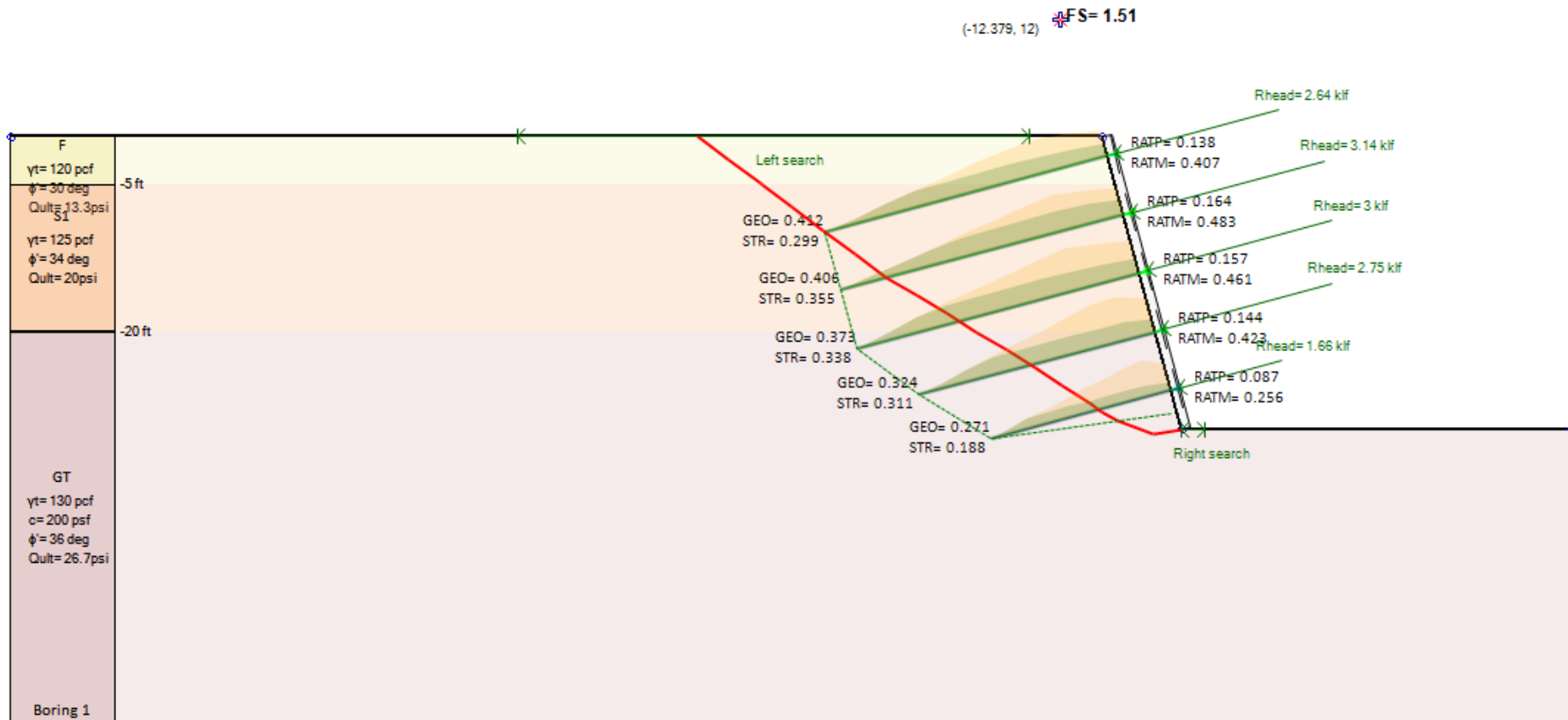
