Overall Stability Modeling of Earth Retaining Systems (ERS)

The Geoprofessional (GP) is responsible for the overall stability of ERS. Evaluation of the overall stability must be performed using limit equilibrium methods of analysis according to AASHTO LRFD BDS/CA Amendment 8th edition (Section 11.6.2.3). Overall stability requirements are presented in the AASHTO/CA Amendments and ERS modules, but the design/analysis guidance is not well defined or provided in the references, especially for ERS using pile and/or reinforcing elements as a part of the wall.

Overall stability evaluation consists of two components:

- Global stability evaluation, where the critical failure plane does not intersect the wall/foundation/reinforcement elements and is outside the entire wall system.
- Compound stability evaluation, where the critical failure plane intersects the wall/foundation/reinforcement elements.

This module provides guidelines on the overall stability analysis of ERS, including the general modeling approach, and presents step-by-step analysis procedures using examples.

The following ERS are addressed in this module via examples:

- Conventional retaining wall - semi-gravity cantilever retaining wall with and without piles.
- Non-gravity cantilever retaining wall - soldier pile and lagging wall.
- Ground anchored ERS - soldier pile and lagging wall with ground anchors.
- Mechanically stabilized embankment (MSE)
- Soil nail wall

General Guidance for Overall Stability Analysis

Global Stability Analysis

For global stability analysis, ERS including the reinforced zone can be modeled as a soil block with a height equal to a maximum representative height and a width to cover the entire wall footprint. An unrealistically high cohesion value should be assigned to the soil block to drive the critical failure surface outside the block. When pile elements are used to support walls, they can be modeled as rigid elements with an unrealistically high shear strength to drive the critical failure surface outside the ERS. Perform global stability analysis before compound stability analysis.

Compound Stability Analysis

If ERS with pile and/or reinforcing elements are constructed on or near a descending slope ground, perform compound stability evaluation, especially for slopes steeper than 3:1 (H:V) consisting of very soft, soft, or loose soil. If ERS is constructed on level ground, and meet global stability requirements, compound stability analysis is not required.

Slope Stability Software and Calculation Options

Use any slope stability software that provides calculation methods satisfying both force and moment equilibriums. For the analysis examples and parameter study shown in this module, the slope stability analysis program, Rocscience Slide2 (November 2022) was used with Morgenstern-Price and/or Spencer methods.

Active versus Passive Force Application Option for Reinforcement Elements

Slope stability software may provide either active or passive force application options to model reinforcement elements in the analysis. The options are related to how a factor of safety (FoS) for geotechnical stability is applied to the reinforcement element force (*T*). The general equations for active and passive support options are presented as follows:

Active Support Option:

$$FoS = \frac{Resistance\ Force}{Driving\ Force - T}$$

After rearranged,

$$Driving\ Force = \frac{Resistance\ Force}{FoS} + T$$

Passive Support Option:

$$FoS = \frac{Resistance\ Force + T}{Driving\ Force}$$

After rearranged,

$$Driving\ Force = \frac{Resistance\ Force}{FoS} + \frac{T}{FoS}$$

As seen from the rearranged equations above, the passive option further reduces reinforcement resistance with FoS while the active option doesn’t. In other words, T as an entered input in the passive option can be considered the ultimate value as FoS is internally applied during the calculation process while T in the active option can be considered the allowable value (ultimate divided by FoS) if additional resistance factors are not entered. Therefore, caution should be taken during the input process to appropriately model the reinforcement element force.

The passive option is valid to model geosynthetic reinforcements with long-term design strength that will undergo equal to or greater displacement than soil. However, when different FoS are intended to apply to long-term design reinforcement resistance to consider the different levels of uncertainty and/or stiffer reinforcement than soils such as steel reinforcements are used, the active option is more effective and easier to apply. Therefore, the active option is recommended over the passive option. (Refer to examples)

Reinforcement Horizontal Spacing

Attention should be paid to the unit of reinforcement force and resistance inputs. If there is an option to enter horizontal spacing of reinforcements, the unit of input should be value per entered horizontal spacing. If there is no such option, the unit of input should be value per one unit length. Proper conversion should be made for input and output interpretation from one unit length to actual reinforcement spacing or vice versa.

Strength Parameter of Existing Slope Ground in Front of ERS

Use representative shear strength parameters of the existing slope material for overall stability analysis. If the existing slope is unstable and the ERS is not used to stabilize the slope, slope stabilization should be considered prior to designing ERS.

Passive Resistance of Discrete Pile Elements

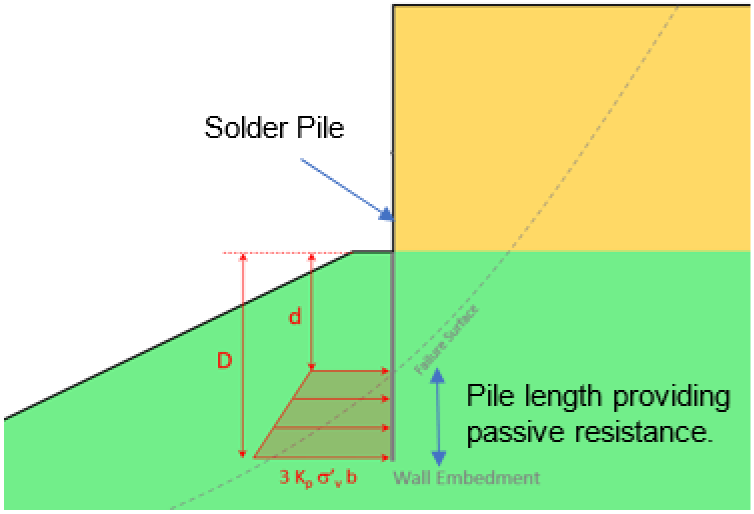
For evaluation of the passive resistance of discrete pile elements, refer to the following references:

- FHWA GEC No. 4, Ground Anchors and Anchored Systems (Chapter 5.5)
- Geotechnical Manual, Earth Pressure Coefficients using the Generalized Limit Equilibrium Method.

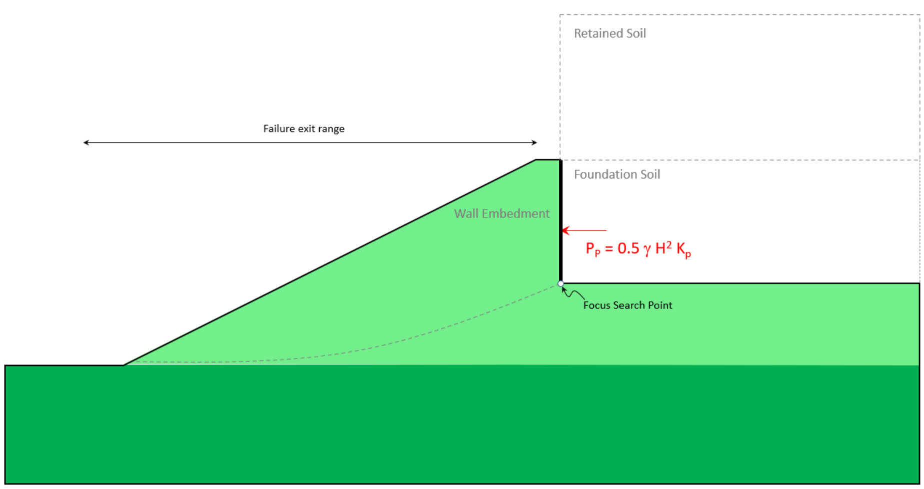
Passive resistance evaluation of pile elements is required as part of compound stability analysis.

