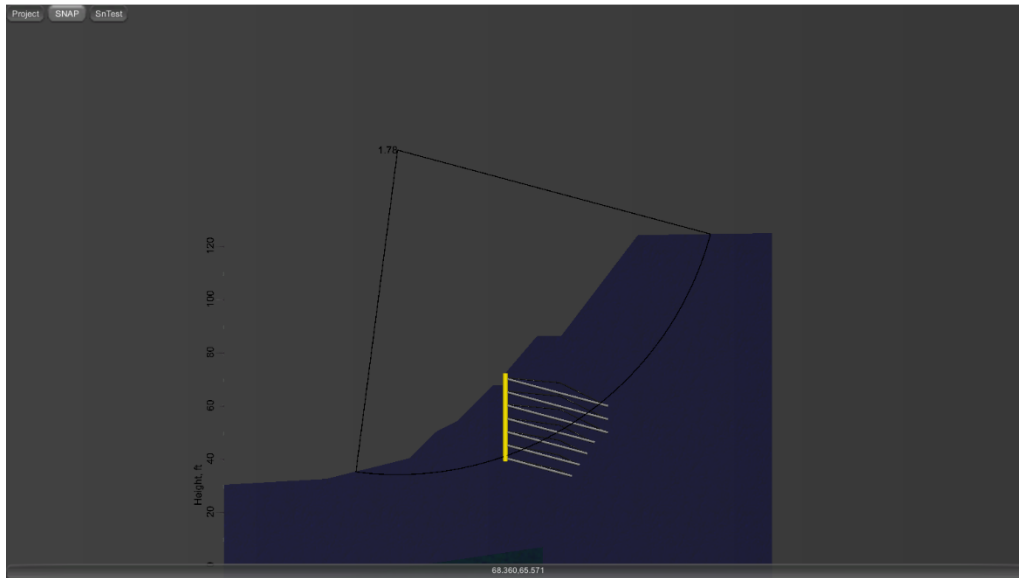
F_T: Lateral earth pressure
F_H: Horizontal lateral earth pressure
F_V: Vertical lateral earth pressure
V₂: Weight of soil above wall
V₁: Weight of soil above wall
F₂: Surcharge load

Ex Vars 4: More external stability intermediate variables

P_{IR}, lbf/ft	Y_{IR}, ft	σ_v, psf	q_{ult}, psf	q_{allow}, psf
42984.9	22.4	10405.6	115015	46006

P_{IR}: Horizontal inertial force
Y_{IR}: Y-coordinate of centroid of mass for inertial force
σ_v: Vertical effective stress at base of footing
q_{ult}: Terzaghi bearing capacity
q_{allow}: Terzaghi bearing capacity q_{allow} = q_{ult}/FOS

Static global stability for construction sequence 1



Construction #	Resolution, ft	MinDepth, ft	Seismics	Center, ft	Radius, ft	FoS
1	2.1	2.0	false	-4.5,156.0	122.0	1.78

Construction #: Construction number, adds stage cuts and nails according to assigned construction sequences

Resolution: Resolution for Bishop Method (smaller values require longer computation time)

MinDepth: Minimum height of failure circle arc. Use this to remove small failure circles.

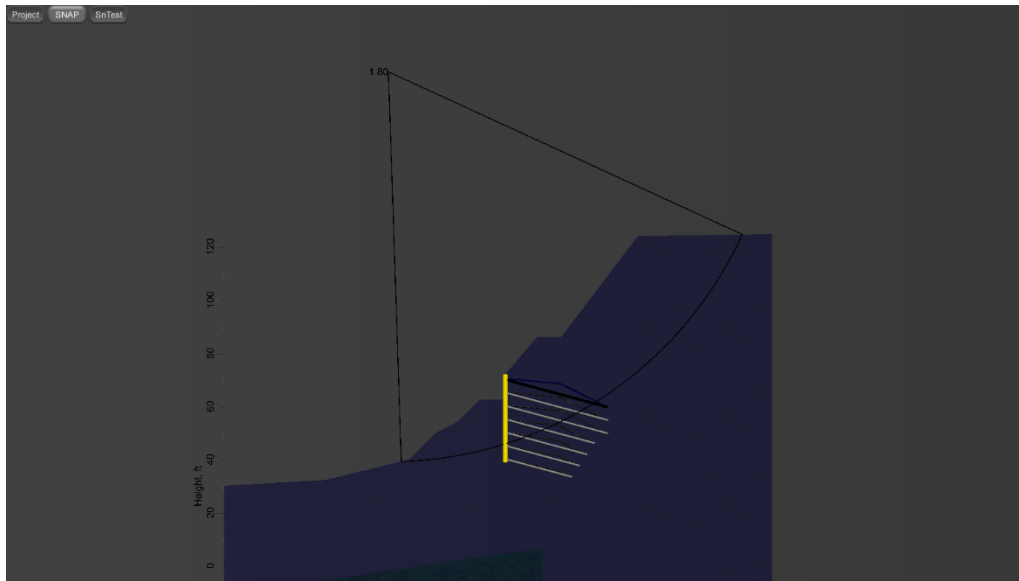
Seismics: Select to use seismic case, unselect for static case

