AB Walls 10 Reinforced Retaining Wall Hand Calculations

PROJECT NAME: SAMPLE HAND CALCULATIONS
PROJECT NUMBER:
DATE:
PREPARED BY: Preliminary

INPUT INFORMATION

WALL NUMBER: Sample Project
CROSS SECTION: 4

ALLAN BLOCK PARAMETERS

block height: h := 0.656 · ft
block depth: t := 0.99 · ft
block length: l := 1.47 · ft
unit percent concrete: c := 60 · %
unit percent voids: v := 40 · %
block setback: ω := 6.52 · deg

WALL PARAMETERS

number of block courses: n := 10
total wall height: H := n · h   H = 6.56 ft
embedment depth in courses: e := 1.433
total embedment depth: D := e · h
D = 0.94 ft
geogrid length: L := 4.0ft
Ltop := 7.0ft

LEVELING PAD DIMENSIONS

Pad width: Lwidth := 2 · ft
Pad depth: Ldepth := 0.5 · ft
toe extension: Ltoe := 0.5 · ft
geogrid length: Lgrid := 0 · ft

SURCHARGE PARAMETERS

surcharge: q := 100psf
qx := 8.0 · ft
surcharge type: xq := 1

Surcharge Type:
1=Live Load
2=Dead Load

BACKSLOPE PARAMETERS

backslope angle: i := 18.4deg
backslope height: hi := 2 · ft

TUMBLE EUROPA COLLECTION

TUMBLED := 2
1=YES
2=NO

POINT LOAD PARAMETERS

point load: P := 0 · psf
surcharge type: Stype := 1

Surcharge Type:
1=Live Load
2=Dead Load

Contact area boundaries from toe of wall:
starting point: x1 := 0.0 · ft
ending point: x2 := 3.5ft

SEISMIC PARAMETERS

acceleration coefficient: Ao := 0.0
allowable lateral deflection:
internal: di := 3 · in
external: dr := 3 · in

SEISMIC FORCE ANALYSIS METHOD (SFAM):

Trapizoidal Wedge = 1
Active Wedge Weight = 2
Greater of the Two = 3
SFAM := 3

SOIL PARAMETERS

INFILL SOIL
friction angle: ϕi := 30 · deg
unit weight: γi := 120 · pcf

RETAINED SOIL
friction angle: ϕr := 30 · deg
unit weight: γr := 120 · pcf

FOUNDATION SOIL (Standard Method)
friction angle: ϕf := 30 · deg
unit weight: γf := 120 · pcf
cohesion cf := 0 · psf

LEVELING PAD SOIL
friction angle: ϕlp := 36 · deg

INTERNAL COMPOUND STABILITY Input Values from AB Walls:

course := 0
Xc := 0.75ft
X2 := 0.99ft
FSi := 1.91
Yc := 13.22ft
Y2 := 0ft
Radius := 13.22ft
X1 := 13.12ft
Y1 := 8.56ft

Bearing Method:
bearing := 1
1=AB Modified Meyerhof
2=Meyerhof

ASHLAR BLEND (Reduction for Abby Blend included in Europa)

ASHLAR := 2
1=YES
2=NO

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GEOGRID PARAMETERS

number of geogrid layers: g := 5 layers
geogrid type A: A := "Miragrid 3XT"
geogrid type B: B := "Miragrid 5XT"

ong term allowable design strength
geogrid type A: LTDS_A := 1558 · plf
geogrid type B: LTDS_B := 2234 · plf

reduction factor for long term creep
RFcr_A := 1.67
RFcr_B := 1.67

factor of safety geogrid overstress (Static): FSos_s := 1.5
factor of safety geogrid overstress (Seismic): FSos_d := 1.1

Geogrid Parameters for Pullout of soil:
Ci := 0.7   αpullout := 1.0

CONNECTION STRENGTH PARAMETERS

PEAK CONNECTION CAPACITY, in the form of a linear equation. y=Mx+B
where: y=connection strength and x=normal load

GEOGRID TYPE A
segment #1 y intercept: B1a := 1420 · plf
slope: M1a := tan(11 · deg)
segment #2 y intercept: B2a := 1420 · plf
slope: M2a := tan(11 · deg)
Intersecting Normal Load

$$Ninta := \frac{B2a - B1a}{M1a - M2a} \qquad Ninta = 0 \cdot \frac{lb}{ft}$$

Maximum tested value: Max_A := 2463plf

GEOGRID TYPE B
segment #1 y intercept: B1b := 1287 · plf
slope: M1b := tan(29 · deg)
segment #2 y intercept: B2b := 1287 · plf
slope: M2b := tan(29 · deg)
Intersecting Normal Load

$$Nintb := \frac{B2b - B1b}{M1b - M2b} \qquad Nintb = 0 \cdot plf$$

Maximum tested value: Max_B := 3227plf

BLOCK SHEAR PARAMETERS

NOTE: Block - Grid - Block AND Block - Block Shear Results are the same for block with a nominal 6 degree setback or greater:

SRW UNIT INTERFACE SHEAR DATA (Block - Block)

	Block setback greater than or equal to 6 degrees:		Block setback less than 6 degrees:	
apparent minimum ultimate shear capacity between segmental units:	au := 2671 · plf	au_max := 4706plf	au3 := 1018 · plf	au3_max := 6218plf
apparent angle of friction between segmental units for peak shear capacity:	λu := 38 · deg		λu3 := 61 · deg	

GEOSYNTHETIC-SRW UNIT INTERFACE SHEAR DATA (Block - Grid - Block)

apparent minimum ultimate service state shear capacity:	au' := 2671plf	au'_max := 4706plf	au3' := 1150plf	au3'_max := 5585plf
apparent angle of friction between segmental units for service state shear capacity:	λu' := 38 · deg		λu3' := 50 · deg	

Note: Shear Capacity Percentage is used only in the Internal Compound Stability Calcualtiuons. This value reduces the allowable face shear.

Shear_Capacity := 100% of tested values.

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SELECT BLOCK LAYERS

range of block layers: $k := n..0$

$unit_k := k$

$Elev_k := (unit_k \cdot h)$

zero := 0ft

SRW Course #:

Course Elev:

NOTE: Course #1 represents the top of leveling pad.

GeoGrid Position: Type 0 for no geogrid and 1..g for geogrid:

$unit_k =$	$Elev_k =$ (ft)	$geo_k :=$	$Glength_k =$ (ft)
10	6.56	0	0
9	5.904	5	7
8	5.248	0	0
7	4.592	4	4
6	3.936	0	0
5	3.28	3	4
4	2.624	0	0
3	1.968	2	4
2	1.312	0	0
1	0.656	1	4
0	0	0	0

GEOGRID LAYOUT PARAMETERS

range of geogrid layers: $j := g..1$

$Ee_j := grid_j \cdot h$

geogrid coursing: $grid_j :=$	geogrid type: $type_j :=$	geogrid length: $length_j :=$	geogrid coursing: $Ee_j =$ (ft)
9	A	Ltop	5.904
7	A	L	4.592
5	A	L	3.280
3	A	L	1.968
1	A	L	0.656

GEOGRID LAYERS ABOVE THE WALL

Are there Geogrid layers above the wall? Grid_Above := 2

1 for Yes

2 for No

How far above the top block to the first layer of grid: Sabove := 0.5ft

Spacing between layers: Spacing := 0.5ft

How many layers above wall are required: Gabove := 3

Length of Grid and Type:

ga := Gabove − 1..0

$Lga_{ga} :=$	$type\_GA_{ga} :=$
12ft	A
12ft	A
12ft	A

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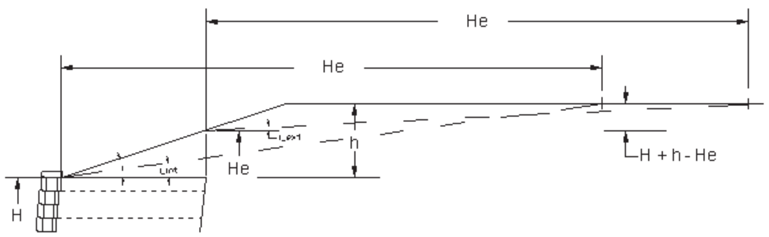
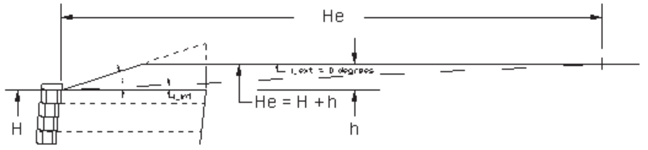
EFFECTIVE WALL HEIGHT AND BROKEN BACK SLOPE DETERMINATION





equivalent lip thickness: $s := if(\omega > 5deg, 0.1829ft, 0.1412ft) = 0.183\,ft$ $s = 0.183\,ft$

effective wall height: $He := if[H + hi < [H + [L - (t - s)] \cdot tan(i)], H + hi, H + [L - (t - s)] \cdot tan(i)]$ $He = 7.622\,ft$

BROKEN BACK SLOPE CALCULATIONS, i' :

Internal Calculations: Determine the true backslope angle:

$i\_int := atan\left(\frac{hi}{He}\right)$ $i\_int = 14.703 \cdot deg$ $i\_int := if(i\_int \geq i, i, i\_int)$ THEREFORE: $i\_int = 14.703 \cdot deg$

External Calculations:

$$i\_ext := if\left[H + hi < H + [L - (t - s)] \cdot tan(i), 0deg, atan\left[\frac{hi - (He - H)}{He}\right]\right]$$

$i\_ext = 7.015 \cdot deg$ $i\_ext := if(i\_ext \geq i, i, i\_ext)$ THEREFORE: $i\_ext = 7.015 \cdot deg$