Passive Resistance of Piles – Compound Stability Analysis

1. Measure pile element length providing passive resistance as shown below.



2. Calculate Kp using conventional earth pressure theory if it is applicable and skip Steps 2 through 6. If not applicable, use the GLE method to calculate Kp.
3. In a separate model, remove all earth material from the active side of the wall.
4. Set the failure surface entry point such that it starts at the tip of the embedded pile.
5. Apply a line load perpendicular to the pile at a height 0.33H from the pile tip
6. Perform LE slope stability analysis by adjusting the load to determine the required force PP that corresponds to a FoS of 1.0.
7. Back-calculate Kp from: PP = $P_P = 0.5\ \gamma\ H^2\ Kp$, where H = pile embedment length providing passive resistance.

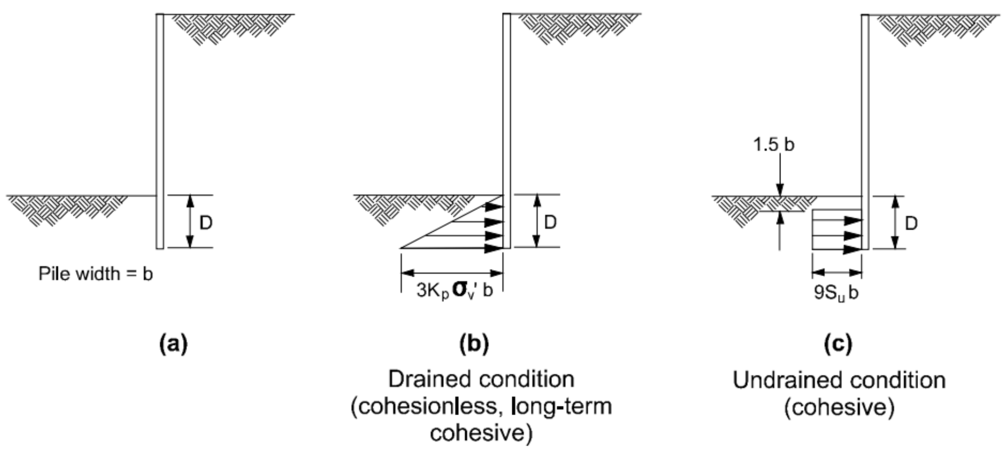


8. Determine passive resistance below the compound failure surface using Brom's method:

$$Passive\ Resistance = 3\ K_p\left(\frac{D+d}{2}\right)\gamma b(D-d)$$

D = Total pile embedded length

d = Pile length from the bottom of ERS to the intersection point of the pile and the critical failure surface.



Brom's method for evaluating ultimate passive resistance (FHWA-IF-99-015)

9. Compare the passive resistance to the demand force calculated previously. A FOS of 1.5 is required (FHWA 1999). If passive resistance is insufficient, increase the pile depth or increase the pile width.

Seismic Overall Stability Analysis

For horizontal seismic acceleration coefficients (k_h) and design procedures for ERS, refer to the *Seismic Design of Earth Retaining Systems* module.

Along with the guidance provided in above the referenced manual, use the following steps for seismic overall stability analysis:

Seismic Global Stability Analysis

1. Perform static overall stability analysis.
2. Perform seismic global stability analysis with ERS design from Step 1 and seismic horizontal acceleration coefficients, and/or as needed, determine yield seismic horizonal acceleration coefficients.
3. Estimate permanent mean seismic displacement.
4. Verify with Bridge Design (BD) if the estimated seismic displacement is acceptable.
5. Update the design if the estimated seismic displacement does not meet the displacement requirement.

Seismic Compound Stability Analysis

1. Perform seismic compound stability analysis with ERS design and seismic horizonal acceleration coefficient from seismic global stability analysis.
2. Verify that piles (reinforcing elements) have sufficient capacity to seismic demand.

Geotechnical plastic conditions may be preferred over the development of plastic conditions on piles for ERS. Geotechnical plastic conditions include sliding, global stability, and passive soil/rotational stability. Since there are a lack of guidance on geotechnical plastic conditions other than sliding at footing base and global stability, seismic compound stability analysis using piles/reinforcing elements will be challenging and may not be necessary. If there is a project-specific need, a similar concept/analysis procedure presented in *Lateral Spreading* Module including the Example module may be used to consider displacement compatibility - between piles and soil displacement until further guidance is available.

For seismic overall stability analysis examples, a seismic horizontal acceleration coefficient of 0.2 was applied and ERS were designed for resulting seismic demands. The seismic displacement analysis procedure including verification of acceptable seismic displacement was not considered for these examples. For details of seismic displacement analysis and verification, refer to *Seismic Design of Earth Retaining Systems* module.

CONVENTIONAL RETAINING WALL

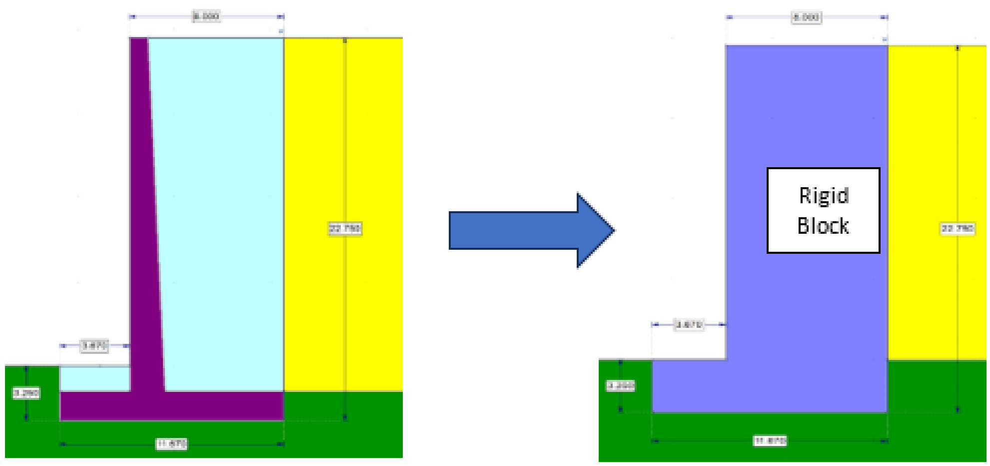
Overall stability analysis for conventional retaining walls is presented using Semi-Gravity Cantilever Retaining Walls (SGCRW) examples with and without piles. The guidance in this section applies to all types of conventional retaining walls.

For geotechnical design and analysis of conventional retaining walls, refer to the *Conventional Retaining Walls* module. For evaluation of the passive resistance of discrete piles, refer to *FHWA GEC No 4: Ground Anchors and Anchored System*.

Compound stability analysis is not required for conventional retaining walls unless pile and/or reinforcing elements are used to support it.

Global Stability Analysis – without piles

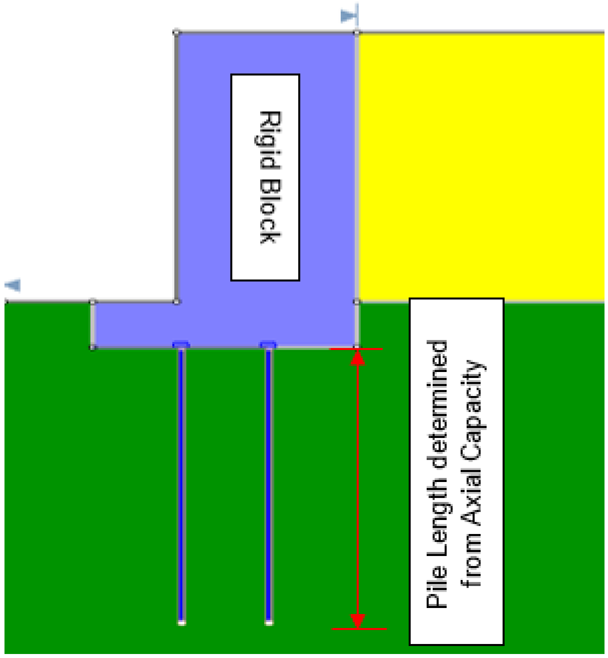
1. Model an SGCRW with a soil block with a height equal to the maximum wall design height (H) plus footing thickness (F) and a width equal to footing width.