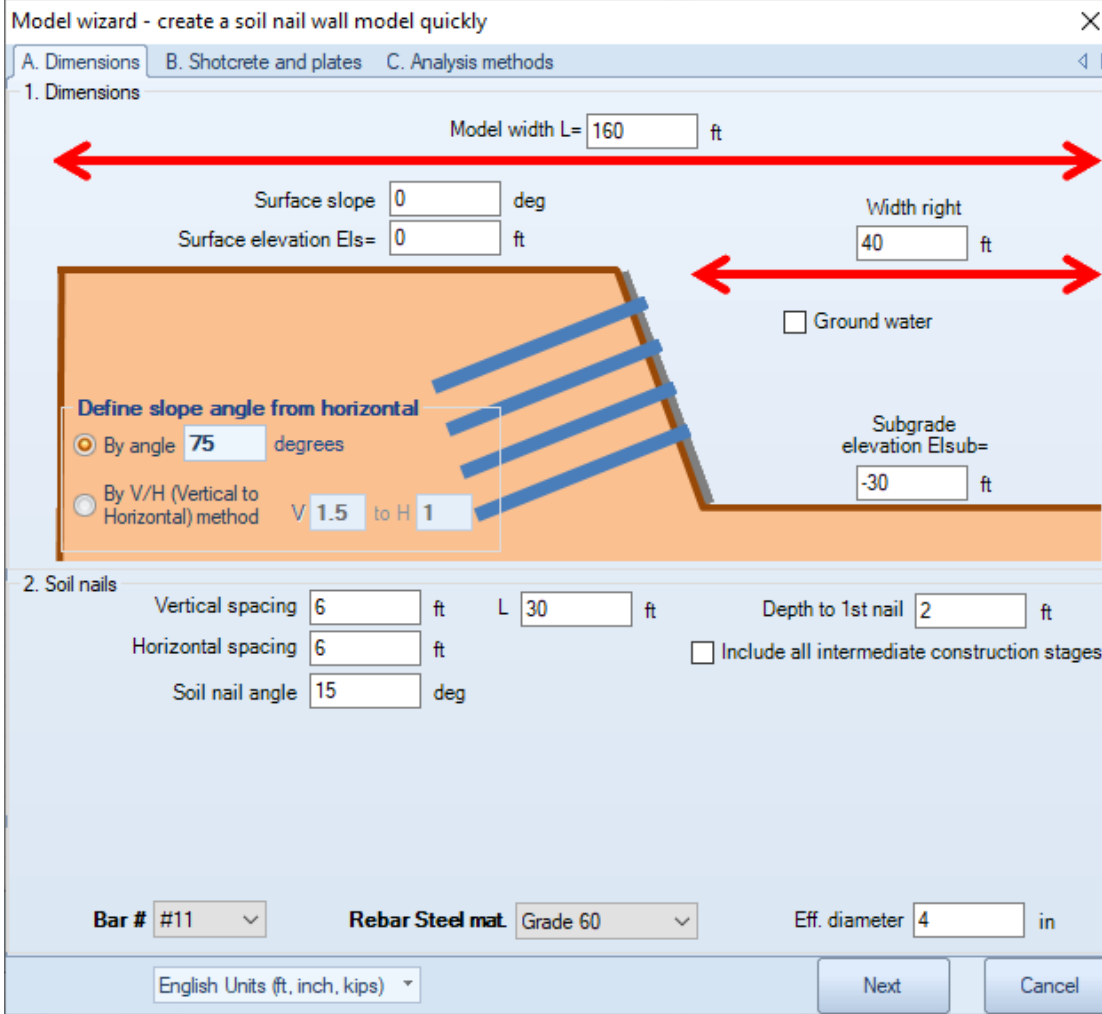