CALCULATION OF STATIC AND DYNAMIC EARTH PRESSURE COEFFICIENTS

weighted friction angle: $\phi wi := \frac{2}{3} \cdot \phi i$ $\phi wi = 20 \cdot deg$ $\phi wr := \frac{2}{3} \cdot \phi r$ $\phi wr = 20 \cdot deg$

wall batter: $\beta := 90 \cdot deg - \omega$ $\beta = 83.48 \cdot deg$

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STATIC:

Active earth pressure coefficient: Infill Soil

$$Kai := \left[\frac{\csc(\beta)\cdot\sin(\beta-\phi i)}{\sqrt{\sin(\beta+\phi wi)}+\sqrt{\left(\frac{\sin(\phi i+\phi wi)\cdot\sin(\phi i-i\_int)}{\sin(\beta-i\_int)}\right)}}\right]^2 \qquad Kai = 0.31$$

Retained Soil

$$Kar := \left[\frac{\csc(\beta)\cdot\sin(\beta-\phi r)}{\sqrt{\sin(\beta+\phi wr)}+\sqrt{\left(\frac{\sin(\phi r+\phi wr)\cdot\sin(\phi r-i\_ext)}{\sin(\beta-i\_ext)}\right)}}\right]^2 \qquad Kar = 0.276$$

DYNAMIC:

Seismic Coefficients: Internal Stability

$Kv := 0$ $\quad Khi1 := (1.45 - Ao)\cdot Ao$ For: di=0 in

$Khi1 = 0$

$$Khi2 := \text{if}\left[di = 0in, 0, 0.74\cdot Ao\cdot\left(\frac{Ao\cdot 1\cdot in}{di}\right)^{0.25}\right]$$ For di>=1 in

$Khi2 = 0$

$Khi := \text{if}(di = 0in, Khi1, Khi2)$ $\quad Khi = 0$

External Stability

$Khr1 := \frac{Ao}{2}$ For: dr=0 in

$Khr1 = 0$

$$Khr2 := \text{if}\left[dr = 0in, 0, 0.74\cdot Ao\cdot\left(\frac{Ao\cdot 1\cdot in}{dr}\right)^{0.25}\right]$$ For dr>=1 in

$Khr2 = 0$

$Khr := \text{if}(dr = 0in, Khr1, Khr2)$ $\quad Khr = 0$

Seismic inertial angle:

$$\theta i := \text{atan}\left(\frac{Khi}{1+Kv}\right) \qquad \theta i = 0\cdot deg$$

$$\theta r := \text{atan}\left(\frac{Khr}{1+Kv}\right) \qquad \theta r = 0\cdot deg$$

Maximum allowable slope under seismic conditions:

$i\_max := \phi r - \theta r$ $\quad i\_max = 30\cdot deg$

note = "Entered slope does not exceed allowable slope"

NOTE: Δi is calculated separately to assure that the denominator or the Kaei and Kaer equations do not negative under the square root bracket.

$$\Delta i := \frac{\sin(\phi i+\phi wi)\cdot\sin(\phi i-i\_int-\theta i)}{\cos(\phi wi-\omega+\theta i)\cdot\cos(\omega+i\_int)}$$

$$\Delta r := \frac{\sin(\phi r+\phi wr)\cdot\sin(\phi r-i\_ext-\theta r)}{\cos(\phi wr-\omega+\theta r)\cdot\cos(\omega+i\_ext)} \qquad \Delta r = 0.316$$

Dynamic earth pressure coefficient: Infill Soil

$$Kaei := \frac{\left(\frac{\cos(\phi i+\omega-\theta i)^2}{\cos(\theta i)\cdot\cos(\omega)^2\cdot\cos(\phi wi-\omega+\theta i)}\right)}{\left(1+\text{if}(\Delta i < 0, 0, \sqrt{\Delta i})\right)^2}$$

$Kaei := \text{if}(Ao = 0, 0, Kaei)$ $\quad Kaei = 0$

Retained Soil

$$Kaer := \frac{\left(\frac{\cos(\phi r+\omega-\theta r)^2}{\cos(\theta r)\cdot\cos(\omega)^2\cdot\cos(\phi wr-\omega+\theta r)}\right)}{\left(1+\text{if}(\Delta r < 0, 0, \sqrt{\Delta r})\right)^2}$$

$Kaer := \text{if}(Ao = 0, 0, Kaer)$ $\quad Kaer = 0$

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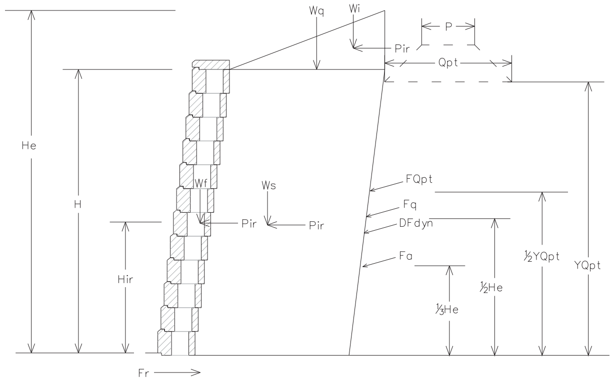
EXTERNAL STABILITY