Center: Center of minimum factor of safety failure circle

Radius: Radius of minimum factor of safety failure circle

FoS: Minimum factor of safety

Static global stability for construction sequence 2



Construction #	Resolution, ft	MinDepth, ft	Seismics	Center, ft	Radius, ft	FoS
2	2.1	2.0	false	-8.0,185.8	146.7	1.80

Construction #: Construction number, adds stage cuts and nails according to assigned construction sequences

Resolution: Resolution for Bishop Method (smaller values require longer computation time)

MinDepth: Minimum height of failure circle arc. Use this to remove small failure circles.

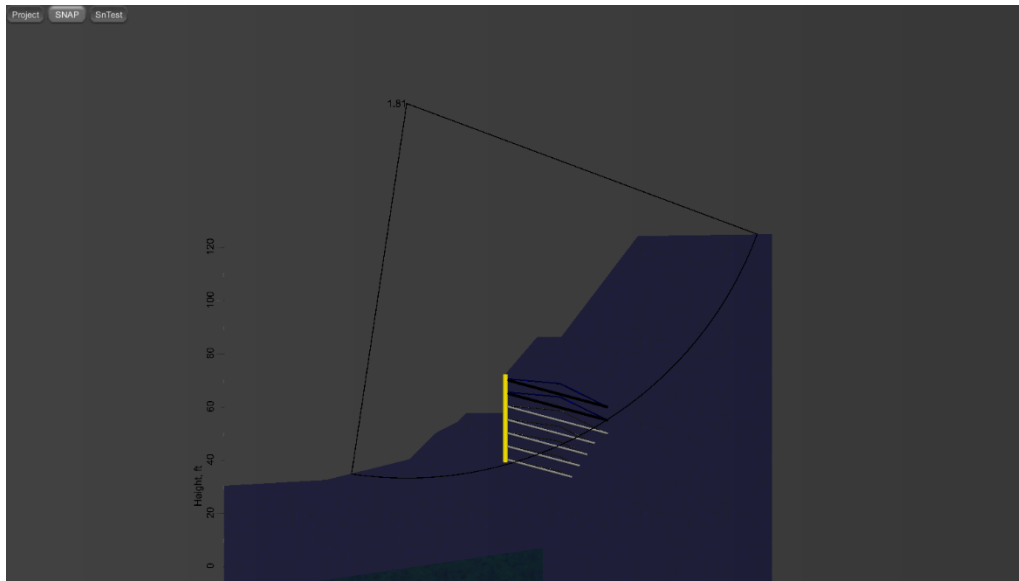
Seismics: Select to use seismic case, unselect for static case

Center: Center of minimum factor of safety failure circle

Radius: Radius of minimum factor of safety failure circle

FoS: Minimum factor of safety

Static global stability for construction sequence 3



Construction #	Resolution, ft	MinDepth, ft	Seismics	Center, ft	Radius, ft	FoS
3	2.1	2.0	false	-1.1,173.9	140.9	1.81

Construction #: Construction number, adds stage cuts and nails according to assigned construction sequences

Resolution: Resolution for Bishop Method (smaller values require longer computation time)

MinDepth: Minimum height of failure circle arc. Use this to remove small failure circles.