## Example 2: Slope Stability FS for Different Stage Conditions Global Stability Safety Factors Comparison



## A1. Model Wizard - Project Geometry & Soil Nails Layout



**Model wizard - create a soil nail wall model quickly**

A. Dimensions    B. Shotcrete and plates    C. Analysis methods

1. Dimensions

Model width L= 160 ft

Surface slope 0 deg

Surface elevation Els= 0 ft

Width right 40 ft

Ground water

Subgrade elevation Elsub= -30 ft

Define slope angle from horizontal

By angle 75 degrees

By V/H (Vertical to Horizontal) method V 1.5 to H 1

2. Soil nails

Vertical spacing 6 ft    L 30 ft    Depth to 1st nail 2 ft

Horizontal spacing 6 ft     Include all intermediate construction stages

Soil nail angle 15 deg

Bar # #11    Rebar Steel mat Grade 60    Eff. diameter 4 in

English Units (ft, inch, kips)    Next    Cancel

### Geometry:

- 30ft Excavation
- 160ft Model Width
- 40ft Distance from the Base of the Wall to the right
- 75deg Slope Angle from Horizontal

### Soil Nails Layout:

- 6ft Vertical Spacing
- 6ft Horizontal Spacing
- 30ft Fixed Length for the Soil Nails
- 15deg Inclined from Horizontal
- Do not include all Construction Stages

### Soil Nails Section:

- #11 Rebar Steel
- Grade 60 Steel Material
- 4inches Hole Diameter

## A2. Model Wizard - Shotcrete Facing & Head Plate Sections

Model wizard - create a soil nail wall model quickly

A. Dimensions | **B. Shotcrete and plates** | C. Analysis methods

Shotcrete properties

Select from available sections: Slab 0

Define new shotcrete section  
 Use two stage facing (temporary and permanent)  Use only one layer of mesh reinforcement

Final facing thickness D: 12 in      Concrete: 3 ksi Concrete

Top bars #: #6 >      Clear. Ctop: 2 in      Rebar: Grade 60

Bottom bars #: #6 >      Clear. Cbot: 3 in

Mesh spacing Sv: 8 in      Mesh spacing Sh: 8 in  
 Horizontal Bottom bars #: #6

Plate data

Select head plate: PL8x8x1.25

Use plate studs      #3/Diam. = 0.375in      Stud length: 6 in      [Reset default bolt sizes]

Use waler bars      #4

Pressures on facing

Pressure on facing as ratio active: 0.75 (Ranges from 0.5 to 1.0 of active (standard 0.75))

English Units (ft, inch, kips)      [Next]      [Cancel]

### Shotcrete Facing Section:

- Permanent Facing with 2 Rows of Rebars
- 12in Thick Facing
- #6 Bars @ 8in Spacing Horizontal & Vertical
- 3 ksi Concrete, Grade 60 Rebar Steel Materials

### Head Plate Section:

- Plate 8in x 8in x 1.25in
- 6in Long #3 Rebar Studs
- #4 Waler Rebars

## A3. Model Wizard - Analysis Methods & Codes

Model wizard - create a soil nail wall model quickly

A. Dimensions   B. Shotcrete and plates   C. Analysis methods

A. Select critical slip surface search method

Circular failure search    Automatic search    Tri-linear search

Correct safety factor when excess unbalanced forces are calculated from soil nails (see theory manual)

Use available shear method for nails

B. Please select design method

FHWA ASD - Allowable Stress Method (GEC7)

C. Shotcrete facings: Please select design method

ACI direct method and FHWA ASD Equations for Rff

Use working stress method (at nail heads)