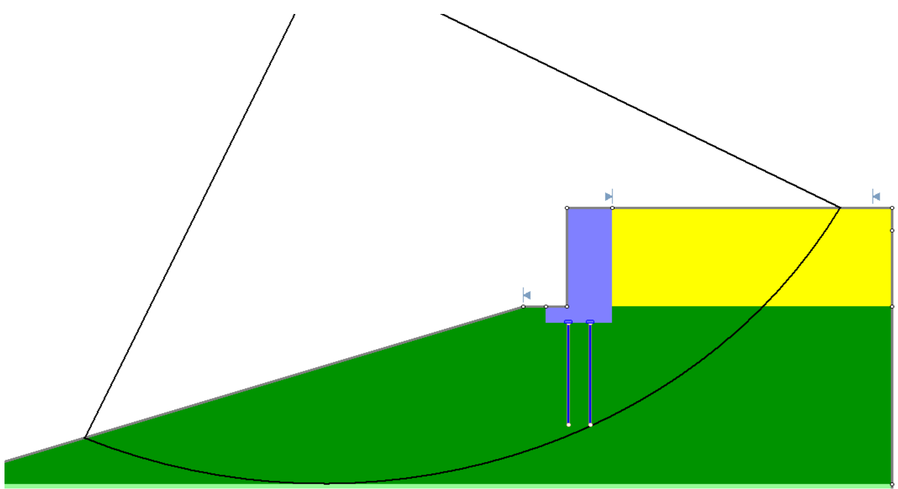
2. Assign the shear strength of the block as an unrealistically high cohesion to enforce potential failure surfaces outside the block and an appropriate friction angle and unit weight.
3. Perform stability analysis to calculate a factor of safety (FoS).
4. If the calculated FoS is less than the required minimum FoS, adjust (increase) footing width until achieving the required FoS.

Global Stability Analysis - with Piles

1. Model an SGCRW with a soil block defined as the same as the previous section along with piles.



2. Assign the shear strength of the block as the same as the previous section and an unrealistically high shear strength of piles to enforce potential failure surfaces outside the block and the pile tips.
3. Perform stability analysis to calculate FoS. If a critical failure surface intersects piles, increase the shear strength of piles to ensure that the critical failure surface does not intersect the piles.



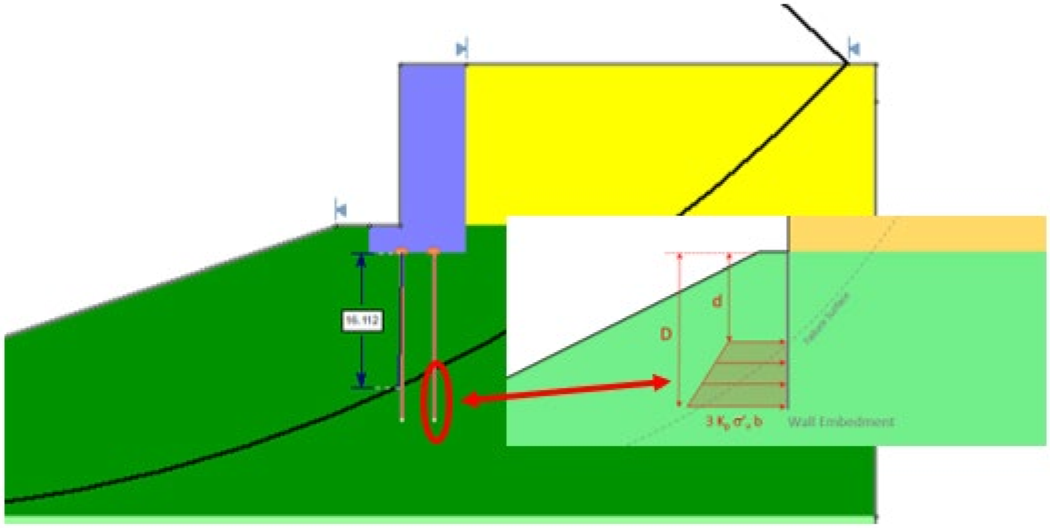
4. If the calculated FoS is less than the required minimum FoS, adjust (increase) pile length until achieving the required FoS.

Compound Stability Analysis - with Piles

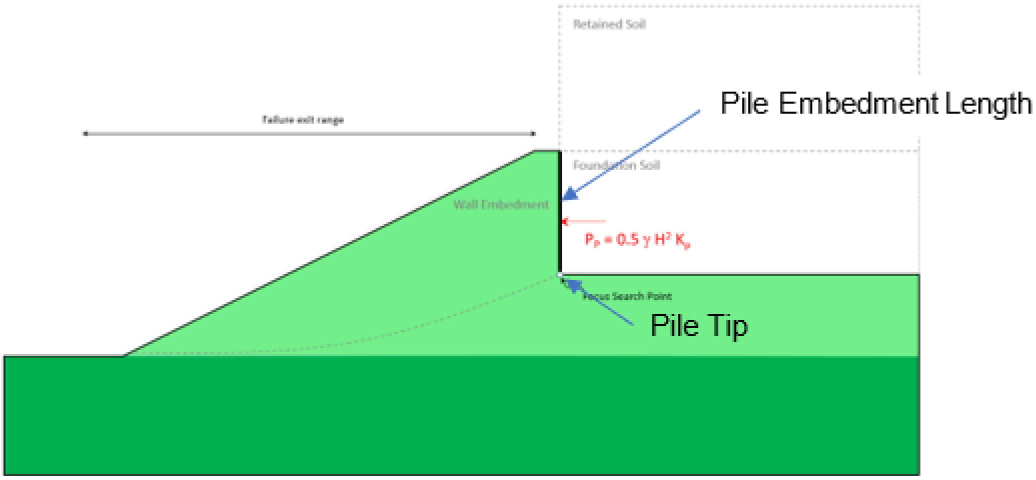
1. Repeat previous steps 1, 2, and 3 except for adjusting (reducing) the shear strength of piles with the pile length calculated from the global stability analysis.
2. Perform stability analysis by reducing the shear strength of piles up to a value to meet the minimum required FOS while the critical failure surface intersects the piles. The adjusted shear strength is the pile shear force demand that will need to be resisted by piles.
3. Measure the pile length below the critical failure surface and verify it is long enough to provide the required pile passive resistance against the pile shear force demand in the previous step. Use Brom's method for the evaluation of the passive resistance of discrete piles.
4. If the passive resistance does not meet the required FoS of 1.5 against the calculated demand force (passive resistance < 1.5 times demand force), increase pile length until achieving the minimum FoS of 1.5 for the required passive resistance of piles.
5. Report the calculated pile shear force demand to Bridge Design as needed.