Free Body Diagram



Where:
- He=Effective Wall Height
- H=Total Wall Height
- Wi=Weight of the Backslope
- Wq=Infill Surcharge Dead Load
- Wf=Weight of the Allan Block Facing
- Ws=Weight of the Geogrid Reinforced Soil Mass
- Pir=Seismic Inertial Force for For Each Gravity Force
- Hir=Pir Resultant Vertical Location
- P=Point Load Surcharge
- Qpt=Translated Point Load
- DFdyn=Dynamic Earth Force
- Fq=Surcharge Force
- FQpt=Point Load Force
- YQpt=Translated Point Load Vertical Location
- Fa=Active Earth Force

concrete unit weight: $\gamma c := 135\cdot pcf$ unit fill unit weight: $\gamma uf := 120\cdot pcf$

DRIVING FORCE CALCULATIONS

ACTIVE EARTH FORCE:

$Fa := \frac{1}{2}\cdot Kar\cdot\gamma r\cdot He^2$ $\quad Fa = 960.661\cdot plf$

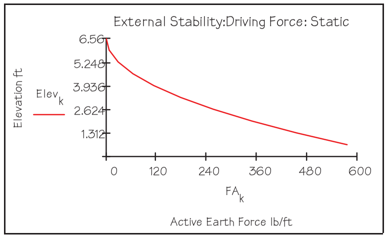
$Fah := Fa\cdot\cos(\phi wr)$ $\quad Fah = 902.726\cdot plf$

$Fav := Fa\cdot\sin(\phi wr)$ $\quad Fav = 328.565\cdot plf$

MOMENT ARMS:

$FaArmh := \frac{1}{3}\cdot He$ $\quad FaArmh = 2.541\,ft$

$FaArmv := L + s + \frac{1}{3}\cdot He\cdot\tan(\omega)$ $\quad FaArmv = 4.473\,ft$


External Stability:Driving Force: Static

DYNAMIC EARTH FORCE:

$Fae := \frac{1}{2}\cdot(1+Kv)\cdot Kaer\cdot\gamma r\cdot He^2$ $\quad Fae = 0\cdot plf$

$DFdyn := Fae - Fa$ $\quad DFdyn = -960.66\cdot plf$

$DFdyn := \text{if}\left(Ao = 0, 0\frac{lb}{ft}, DFdyn\right)$ $\quad DFdyn = 0\cdot plf$

$DFdynh := DFdyn\cdot\cos(\phi wr)$ $\quad DFdynh = 0\cdot plf$

$DFdynv := DFdyn\cdot\sin(\phi wr)$ $\quad DFdynv = 0\cdot plf$

MOMENT ARMS:

$DFdynArmh := 0.5\cdot He$ $\quad DFdynArmh = 3.811\,ft$

$DFdynArmv := L + s + 0.5\cdot He\cdot\tan(\omega)$ $\quad DFdynArmv = 4.618\,ft$

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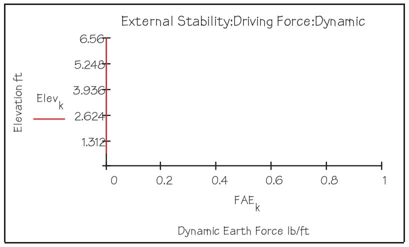

Determine the furthest point back from the toe of the wall that ANY surcharge will apply force to the wall (MaxPoint):

$$ss1 := \frac{H}{\tan\left(45 \cdot deg + \frac{\phi r}{2}\right)} \qquad ss2 := \frac{(ss1 + L + s - t - H \cdot \tan(\omega)) \cdot \tan(i\_ext) \cdot \sin(90 \cdot deg + i\_ext)}{\sin\left(45 \cdot deg + \frac{\phi r}{2} - i\_ext\right)} \cdot \cos\left(45 \cdot deg + \frac{\phi r}{2}\right)$$

$ss1 = 3.787\,ft$

$MaxPoint := L + s + ss1 + ss2$ $\qquad MaxPoint = 8.447\,ft$ $\qquad ss2 = 0.476\,ft$

If the surcharge is behind the mass determine the distance from the back of the mass to the face of the square foot surcharge (qx1):

$qx1 := [qx - (t + H \cdot \tan(\omega))] \cdot \tan(i\_ext)$ $\qquad qx1 = 0.77\,ft$

Determine the effective height of the square foot surcharge if the force is behind the mass (Yq_sf):

$$Yq\_sf := \left[(H + qx1) - (qx - L - s) \cdot \left(\tan\left(45 \cdot deg + \frac{\phi r}{2}\right)\right)\right] \cdot \left[1 + \sin\left(45 \cdot deg + \frac{\phi r}{2}\right) \cdot \left(\frac{\sin(90 \cdot deg + \omega) \cdot \tan(\omega)}{\sin\left(45 \cdot deg + \frac{\phi r}{2} - \omega\right)}\right)\right] \qquad Yq\_sf = 0.807\,ft$$

Determine the end of grid at the top of the wall:

$Endg := L + s + H \cdot \tan(\omega)$ $\qquad Endg = 4.933\,ft$

Determine the effective height of the square foot surcharge to use if the force is behind the mass (He_q):

$He\_q := if(qx < MaxPoint, if(qx < Endg, He, Yq\_sf), 0ft)$ $\qquad He\_q = 0.807\,ft$

Determine the end of grid at the effective height of the square foot surcharge:

$EndgYq\_sf := L + s + He\_q \cdot \tan(\omega)$ $\qquad EndgYq\_sf = 4.275\,ft$

SQUARE FOOT SURCHARGE INLUENCE:

If the square foot surcharge acts above the mass the applied load is the q as input above. If the surcharge is applied only behind the mass the load is translated down into the soil to a point at which the force lines intersect the back of the mass. This translation through the soil causes the load to be distributed over a larger footprint. Because the square foot surcharge does not have an ending point like the x2 in the point load calculations the applied load is truncated at the Maxpoint location. The following, q_sfi. equation calculates the translated square foot surcharge.

$$q\_sfi := \frac{q \cdot (MaxPoint - qx)}{[(qx - EndgYq\_sf) \cdot 2 + (MaxPoint - qx)]} \qquad q\_sfi = 5.658 \cdot psf$$

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Surcharge based on its position relative to the reinforced mass:

$q\_sf := if(qx < MaxPoint, if(qx < Endg, q, q\_sfi), 0psf)$ $\qquad q\_sf = 5.658 \cdot psf$

SQUARE FOOT SURCHARGE FORCE:

$Fq := if(qx < MaxPoint, if(qx < Endg, q \cdot Kar \cdot He, q\_sfi \cdot Kar \cdot He\_q), 0plf)$ $\qquad Fq = 1.258 \cdot plf$

MOMENT ARMS:

$Fqh := Fq \cdot \cos(\phi wr)$ $\qquad Fqh = 1.182 \cdot plf$ $\qquad FqArmh := 0.5 \cdot He\_q$ $\qquad FqArmh = 0.403\,ft$

$Fqv := if(xq = 2, Fq \cdot \sin(\phi wr), 0plf)$ $\qquad Fqv = 0 \cdot plf$ $\qquad FqArmv := L + s + 0.5 \cdot He\_q \cdot \tan(\omega)$ $\qquad FqArmv = 4.229\,ft$

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POINT LOAD SURCHARGE:

If the surcharge is behind the mass determine the distance from the back of the mass to the face of the square foot surcharge (Qx1):

$Qx1 := [x1 - (t + H \cdot \tan(\omega))] \cdot \tan(i\_ext)$

Determine the effective height of the square foot surcharge if the force is behind the mass (YQ_pt):

$$YQ\_pt := \left[(H + Qx1) - (x1 - L - s) \cdot \left(\tan\left(45 \cdot deg + \frac{\phi r}{2}\right)\right)\right] \cdot \left[1 + \sin\left(45 \cdot deg + \frac{\phi r}{2}\right) \cdot \left(\frac{\sin(90 \cdot deg + \omega) \cdot \tan(\omega)}{\sin\left(45 \cdot deg + \frac{\phi r}{2} - \omega\right)}\right)\right] \qquad YQ\_pt = 15.254\,ft$$

Determine the effective height of the point load surcharge to use if the force is behind the mass (He_Q):

$He\_Q := if(x1 < MaxPoint, if(x1 < Endg, He, YQ\_pt), 0ft)$ $\qquad He\_Q = 7.622\,ft$

Location of the end of the grid at the YQpt elevation:

$EndgYQ\_pt := L + s + He\_Q \cdot \tan(\omega)$ $\qquad EndgYQ\_pt = 5.054\,ft$

If the ending position of the point load surcharge (x2) is beyond the MaxPoint of influence the load is truncated at the MaxPoint location:

$x2 := if(x2 > MaxPoint, MaxPoint, x2)$ $\qquad x2 = 3.5\,ft$

If the point load surcharge acts above the mass the applied load is the P as input above. If the surcharge is applied only behind the mass the load is translated down into the soil to a point at which the force lines intersect the back of the mass. This translation through the soil causes the load to be distributed over a larger footprint. The following, Qpti. equation calculates the translated square foot surcharge.

$$Qpi := \frac{P \cdot (x2 - x1)}{(x2 - x1)} \qquad Qpi = 0 \cdot psf \qquad Qpti := \frac{P \cdot (x2 - x1)}{[(x1 - EndgYQ\_pt) \cdot 2 + (x2 - x1)]} \qquad Qpti = 0 \cdot psf$$

Point Load Surcharge Influence

If the point load contacts only with the reinforced mass it will add stability to the wall structure, therefore the loads are only considered in the internal stability calculations.

$$Qp := if\left(x2 \ge Endg, Qpi, 0\frac{lb}{ft^2}\right) \qquad Qp = 0 \cdot psf$$

If the point load contacts in beyond the reinforced mass and its influence zone buffer it will only affect the external stability. If it overlaps both the influence zone and retained soil it will effect both internal and external stability.