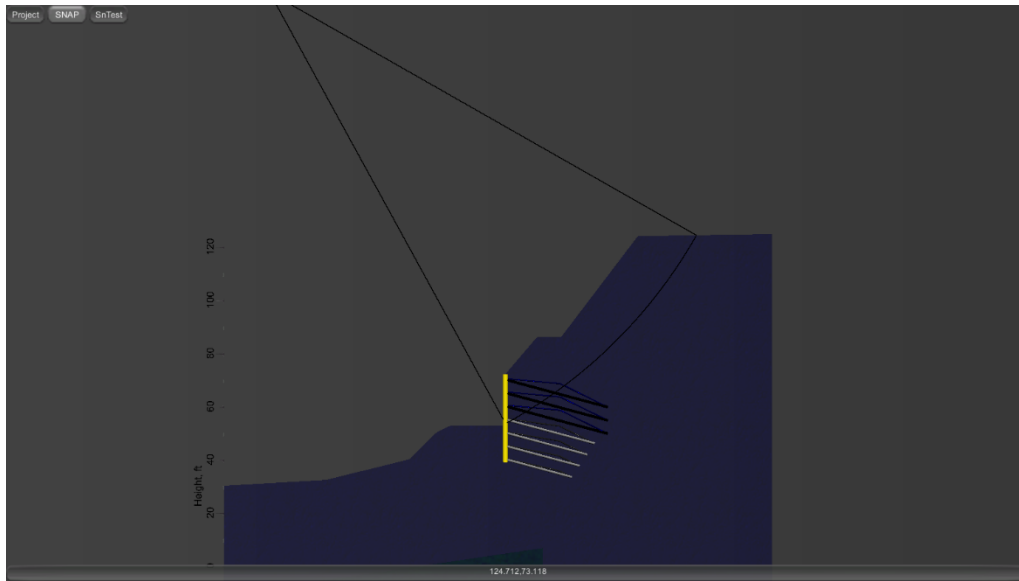
Seismics: Select to use seismic case, unselect for static case

Center: Center of minimum factor of safety failure circle

Radius: Radius of minimum factor of safety failure circle

FoS: Minimum factor of safety

Static global stability for construction sequence 4



Construction #	Resolution, ft	MinDepth, ft	Seismics	Center, ft	Radius, ft	FoS
4	2.1	2.0	false	-52.8,215.6	184.9	1.74

Construction #: Construction number, adds stage cuts and nails according to assigned construction sequences

Resolution: Resolution for Bishop Method (smaller values require longer computation time)

MinDepth: Minimum height of failure circle arc. Use this to remove small failure circles.

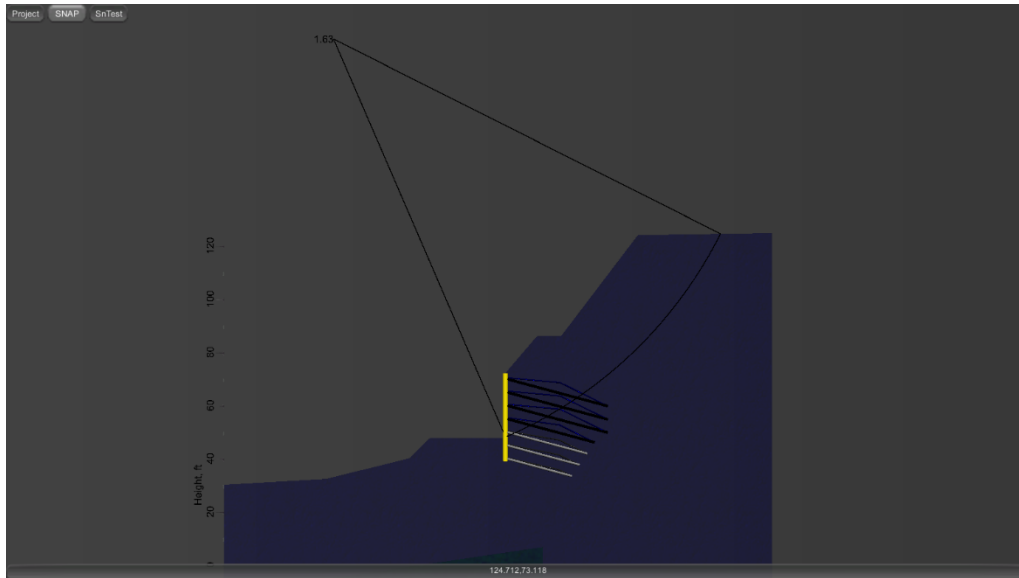
Seismics: Select to use seismic case, unselect for static case

Center: Center of minimum factor of safety failure circle

Radius: Radius of minimum factor of safety failure circle

FoS: Minimum factor of safety

Static global stability for construction sequence 5



Construction #	Resolution, ft	MinDepth, ft	Seismics	Center, ft	Radius, ft	FoS
5	2.1	2.0	false	-28.7,197.7	163.1	1.63

Construction #: Construction number, adds stage cuts and nails according to assigned construction sequences

Resolution: Resolution for Bishop Method (smaller values require longer computation time)

MinDepth: Minimum height of failure circle arc. Use this to remove small failure circles.