Passive Resistance of Piles – Compound Stability Analysis

1. Measure pile element length providing passive resistance as below.



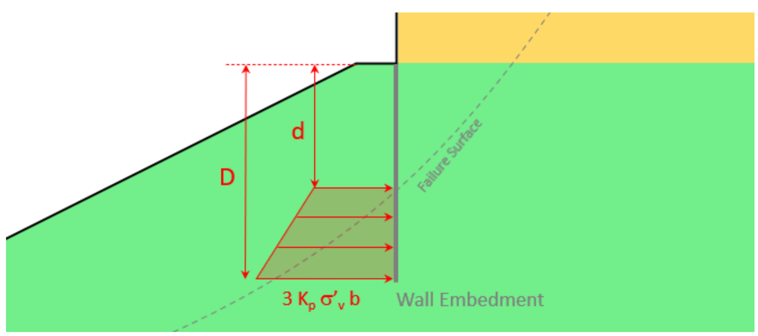
2. Calculate Kp using conventional earth pressure theory if it is applicable and skip Steps 2 through 6. If not applicable, use the GLE method to calculate Kp.
3. In a separate model, remove all earth material from the active side of the wall.
4. Set the failure surface entry point such that it starts at the tip of the embedded pile.
5. Apply a line load perpendicular to the pile at a height 0.33H from the pile tip
6. Perform LE slope stability analysis by adjusting the load to determine the required force PP that corresponds to a FoS of 1.0.
7. Back-calculate Kp from: $P_P = 0.5\ \gamma\ H^2\ Kp$, where H = pile embedment length providing passive resistance.



8. Determine passive resistance below the compound failure surface using Brom's method:

$$Passive\ Resistance = 3\ K_p \left(\frac{D+d}{2}\right) \gamma b (D-d)$$

D = Total pile embedded length
d = Pile length from the bottom of ERS to the intersection point of the pile and the critical failure surface.



9. Compare the passive resistance to the demand force calculated previously. A FoS of 1.5 is required (FHWA 1999). If passive resistance is insufficient, increase the pile depth or increase the pile width.

Repeat the above steps for seismic stability analyses, applying an appropriate horizontal seismic load coefficient (k_h). Perform the analyses for FoS of 1.0.

NON-GRAVITY CANTILEVER RETAINING WALL

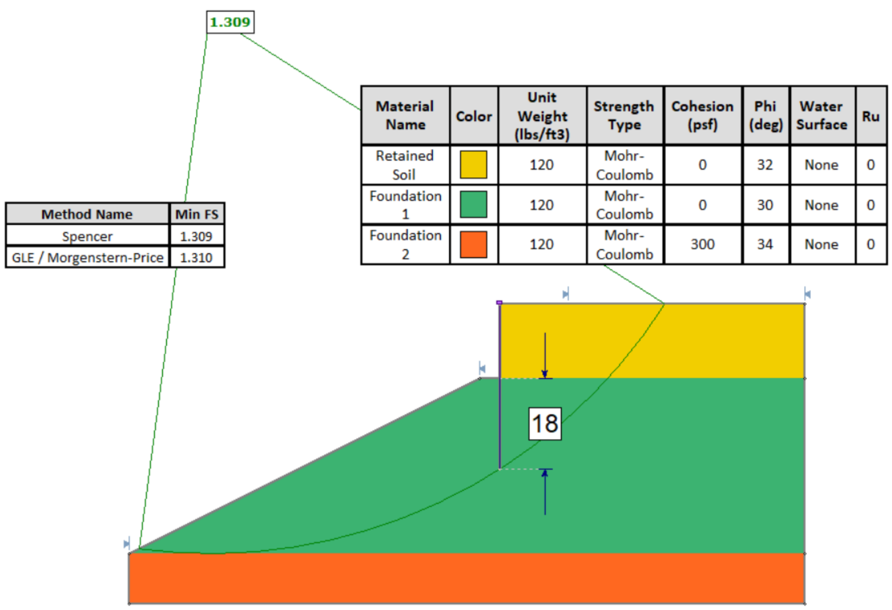
Global Slope Stability

Overall slope stability analysis is performed to evaluate potential failure surfaces outside of the pile embedded length. In GLE analysis such failure surfaces can be evaluated by forcing the failure surface to be right outside and below the embedded pile depth by assigning an unrealistically high shear strength value to the pile.

Perform global stability analysis using the following steps.

Estimate Retaining Wall Embedment

1. Model the retained soil, retaining wall and ground condition in front of the retaining wall. Assign appropriate soil properties.



Method Name	Min FS
Spencer	1.309
GLE / Morgenstern-Price	1.310

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Retained Soil		120	Mohr-Coulomb	0	32	None	0
Foundation 1		120	Mohr-Coulomb	0	30	None	0
Foundation 2		120	Mohr-Coulomb	300	34	None	0

2. Create pile wall using pile element of appropriate length and assign an unrealistically high shear strength value.

General | Shear | Design Factors (None)

Type	Data
Force Application and Orientation	
Force Application	Active (Method A)
Force Orientation	Perpendicular to pile
Spacing	
Out-Of-Plane Spacing (ft)	8

General | Shear | Design Factors (None)

Type	Data
Failure Mode	Shear
Pile Shear Strength (lbs)	200000

3. Perform limit equilibrium slope stability analysis.
4. If the potential failure surface intersects the pile, increase the shear strength of the pile to make the potential failure outside the pile element. If the calculated FoS is less than the required minimum FoS, increase the length of the pile until the calculated FoS meets the requirement.
5. The required pile embedment depth is the depth for which the required FOS is achieved, and the failure surface is outside of the pile length
6. Repeat the above steps for seismic global stability analyses, applying an appropriate horizontal seismic load coefficient (kh). The highest of the lengths obtained by static and seismic analysis will govern the design.

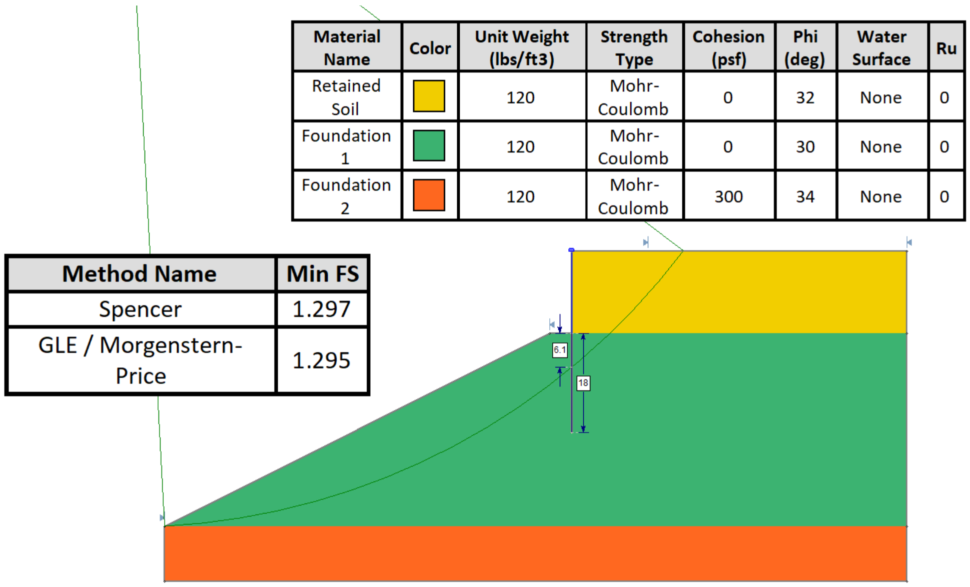
Compound Stability Analysis

Compound stability analysis evaluates potential failure surfaces passing through the embedded piles. Piles are modeled as structural elements and pile shear strength is determined by iterative adjustment of assigned shear forces to achieve required FoS.

Perform compound stability analysis using the following steps.