$Qpt := if(x1 \ge Endg, Qpti, Qpi)$ $\qquad Qpt = 0 \cdot psf$

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If the point load contact beyond the reinforced mass plus its influence zone buffer it will have no effect on the wall, Qpt=0.

$Qpt := \text{if}(x1 < MaxPoint, Qpt, 0psf)$ $Qpt = 0 \cdot psf$

Note:
Qpt is the translated distributed point load surcharge used to determine the point load force that will be influencing the external stability of the retaining wall structure. Qpt is a function of the location of the contact area with respect to the geogrid reinforcement. Qp will be used to calculate the point load surcharge if it acts directly on top of the reinforced soil. No translation calculations are necessary for Qp because its applications area is on top of the reinforced mass and its influence zone buffer.

POINT LOAD SURCHARGE FORCE:

$FQpt := Qpt \cdot Kar \cdot He\_Q$ $FQpt = 0 \cdot plf$

$FQpth := FQpt \cdot \cos(\phi wr)$ $FQpth = 0 \cdot plf$

$FQptv := \text{if}(Stype = 2, FQpt \cdot \sin(\phi wr), 0plf)$ $FQptv = 0 \cdot plf$

MOMENT ARM:

$FQptArmh := \frac{He\_Q}{2}$ $FQptArmh = 3.811\,ft$

$FQptArmv := L + s + .5 \cdot He\_Q \cdot \tan(\omega)$ $FQptArmv = 4.618\,ft$

POINT LOAD SURCHARGE WEIGHT:

$WQpt1 := Qpi \cdot (x2 - x1)$ $WQpt1 = 0 \cdot plf$

MOMENT ARM:

$WQptArm1 := x1 + \frac{(x2 - x1)}{2}$ $WQptArm1 = 1.75\,ft$

$WQpt2 := Qpi \cdot (Endg - x1)$ $WQpt2 = 0 \cdot plf$

$WQptArm2 := x1 + \left[\frac{(Endg - x1)}{2}\right]$ $WQptArm2 = 2.466\,ft$

$WQpt := \text{if}(x2 \le Endg, WQpt1, WQpt2)$

$WQptArm := \text{if}(x2 \le Endg, WQptArm1, WQptArm2)$

$WQptArm = 1.75\,ft$

$WQpt := \text{if}(x1 > Endg, 0plf, WQpt)$

$WQpt = 0 \cdot plf$

$WQp := \text{if}(Stype = 2, WQpt, 0plf)$ $WQp = 0 \cdot plf$

RESISTING FORCE CALCULATIONS:

WEIGHT OF THE BACKSLOPE:

$Wi := 0.5 \cdot \gamma r \cdot (He - H) \cdot [L - (t - s)]$

$Wi = 203.478 \cdot plf$

MOMENT ARM:

$WiArm := \frac{2}{3} \cdot [L - (t - s)] + H \cdot \tan(\omega) + t$

$WiArm = 3.868\,ft$

Determine the position of the square foot surcharge (qp):

$qp := \text{if}[qx < Endg, \text{if}[qx > H \cdot \tan(\omega) + t, (Endg) - qx, L - (t - s)], 0ft]$ $qp = 0\,ft$

MOMENT ARM for Weight of Dead Load Surcharge:

$WqArm := \text{if}\left[qx < Endg, \text{if}\left[qx > H \cdot \tan(\omega) + t, \frac{1}{2}qp + qx, \frac{1}{2} \cdot [L - (t - s)] + H \cdot \tan(\omega) + t\right], 0ft\right]$ $WqArm = 0\,ft$

WEIGHT OF THE DEAD LOAD SURCHARGE:

$Wq := \text{if}[xq = 2, (qp) \cdot q, 0plf]$ $Wq = 0 \cdot plf$

WEIGHT OF THE FACING:

$Wf := H \cdot t \cdot (c \cdot \gamma c + v \cdot \gamma uf)$ $Wf = 837.778 \cdot plf$

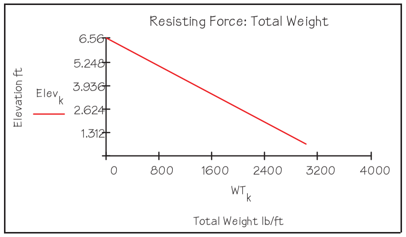
WEIGHT OF THE REINFORCED SOIL MASS:

$Ws := H \cdot [L - (t - s)] \cdot \gamma i$ $Ws = 2513.451 \cdot plf$

TOTAL WEIGHT:

$Wt := Wf + Ws$ $Wt = 3351.228 \cdot plf$

MOMENT ARM:
$WtArm := 0.5 \cdot (L + s) + 0.5 \cdot H \cdot \tan(\omega)$ $WtArm = 2.466\,ft$



SLIDING RESISTANCE:

$Frstatic := (Fav + Fqv + FQptv + Wi + Wq + Wf + Ws + WQp) \cdot \tan(\phi i)$ $Frstatic = 2242.008 \cdot plf$