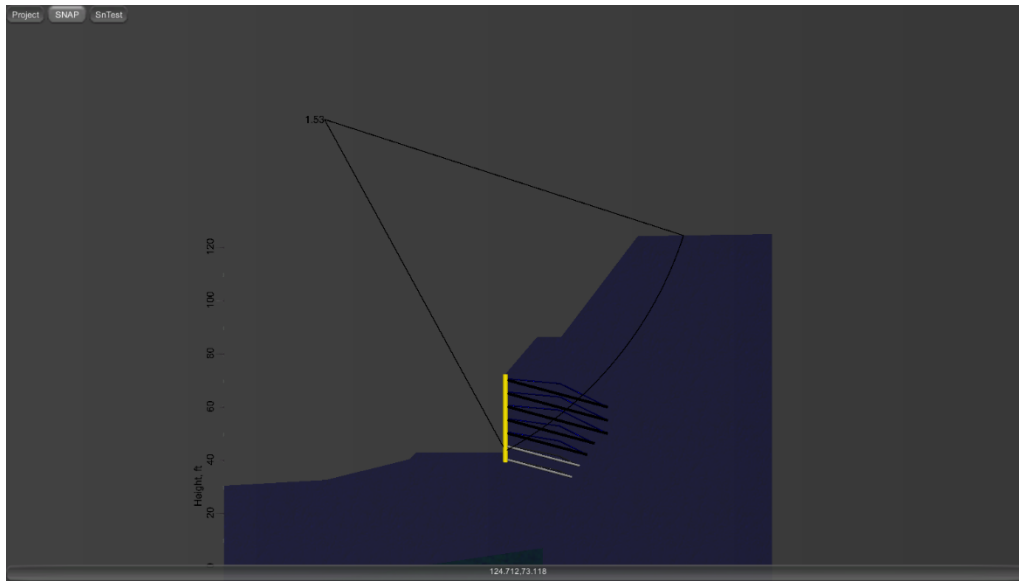
Seismics: Select to use seismic case, unselect for static case

Center: Center of minimum factor of safety failure circle

Radius: Radius of minimum factor of safety failure circle

FoS: Minimum factor of safety

Static global stability for construction sequence 6



Construction #	Resolution, ft	MinDepth, ft	Seismics	Center, ft	Radius, ft	FoS
6	2.1	2.0	false	-32.1,167.9	142.2	1.53

Construction #: Construction number, adds stage cuts and nails according to assigned construction sequences

Resolution: Resolution for Bishop Method (smaller values require longer computation time)

MinDepth: Minimum height of failure circle arc. Use this to remove small failure circles.

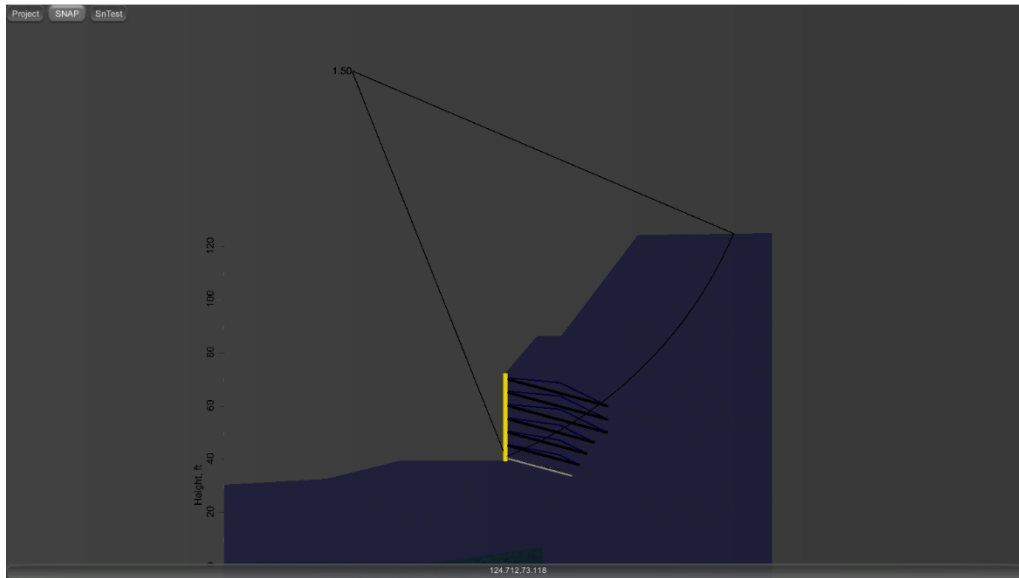
Seismics: Select to use seismic case, unselect for static case