Estimate Demand Force

1. Model the retained soil, retaining wall and ground condition in front of the retaining wall. Assign appropriate soil properties
2. Create pile wall using pile element, assign pile depth obtained from the global stability analysis. Assign a realistic pile shear strength
3. Perform limit equilibrium slope stability analysis.
4. If the calculated FoS is less than the required minimum FoS and the failure surface passes through the pile element, then increase the pile shear strength in smaller increments until the required FoS is achieved. If the calculated FoS is higher than the required FoS and the failure surface passes outside the pile element, then decrease the pile shear strength until the required FoS is achieved.



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Retained Soil		120	Mohr-Coulomb	0	32	None	0
Foundation 1		120	Mohr-Coulomb	0	30	None	0
Foundation 2		120	Mohr-Coulomb	300	34	None	0

Method Name	Min FS
Spencer	1.297
GLE / Morgenstern-Price	1.295

5. The required pile shear force demand is the shear strength for which the required FoS is achieved.
6. Measure the pile length below the critical failure surface and verify it is long enough to provide the required pile passive resistance against the pile shear force demand in the previous step. Use Brom's method for the evaluation of the passive resistance of discrete piles.
7. If the passive resistance does not meet the required FoS of 1.5 against the calculated demand force (passive resistance < 1.5 times demand force), increase pile length until achieving the minimum FoS of 1.5 for the required passive resistance of piles.
8. Repeat the above steps for seismic compound stability analyses, applying an appropriate horizontal seismic load coefficient (kh).

For passive resistance of piles, follow the steps previously presented in the passive resistance of pile - compound stability analysis.

Repeat the above steps for seismic stability analyses, applying an appropriate horizontal seismic load coefficient (k_h). Perform the analyses for FoS of 1.0.

GROUND ANCHOR WALL

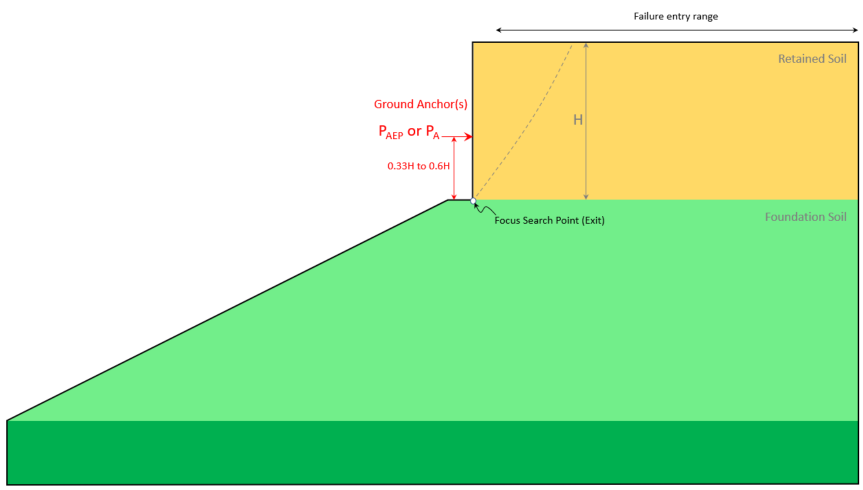
Overall stability analysis for ground anchor walls is presented using soldier pile ground anchor wall examples. The guidance in this section can apply to all types of ground anchored retaining walls.

Refer to the *Ground Anchor Earth Retaining Systems* and *Non-Gravity Cantilever Retaining Walls* modules for additional design guidance.

For overall stability analysis of ground anchor walls, there is no need to model the ground anchor system, and the effect of anchor systems (anchor resistance/force) is considered in the analysis by applying anchor force to the wall face.

Global Stability Analyses

Determine the total force per unit length of a wall (P_{AEP}) based on the apparent earth pressure (AEP) distribution (Figures 3.11.5.7.1-1(a) and AASHTO Equations 3.11.5.7.1-1(b)) to stabilize the retained soil mass by the ground anchor(s).



1. Assign realistic soil properties for the retained and foundation soil.
2. Set the search limits to force the exiting failure through the base using either a circular or block failure search.
3. Apply a line load (required stabilizing force) with a horizontal orientation on the face of the retained soil face. The load is typically applied at 0.33 to 0.6 times the face height from the base. See Step 4 for magnitude of line load
4. Perform limit equilibrium (LE) slope stability analysis, using the following methods to determine P_{AEP} (per *Ground Anchor Earth Retaining Systems* module):

   Method 1: Find the required stabilizing force (P_A) that computes a factor of safety (FoS) of 1.0. The FoS of 1.0 is equivalent to the active earth pressure condition. Multiply PA by 1.33 to obtain the P_{AEP} (P_{AEP} = 1.33 x P_A).

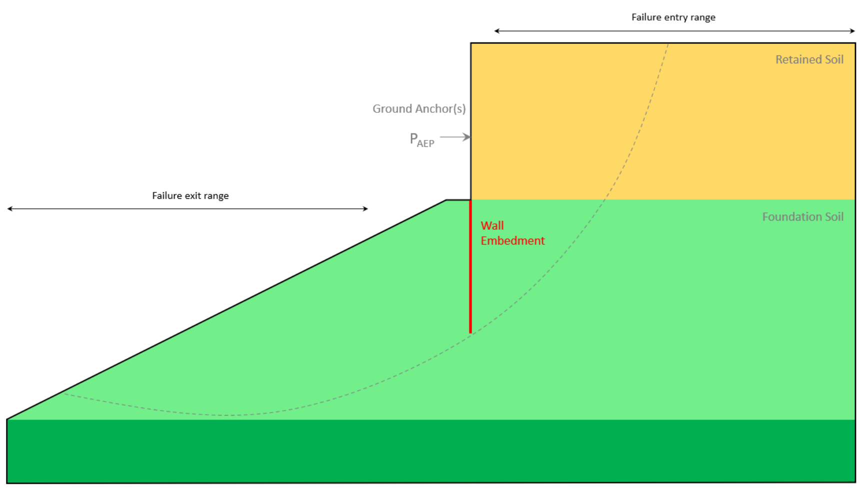
   Method 2: Find the required stabilizing force, P_{AEP}, that computes FoS of:

   - 1.33 (well-defined soil parameters and a slope that is not supporting structures); or
   - 1.54 (limited soil information and a slope that is supporting structures).

Do not apply the multiplier of 1.33 used in Method 1 to P_{AEP}.

If both methods are considered, the largest computed P_{AEP} governs.

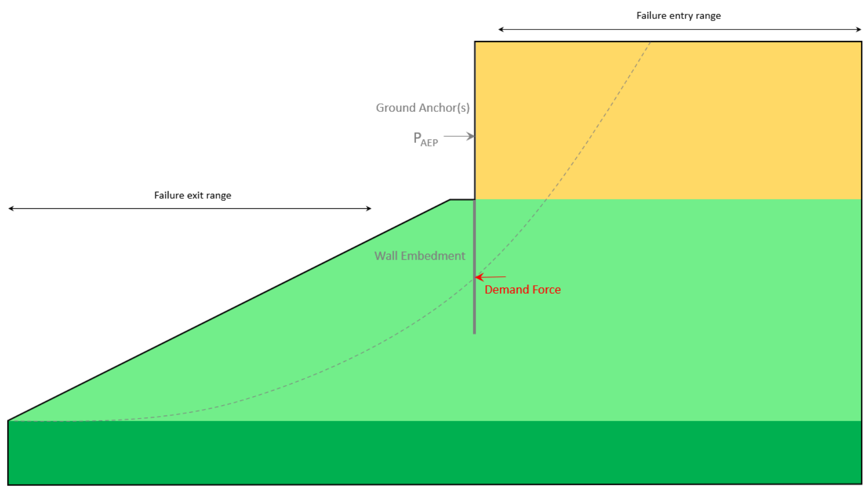
Determine the embedment depth of the wall such that failure will not occur within the wall in the analysis.