D. Please select if this wall is temporary or permanent

Permanent wall

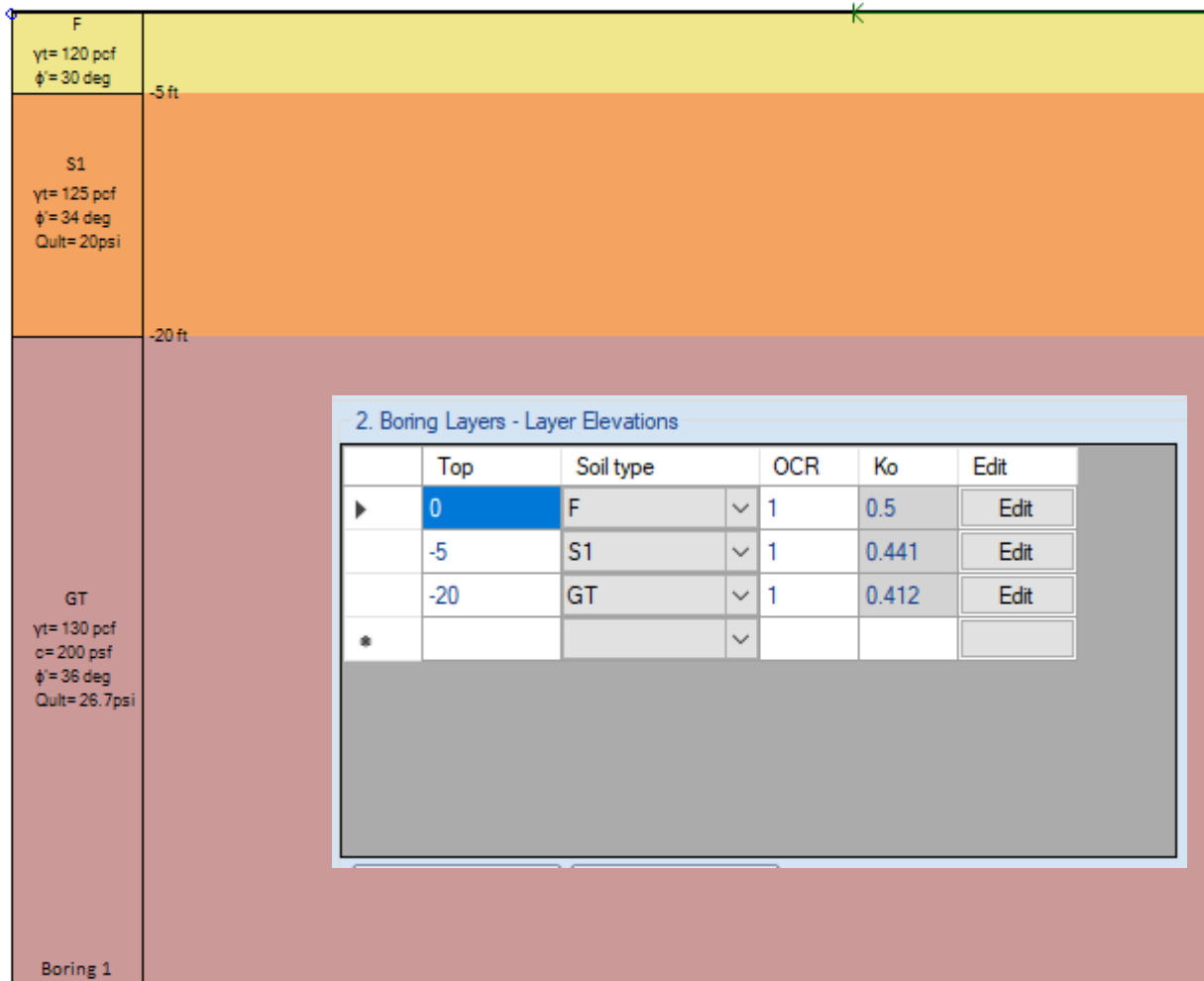
English Units (ft, inch, kips)   Ok   Cancel

← Initial Slope Surface Search Method:  
- Automatic Search Approach

← Geotechnical Design Method:  
- FHWA Allowable Stress Method (GEC 7)

← Structural Design Codes:  
- ACI direct Method for the Shotcrete Facing  
- FHWA Allowable Stress Design Equations for Steel Members

## B. Soil Properties and Stratigraphy (Soil Layers)



Elev. (ft)	Soil (-)	$\gamma_t$ (pcf)	C' or Su (psf)	$\phi'$ (deg)
0	F - Sand	120	0	30
-5	S1 - Sand	125	0	34
-20	GT - Till	130	200	36

A. General | B. Elasto-plastic | Lateral | E. Adv.

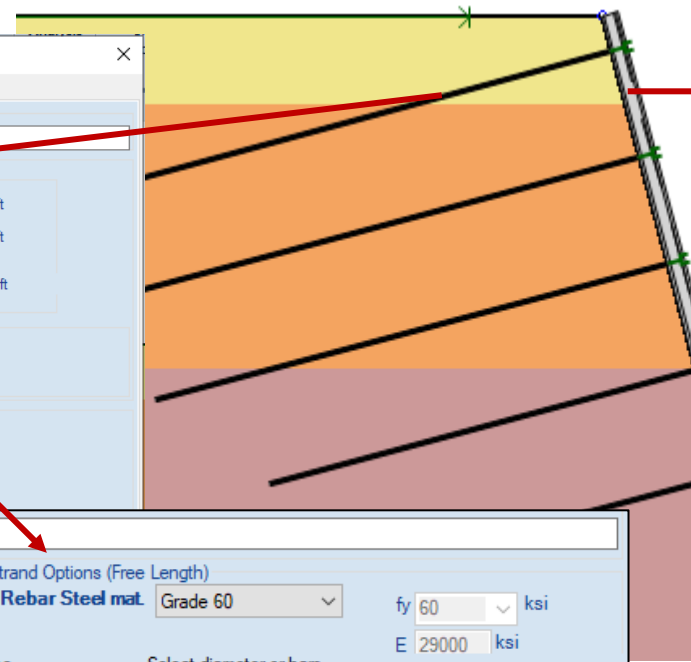
4. Unit Weights - Density  
 $\gamma_t$  120 pcf  $\gamma_{dry}$  120 pcf  $\gamma_s = 57.6$