$Frseismic := (Fav + DFdynv + Fqv + FQptv + Wi + Wq + Wf + Ws + WQp) \cdot \tan(\phi i)$ $Frseismic = 2242.008 \cdot plf$

SEISMIC INERTIAL FORCE:

The weight of each component of the wall structure has a horizontal inertial force acting at its centroid during a seismic event. The three components that have this inertial force are the block facing the reinforced soil mass and the backslope soil. The resultant Pir is the sum of all three. The weight of the reinforced soil mass and the backslope soil is based on a reinforcement length of 0.5H.

weight of the block face: $Wf = 837.778 \cdot plf$

weight of the reinforced soil mass: $Ws' := \left[0.5 \cdot H - (t - s)\right] \cdot \gamma i \cdot H$ $\quad Ws' = 1946.667 \cdot plf$

weight of the backslope soil: $Wi' := \frac{1}{2} \cdot \left[0.5 \cdot H - (t - s)\right]^2 \cdot \gamma r \cdot \tan(i)$ $\quad Wi' = 122.056 \cdot plf$

SEISMIC INERTIAL FORCE: $Pir := Khr \cdot (Wf + Ws' + Wi')$ $\quad Pir = 0 \cdot plf$

MOMENT ARM:

$$Hir := \frac{Khr \cdot Wf \cdot \frac{H}{2} + Khr \cdot Ws' \cdot \frac{H}{2} + Khr \cdot Wi' \cdot \left[H + \frac{1}{3} \cdot \left[0.5 \cdot H - (t - s)\right] \cdot \tan(i)\right]}{Pir} \qquad Hir = 0$$

EXTERNAL STABILITY FACTORS OF SAFETY

FACTOR OF SAFETY FOR SLIDING:

Static Conditions: FSstaticsliding>=1.5

$$FSstaticsliding := \frac{Frstatic}{Fah + Fqh + FQpth} \qquad FSstaticsliding = 2.48$$

Seismic Conditions: FSseicmicsliding>=1.1

$$FSseismicsliding := \frac{Frseismic}{Fah + DFdynh + Fqh + FQpth + Pir} \qquad FSseismicsliding = 2.48$$

FACTOR OF SAFETY FOR OVERTURNING:

Static Conditions: FSstaticoverturning>=2.0

$$FSstaticoverturning := \frac{Wt \cdot WtArm + Wi \cdot WiArm + Wq \cdot WqArm + WQp \cdot WQptArm + Fav \cdot FaArmv + Fqv \cdot FqArmv + FQptv \cdot FQptArmv}{Fah \cdot FaArmh + Fqh \cdot FqArmh + FQpth \cdot FQptArmh}$$

$FSstaticoverturning = 4.587$

Seismic Conditions: FSseismicoverturning>=1.5

$$numerator := Wt \cdot WtArm + Wi \cdot WiArm + Wq \cdot WqArm + WQp \cdot WQptArm + Fav \cdot FaArmv + Fqv \cdot FqArmv + FQptv \cdot FQptArmv + DFdynv \cdot DFdynArmv$$

$$FSseismicoverturning := \frac{numerator}{Fah \cdot FaArmh + DFdynh \cdot DFdynArmh + Fqh \cdot FqArmh + FQpth \cdot FQptArmh + Pir \cdot Hir}$$

$FSseismicoverturning = 4.587$

BEARING CAPACITY CALCULATIONS: Standard Method

Vertical Force Resultant:

$$R := Wf + Ws + Wi + Wq + Fav + DFdynv + Fqv + FQptv + WQpt \qquad R = 3883.271 \cdot plf$$

Location of the Resultant Force:

$$positive := Wt \cdot WtArm + Wi \cdot WiArm + Wq \cdot WqArm + WQpt \cdot WQptArm + Fav \cdot FaArmv + DFdynv \cdot DFdynArmv + Fqv \cdot FqArmv + FQptv \cdot FQptArmv$$

$$negative := Fah \cdot FaArmh + DFdynh \cdot DFdynArmh + Fqh \cdot FqArmh + FQpth \cdot FQptArmh + Pir \cdot Hir$$

$positive = 10522.08\,lb$

$negative = 2294.04\,lb$

$$x := \frac{positive - negative}{R} \qquad x = 2.119\,ft$$

Determine the eccentricity, E, of the resultant vertical force. If the eccentricity is negative the maximum bearing pressure occurs at the heal of the mass. Therefore, a negative eccentricity causes a decrease in preasure at the toe. For conservative calculations E will always be considered greater than or equal to zero.

$$E := 0.5 \cdot (L + s) - x \qquad E = -0.027\,ft \qquad E1 := if(E < 0ft, 0ft, E) \qquad E1 = 0\,ft$$

Determine the average bearing pressure acting at the centerline of the wall.

$$\sigma avg := \frac{R}{(L + s)} \qquad \sigma avg = 928.368 \cdot psf$$

Determine the moment about the centerline of the wall due to the resultant bearing load.