Center: Center of minimum factor of safety failure circle

Radius: Radius of minimum factor of safety failure circle

FoS: Minimum factor of safety

Static global stability for construction sequence 7



Construction #	Resolution, ft	MinDepth, ft	Seismics	Center, ft	Radius, ft	FoS
7	2.1	2.0	false	-21.8,185.8	156.3	1.50

Construction #: Construction number, adds stage cuts and nails according to assigned construction sequences

Resolution: Resolution for Bishop Method (smaller values require longer computation time)

MinDepth: Minimum height of failure circle arc. Use this to remove small failure circles.

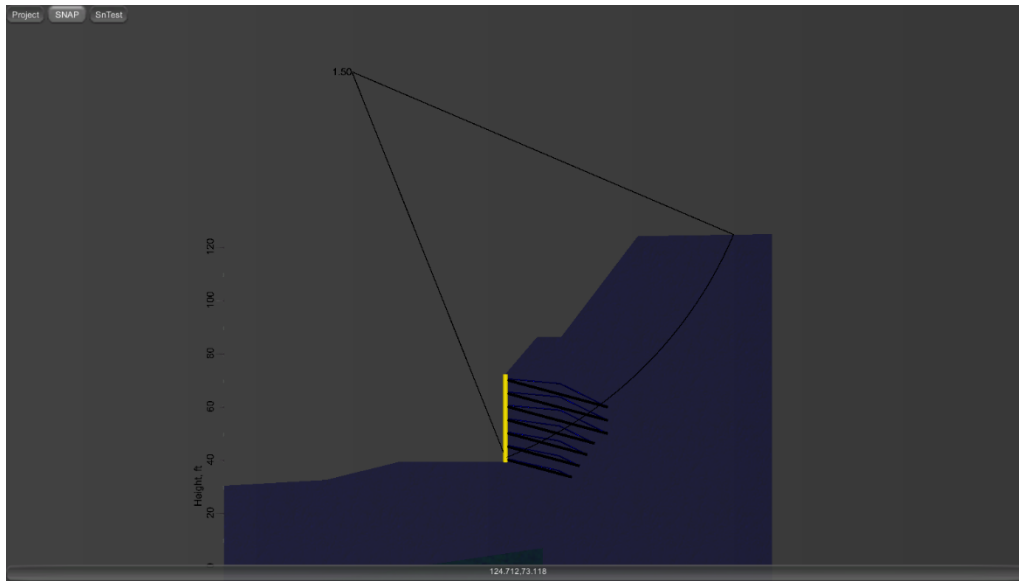
Seismics: Select to use seismic case, unselect for static case

Center: Center of minimum factor of safety failure circle

Radius: Radius of minimum factor of safety failure circle

FoS: Minimum factor of safety

Static global stability for construction sequence 8



Construction #	Resolution, ft	MinDepth, ft	Seismics	Center, ft	Radius, ft	FoS
8	2.1	2.0	false	-21.8,185.8	156.3	1.50

Construction #: Construction number, adds stage cuts and nails according to assigned construction sequences

Resolution: Resolution for Bishop Method (smaller values require longer computation time)

MinDepth: Minimum height of failure circle arc. Use this to remove small failure circles.

Seismics: Select to use seismic case, unselect for static case

Center: Center of minimum factor of safety failure circle

Radius: Radius of minimum factor of safety failure circle

FoS: Minimum factor of safety