5. Strength Parameters and Poisson Ratio  
 Drained strength properties  
 $c'$  0 psf  $\phi'$  30 degrees  
 $\nu$  0.35

5. At-rest coefficients  
 $KoNC$  0.5  $nOCR$  0.5  
 $Ko = KoNC * (OCR)^{nOCR}$

6. Ultimate bond (grouted piles when bond option is selected)  
 $q_{skin,u}$  20 psi

## C. Structural Sections - Manual Review/Input



**Edit soil nail**

A. General B. Results C. Detailed results C. Envelope

1. Name  
N0

1. Dimensions

1.1 Start coordinates  
X: -7.502577388 ft  
Z: -2 ft

1.2 Angles  
 $\alpha$ : 15 deg

1.3 Lengths  
Lfree: 0 ft  
Lfix: 30 ft  
Horizontal Spacing: 6 ft

1.4 Head Plates  
Plate Section: PL8x1.25  
Cover plate angle: 105 deg

2. Support Type and Structural Section Used  
Structural Section: N1

3. Activate/Deactivate Support - Permanent or Temporary  
 Activate support for this stage

4. Apply settings to Stages  
 This Stage Only

**N1**

2. Strand Options (Free Length)  
Rebar Steel mat: Grade 60  
fy: 60 ksi  
E: 29000 ksi

Type: Select diameter or bars

Strands or user bars

Solid Bar  
Or Bar #: #11 No. 1  
Total net area A: 1.56 in<sup>2</sup>

User area

3. Grout Options (Fixed Body)  
Concrete mat: 5 ksi Concrete  
D<sub>fix</sub> = a x D<sub>perf</sub>: D<sub>fix</sub> 4 in

**Facing for soil nails (shotcrete or other)**

A. Data B. Results C. Results for this stage D. Advanced

1. Name  
Soil nail facing

2. Facing type  
Shotcrete (uses concrete slab sections)

3. Slab section used for facing  
Slab 0

4. Activate/Deactivate  
 Activate facing for this stage

5. Edit facing points

6. Options for staged excavation  
 Enable activation of individual stages

Diagram: 12in, 3in, 2in, #6

**Slab 0**

2. Structural Materials  
Concrete: 3 ksi Concrete f<sub>ck</sub>: 3 ksi  
E: 3122.02 ksi  
Rebar: Grade 60 f<sub>yk</sub>: 60 ksi

3. Section Dimensions  
D: 12 in B: 12 in

4. Longitudinal Slab Reinforcement  
Vert. Front bars #: #6 C<sub>top</sub>: 2 in Space H: 8 in  
Hor. Front bars #: #6 Space V: 8 in  
Vert. Base bars #: #6 C<sub>bot</sub>: 3 in Space H: 8 in  
Hor. Base bars #: #6 Space V: 8 in