1. In a separate analysis, model a vertical wall element (soldier pile) and assign a shear strength large enough to ensure failure below the wall (see Step 7). Initial embedment depth can be made equal to the retained height.
2. Set the entry failure search limits behind the retaining wall, and the exit failure search limits in front of the wall. Use a circular failure search.
3. Perform GLE slope stability analysis (the large wall shear strength will force the failure surface to develop below the wall). Vary the wall depth until the minimum required FoS is met.

Compound Slope Stability

Determine the wall shear strength (force) such that failure will occur within the wall element for the minimum required FoS. This is the demand force that will need to be resisted.



1. In a separate analysis, model the P_{AEP} and wall length determined from the global slope stability analyses.
2. Set the entry failure search limits behind the retaining wall, and the exit failure search limits in front of the wall. Use a circular failure search.
3. Perform GLE slope stability analysis, decreasing the wall shear strength to allow failure to occur within the wall element. Iterate the wall shear strength until the required FoS is computed. This is the demand force that will need to be resisted.

For passive resistance of piles, follow the steps previously presented in the passive resistance of pile - compound stability analysis.

Repeat the previous steps for seismic analyses, applying an appropriate horizontal seismic load coefficient (k_h). Perform the analyses for FoS of 1.0.

MECHANICALLY STABILIZED EMBANKMENT

For Mechanically Stabilized Embankment (MSE) reinforcement details, refer to the following MSE Design guidance document and Plans:

- Bridge Design Aids 3-8, 2013
- XS sheets, 13-020-2

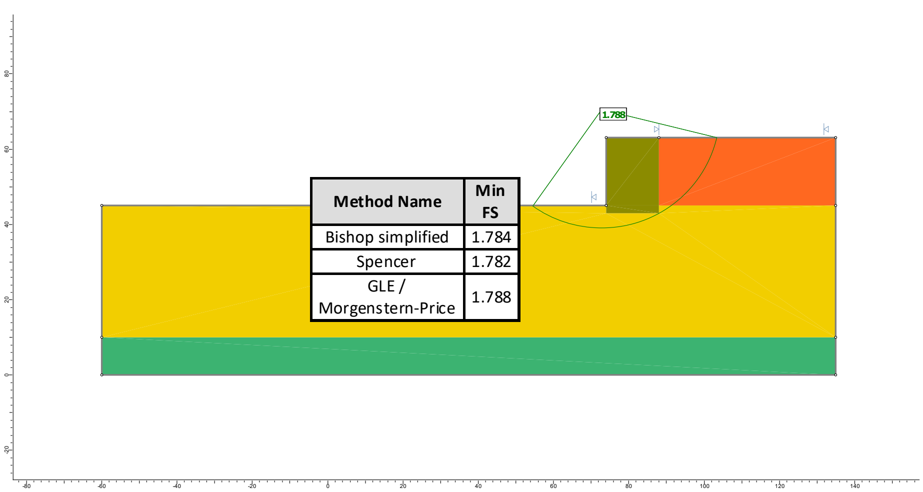
According to the above references, the minimum reinforcement length must be at least 0.7 times the maximum representative MSE design Height (H) or 8 feet, whichever is greater.

Design examples are presented following the procedures. In addition, technical details are summarized in the Appendix.

<u>Global Stability Analysis</u>

The global stability analysis evaluates the stability of an MSE with a potential failure surface passing through outside of the reinforced zone of the MSE. For this analysis, there is no need to model actual reinforcements. The reinforced zone can be modeled as an MSE block with a high equivalent strength value, such as apparent cohesion = 1000 psf, apparent friction angle = 34 degrees, and unit weight of 120 pcf that drive the potential failure surfaces outside the reinforced zone. The steps for the analysis are as shown below:

1. Model an MSE block with a height equal to the maximum representative MSE wall design height (H) and a width equal to 0.7 times H.



2. Assign the shear strength of the block as unrealistic high cohesion and appropriate friction angle and unit weight.
3. Perform stability analysis for a required FoS.
4. If the critical failure surface intersects the MSE block, increase the shear strength of the block to drive the critical failure surface outside the block.
5. If the calculated FoS is less than the required FoS, increase the width of the MSE block until the calculated FOS meets the requirement.
6. The required reinforcement length for global stability is the width of the MSE block from Step 5.

Compound Stability Analysis

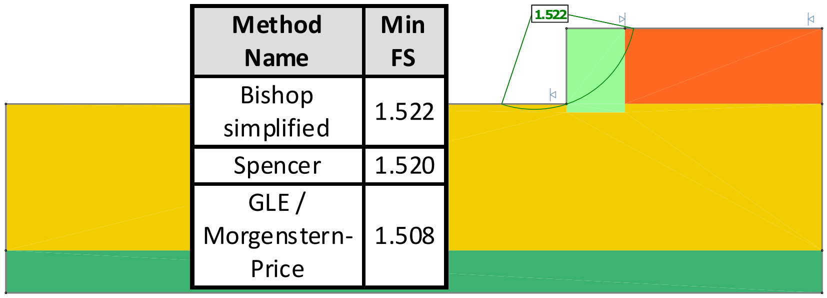
The compound stability evaluates the stability of the MSE with potential failure surfaces that intersect reinforcements. The analysis requires modeling the engineering properties of the reinforcements such as tensile strength, and soil/reinforcement interface.

However, based on a parameter study performed for the development of this document, only the bottom three rows of reinforcements for Caltrans MSE design will affect the compound stability of an MSE. The parameter study was performed with varied wall heights, slope angles in front of the wall, and soil properties. The study indicates that only the engineering properties of the bottom three rows of reinforcements affect the calculated FoS. The parameter study is included in Appendix.

Based on the parameter study, a simplified method, Method 1, is recommended used for compound stability analysis for a single-tier MSE wall. The steps for the analysis are as shown below:

Method 1 – Simplified Method

1. Model an MSE wall block with a height equal to the maximum representative MSE wall design height (H) and a width equal to the reinforcement length estimated from the global stability analysis.
2. Assign the shear strength of the block as cohesion = 350 psf and friction angle = 34 degrees.
3. Set and adjust search limits to have critical failure surfaces intersect the bottom corner of the MSE block



Method Name	Min FS
Bishop simplified	1.522
Spencer	1.520
GLE / Morgenstern-Price	1.508