Diagram: Top, Bottom, C<sub>top</sub>, C<sub>bot</sub>, D, B, x

## D1. Temporary Conditions (48 Hours) - Input

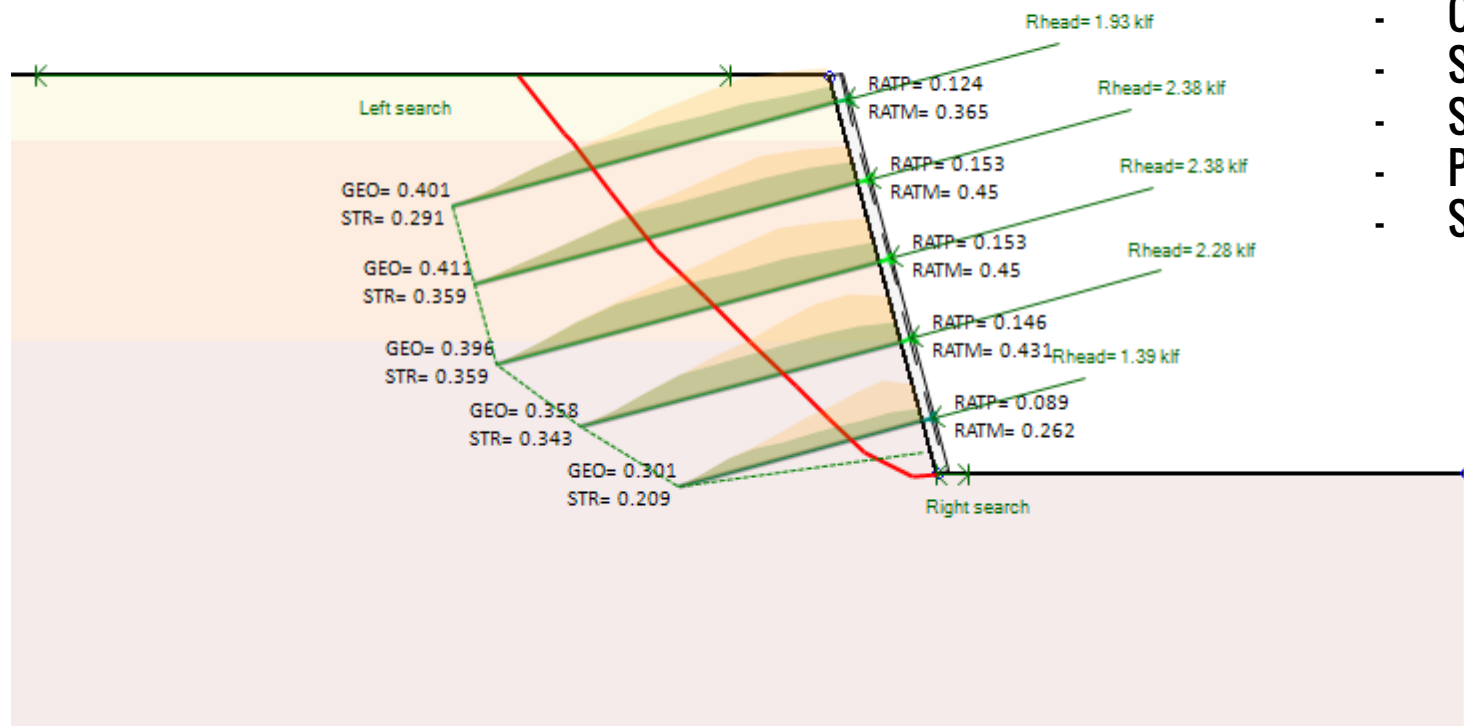
Stage conditions	Short term 48hrs
Min required FS	1.3
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Automatic
Left limits	-68.038ft to -15.538ft
Right limits	0ft to 2.5ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FSO	1
MP interslice factor 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	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Select temporary conditions (48 hours)  
Review the minimum required FS and the partial factors for the selected conditions

## D2. Temporary Conditions (48 Hours) - Slope Stability FS

Morgenstern-Price, FS<sub>suggested.min</sub> = 1.3  
 Automatic search (Left exit pt: -31.546ft, 0ft)  
 (Right exit pt: 0ft, -30ft)

(-7.886, 12) **FS = 1.602**



### Presented Results:

- Critical Slope Surface
- Slope Stability FS (GLE Method)
- Soil Nail Head Reactions
- Plate Punching & Moment Check Ratios
- Soil Nail Structural & Geotechnical Check Ratios



## E1. Permanent Conditions - Input

The screenshot shows the 'Analysis method' dropdown menu with the following options:

- BP Bishop
- GLE MLP General limit equilibrium (Moment-force)
- Spencer Spencer
- Seismic Options
  - Edit seismic options
- Stage conditions (select one)
  - Typical slope conditions (general FS)
  - Temporary excavation 48 hrs (soil nail walls)
  - Temporary structure (long term)
  - Permanent structure (long term)
  - Extreme event - Seismic
  - Extreme event - High water
  - Temporary excavation non-critical (48hrs)
- Advanced
  - Store intermediate failure surfaces
  - Bond resistance obtained from tests
  - Minimum active pressure options

The table on the right lists the following stage conditions:

Stage conditions	Permanent structure long term
Min required FS	1.5
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Automatic
Left limits	-68.038ft to -15.538ft
Right limits	0ft to 2.5ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	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

Select Permanent Structure conditions (long term)  
Review the minimum required FS and the partial factors for the selected conditions

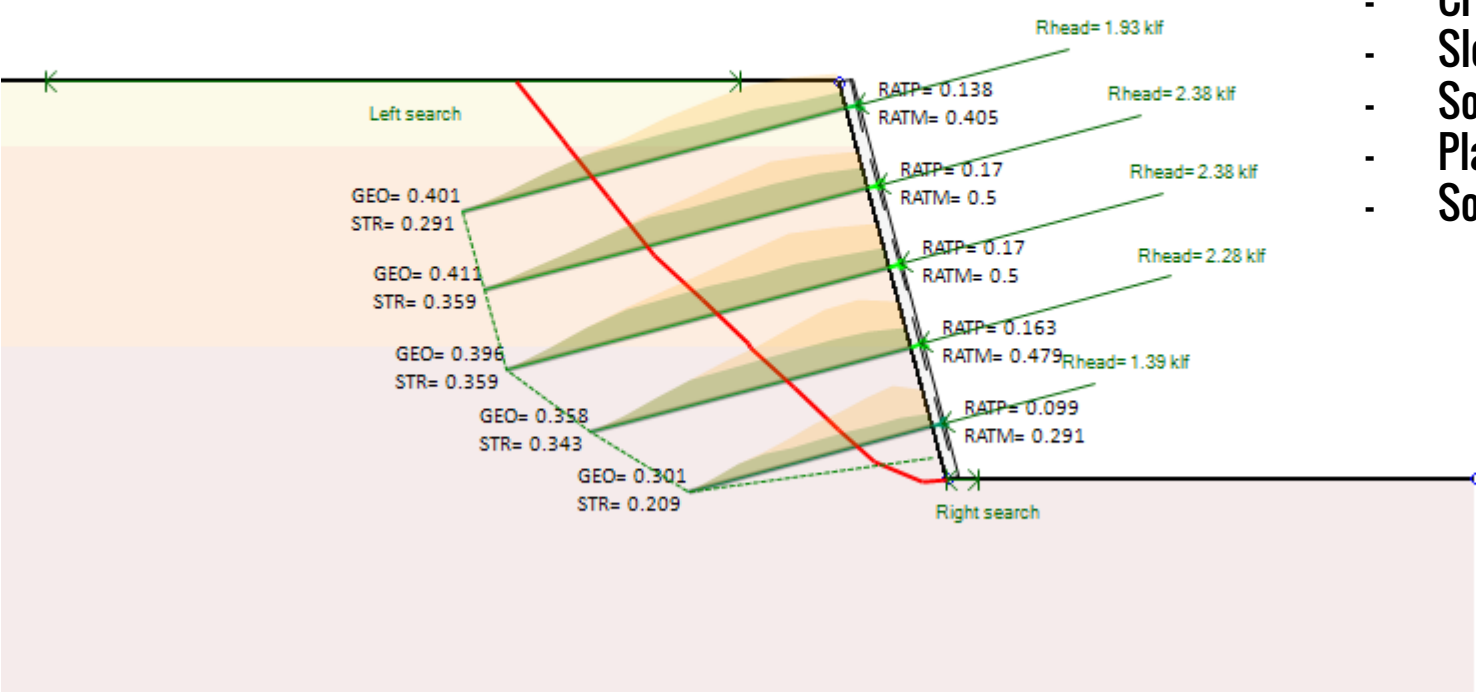
## E2. Permanent Conditions - Slope Stability FS

Morgenstern-Price, FSsuggested.min = 1.5  
 Automatic search(Left exit pt: -32.452ft, 0ft)  
 (Right exit pt: 0ft, -30ft)

(-8.113, 12) **FS= 1.598**

### Presented Results:

- Critical Slope Surface
- Slope Stability FS (GLE Method)
- Soil Nail Head Reactions
- Plate Punching & Moment Check Ratios
- Soil Nail Structural & Geotechnical Check Ratios



## F1. Extreme Conditions (Seismic) - Input

The screenshot shows the 'Analysis method' dropdown menu with 'Extreme event - Seismic' selected. The 'Seismic Effects for Both Walls' dialog box is open, showing the following settings:

- 1. Design Accelerations:**
  - Include seismic effects in this stage
  - AxDesign = 0.1, AzDesign = 0 g
- 2. Base Acceleration and site effects:**
  - 2.a Building Code Options: Building Code = None, Soil Type Class = None
  - 2.b Base Acceleration and Site Effects: Base Acceleration = 0 g, Site Soil Response Factor Ss = 1, Topographic Site Response St = 1, Importance Factor I = 1
- 3. Wall Behavior and Response R factor:**
  - 3.a Basic Wall Behavior:  Flexible
  - 3.b Flexible Wall Behavior - R calculations:  R= User,  R according to Richards Elms,  R according to Building Code,  R according to Liao Whitman
  - 3.c Specific R method options: 3.c.1: R value (Structure Response) = 1
- 4. Seismic Thrust Options:**
  - Seismic pressures added as external pressures
  - Semigid (qEQ = aDesign x B x Sv\_total), B = 0.75
  - Mononobe-Okabe (Only frictional soils, a = aDesign)
  - Trapezoidal distribution:  User defined distribution,  User specified external pressures
- 5. Water Behavior:**
  - Pervious,  Impervious,  Automatic (EC8 Limits)
  - Use actual water pressures for Hydrodynamic effects
- 6. Height Options:**
  - Calculate thrust to excavation subgrade,  Calculate thrust to bottom of wall.
- 8. Apply General Settings:**
  - Apply settings to all stages (except use of seismic)

Stage conditions	Extreme event, flood or seismic
Min required FS	1.1
Method	Morgenstern-Price
Nail methods	Available shear
Earthquake	ax= 0.1g, az= 0g
Seismic pressures	Mononobe-Okabe
Surface search	Automatic
Left limits	-68.038ft to -15.538ft
Right limits	0ft to 2.5ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lambda,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	1.1
FS on facing punching	1.1
FS on bolts	1.3
FS on bearing	2.3

Select Extreme Event conditions (seismic)

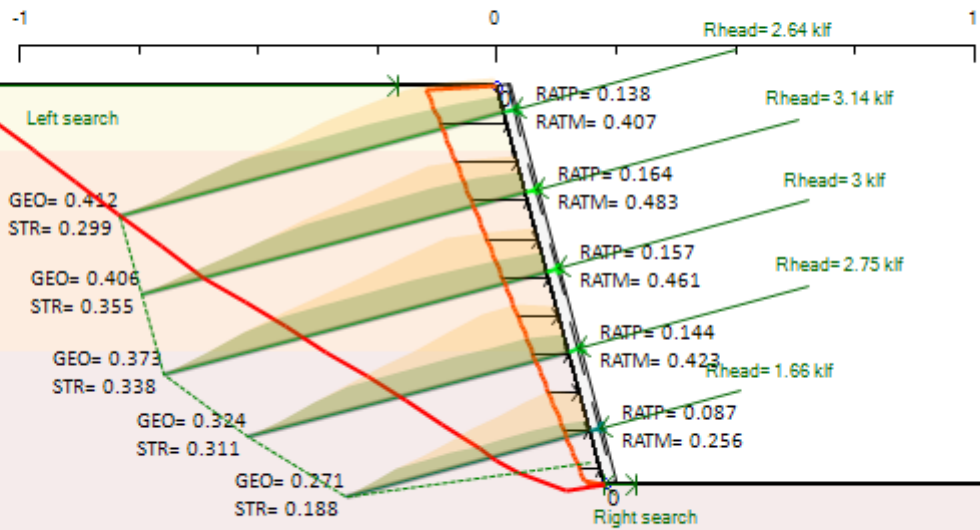
Edit Seismic Options: Define the earthquake acceleration & the seismic pressures method

## F2. Extreme Conditions (Seismic) - Slope Stability FS

Morgenstern-Price, FSsuggested.min = 1.1  
 Automatic search(Left exit pt: -49.517ft, 0ft)  
 (Right exit pt: 0ft, -30ft)

(-12.379, 12) **FS= 1.51**

Pressures (ksf)



### Presented Results:

- Critical Slope Surface
- Slope Stability FS (GLE Method)
- Seismic Pressures Diagram
- Soil Nail Head Reactions
- Plate Punching & Moment Check Ratios
- Soil Nail Structural & Geotechnical Check Ratios

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