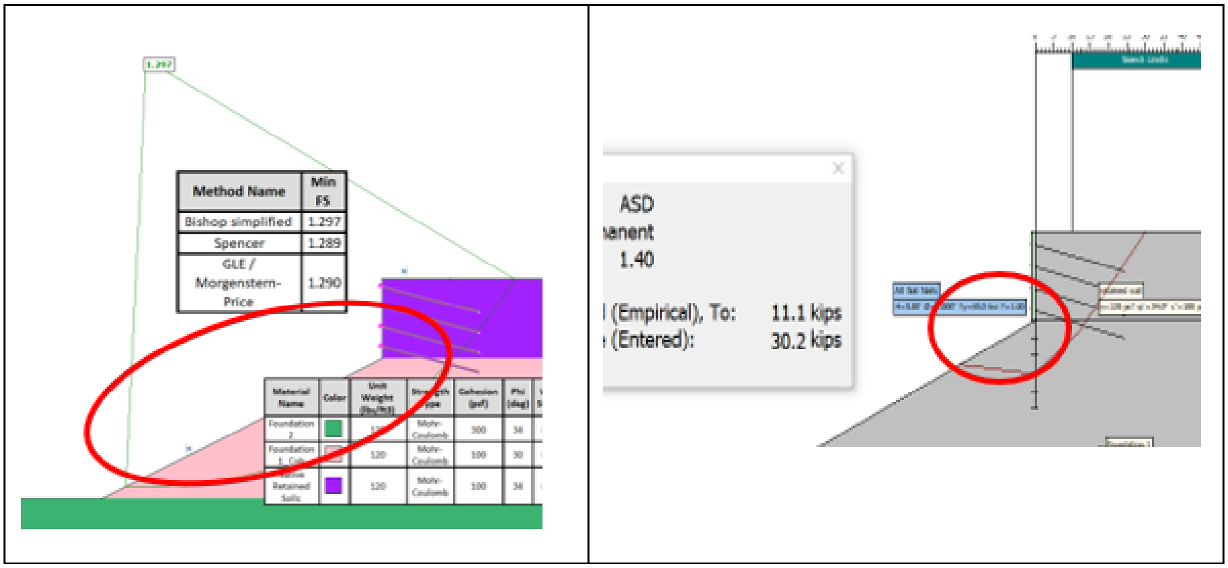
4. Perform the stability analysis for a required FoS.
5. If the calculated FoS is less than the required FoS and the critical failure surface intersects above the bottom corner of the block, adjust the search limits to drive critical failure surfaces through the bottom corner of the block.
6. If the calculated FoS is less than the required FoS for the critical failure surface intersecting the bottom corner of the block, increase the width of the MSE block until the calculated FOS meets the requirement.
7. The required reinforcement length is the width of the MSE block from Step 6.

Repeat the previous steps for seismic analyses, applying an appropriate horizontal seismic load coefficient (k_h). Perform the analyses for FoS of 1.0.

For compound stability analysis of MSE, Method 1 does not require modeling of soil reinforcements and the reinforcement strength is accounted for using an apparent cohesion of 350 psf. However, in some cases such as a tiered MSE or an MSE with a steep sloping ground above where the potential failure surface may above or around mid-height of the MSE wall, complete modeling of reinforcements will be needed in analysis. For such cases, Methods 2 and 3 are provided in Appendix A4. In addition, these methods may be used to justify the increase of the reinforcement length if a significant increase is needed based on Method 1 analysis.

SOIL NAIL WALL

Soil nail walls are designed using Snail software. However, due to simplified assumptions for passive-type failure surfaces below the toe of a wall in Snail, the *Soil Nail Walls* module and Snail guidance recommend performing overall stability analysis using a slope stability program. The difference between critical failure surfaces below the toe of soil nail walls for Snail and GLE slope stability program are shown in the following analysis output (refer to “red circled” failure surfaces below).



The overall stability of soil nail walls using slope stability software does not require separate models for global and compound stability, and both analyses can be performed in a single analysis model by adjusting search limits where all soil nail elements are modeled.

Since most of the available slope stability software have differently defined engineering properties of soil nails and facing compared to Snail, these inputs should be modified for the overall stability analysis. For input relation between Snail and Slide2, refer to Table 1 below.

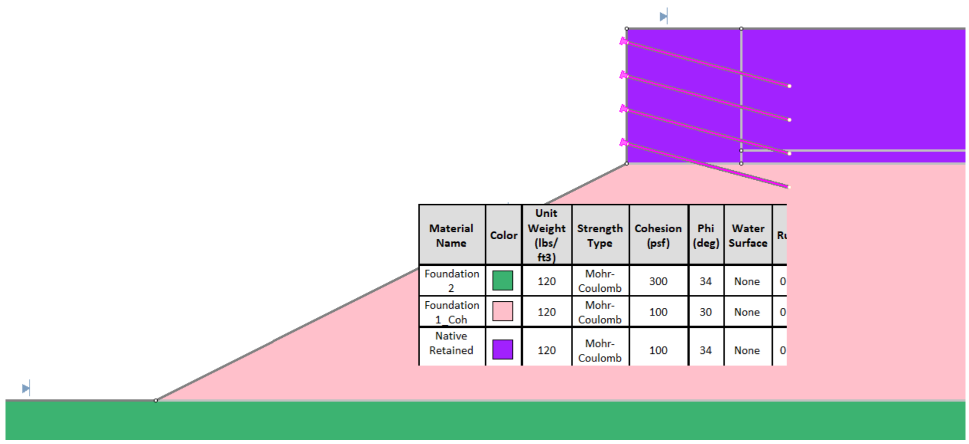
Table 1: Soil Nail Wall – Soil Nail and Facing Engineering Properties

Snail Input	Slide2 Input Parameters	Relationship between Slide2 and Snail
fy (ksi) - Nails	Tensile Capacity (lbs)	fy x $\pi d^2/4$ x 1,000
d (in) - Nail Diameter		
Allowable Facing Resistance (kips)	Plate Capacity (lbs)	Allowable Facing Resistance x 1,000 x Partial Factor[1]
fs (psi) - Bond Strength	Bond Strength (lbs/ft)	fs x πD x 12
D (in) - Drilled Hole Diameter		

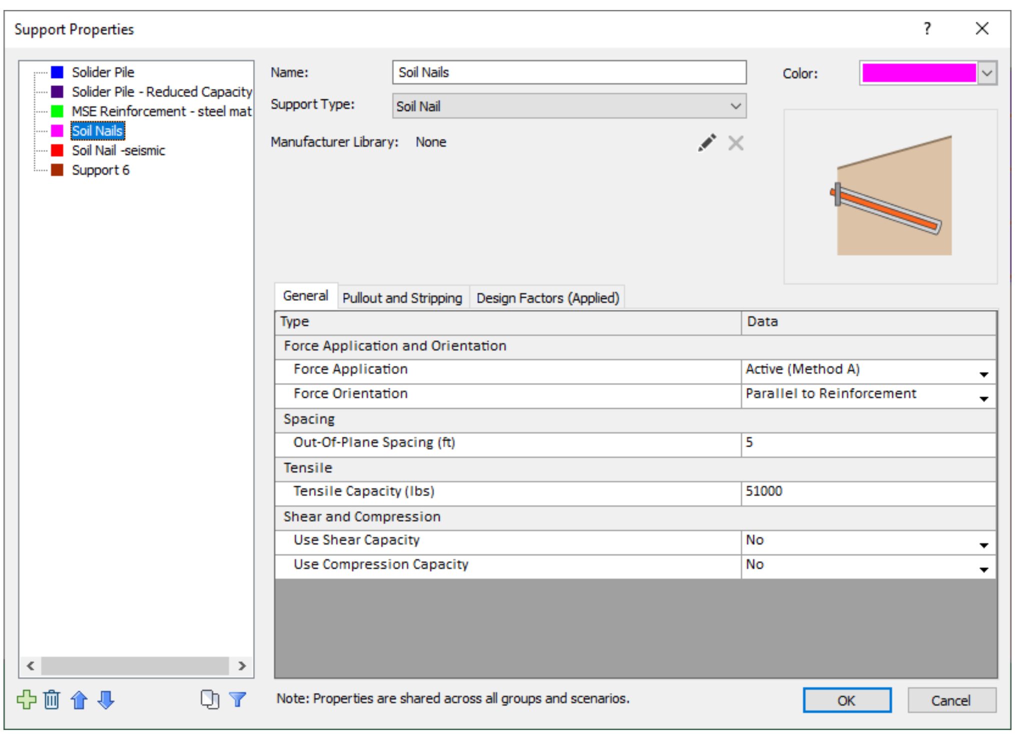
[1] If Plate Capacity is entered as a nominal ultimate value along with the Partial Factor entered from the Design Factor entry, Allowable Facing Resistance from the Snail should be multiplied by the Partial Factor for the Plate Capacity input.

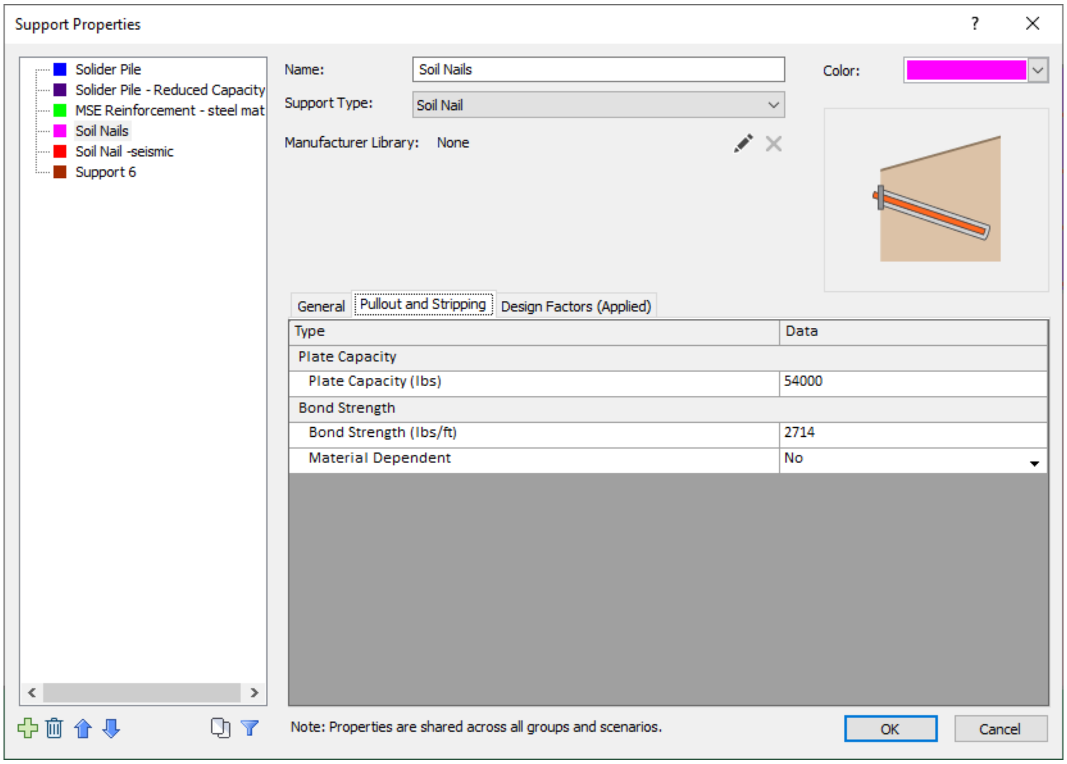
<u>Global/Compound Stability Analysis for Soil Nail Walls</u>

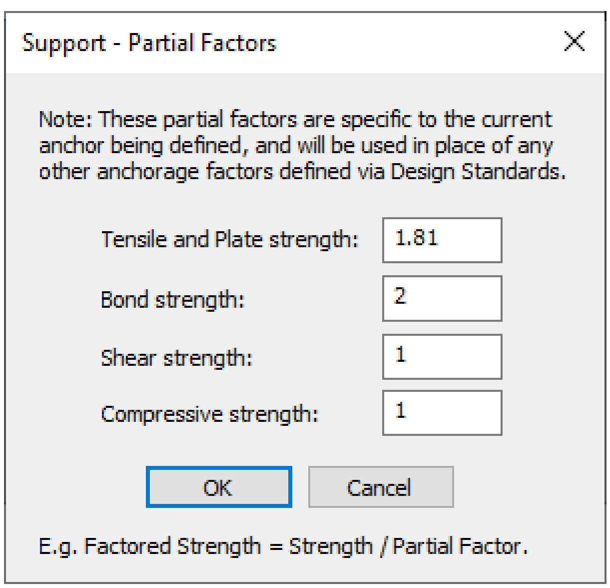
1. Model soil nail reinforcements, and wall geometry.
2. Assign the shear strength of soil layers.



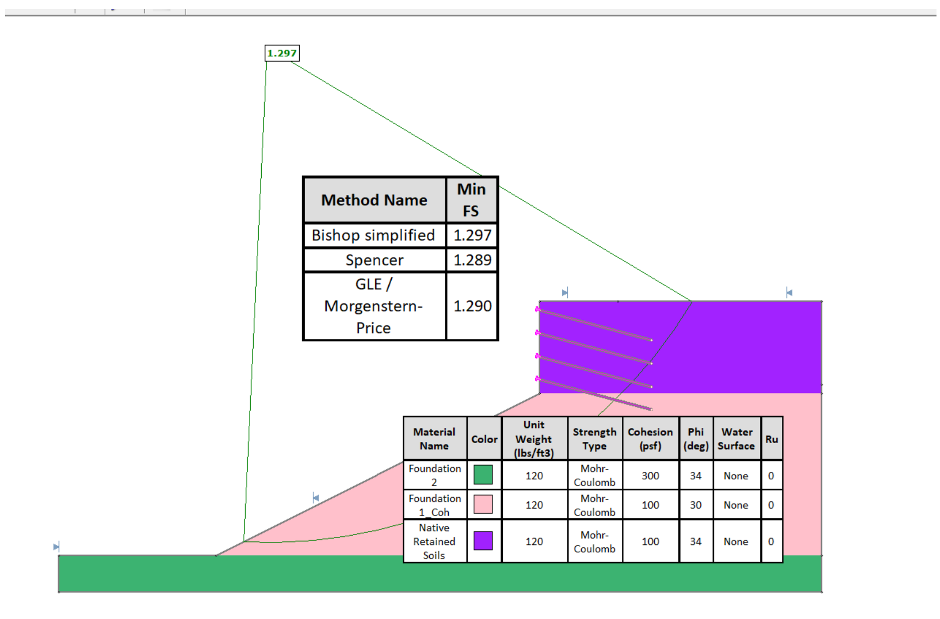
3. Create the engineering properties of soil nails per Tables 5.1.




Support Properties
Solider Pile
Solider Pile - Reduced Capacity
MSE Reinforcement - steel mat
Soil Nails
Soil Nail -seismic
Support 6
Name:
Soil Nails
Support Type:
Soil Nail
Manufacturer Library:
None
Color:
General
Pullout and Stripping
Design Factors (Applied)
Type
Data
Plate Capacity
Plate Capacity (lbs)
54000
Bond Strength
Bond Strength (lbs/ft)
2714
Material Dependent
No
Note: Properties are shared across all groups and scenarios.
OK
Cancel


Support - Partial Factors
Note: These partial factors are specific to the current anchor being defined, and will be used in place of any other anchorage factors defined via Design Standards.
Tensile and Plate strength:
1.81
Bond strength:
2
Shear strength:
1
Compressive strength:
1
OK
Cancel
E.g. Factored Strength = Strength / Partial Factor.

4. Perform the stability analysis.



5. If the calculated FoS is less than the required FoS, increase the reinforcement parameters including length, spacing, etc.

Repeat the previous steps for seismic analyses, applying an appropriate horizontal seismic load coefficient (k_h). Perform the analyses for FoS of 1.0.