$$Mcl := R \cdot E1 \qquad Mcl = 0\,lb \cdot \frac{ft}{ft} \qquad \text{section modulus} \quad S := \frac{(1.0 \cdot ft) \cdot (L + s)^2}{6} \qquad S = 2.916\,ft^3$$

Differenced in bearing pressure due to the eccentric loading.

$$\sigma mom := \frac{Mcl \cdot 1 \cdot ft}{S} \qquad \sigma mom = 0 \cdot psf$$

therefore: $\sigma max := \sigma avg + |\sigma mom|$ $\quad \sigma max = 928.368 \cdot psf$

$\sigma min := \sigma avg - |\sigma mom|$ $\quad \sigma min = 928.368 \cdot psf$

Meyerhof Method:

Determine the effective length of the leveling pad

$$b := (L + s) - 2E1 \qquad b = 4.183\,ft$$

Determine the applied load on the leveling pad

$$Qa := \frac{(Wf + Ws + Wi + Wq + WQpt)}{b} \qquad Qa = 849.819 \frac{lb}{ft^2} \qquad \sigma max1 := if(bearing = 1, \sigma max, Qa) \qquad \sigma max1 = 928.368 \frac{lb}{ft^2}$$

ULTIMATE BEARING CAPACITY CALCULATION:

Meyerhof bearing capacity equation: $\sigma ult=1/2^*\gamma f^*Lwidth^*N\gamma + cf^*Nc + \gamma f^*(Ldepth+D)^*Nq$

Where:

$$Nq := (\exp(\pi \cdot \tan(\phi f))) \cdot \left(\tan\left(45 \cdot deg + \frac{\phi f}{2}\right)\right)^2 \qquad Nq = 18.401$$

$$Nc := (Nq - 1) \cdot \cot(\phi f) \qquad Nc = 30.14$$

$$N\gamma := (Nq - 1) \cdot \tan(1.4 \cdot \phi f) \qquad N\gamma = 15.668$$

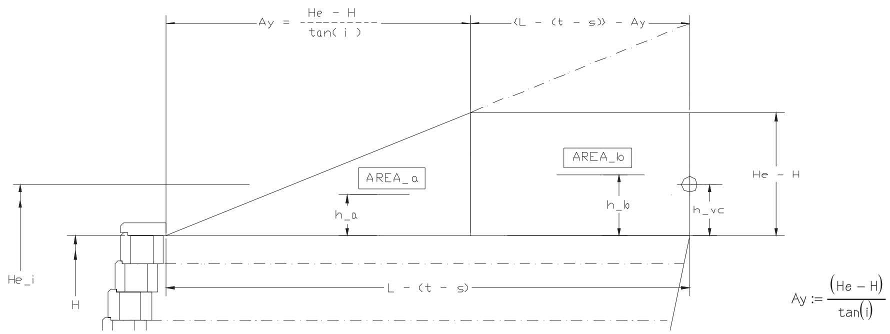
Therefore:

$$\sigma ult := \frac{1}{2} \cdot \gamma f \cdot Lwidth \cdot N\gamma + cf \cdot Nc + \gamma f \cdot (Ldepth + D) \cdot Nq \qquad \sigma ult = 5059.985 \cdot psf$$

Factor of safety:

$$FSbearing := \frac{\sigma ult}{\sigma max1} \qquad FSbearing = 5.45$$

INTERNAL STABILITY



$$Ay := \frac{(He - H)}{\tan(i)}$$

$Ay = 3.193\,ft$

Free Body Diagram

Where:
Gj =Depth to each geogrid layer

Acj =influence area of each geogrid layer

He_i =effective wall height for internal stability

h_vc = height above wall to the geometric vertical center of the slope

Area_a

$a := 0.5(He - H)\cdot(Ay)$ $\quad a = 1.696\,ft^2$

$h\_a := \frac{1}{3}(He - H)$ $\quad h\_a = 0.354\,ft$

$h\_vc := \left[\frac{(a\cdot h\_a + b\cdot h\_b)}{a + b}\right]$ $\quad h\_vc = 0.354\,ft$

Area_b

$b := (He - H)\cdot[[L - (t - s)] - Ay]$

$b = -0\,ft^2$

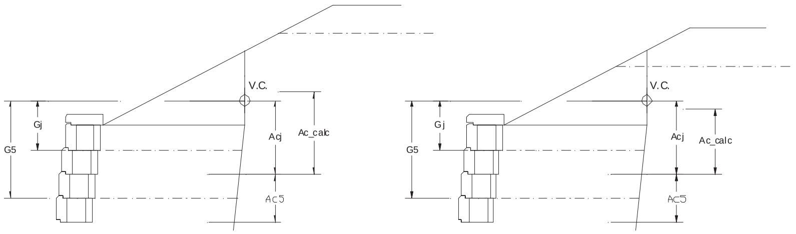
$h\_b := \frac{1}{2}(He - H)$ $\quad h\_b = 0.531\,ft$

Internal Effective Height: $He\_i := H + h\_vc$

$He\_i = 6.914\,ft$

Note:
For internal stability calculations sample calculations will be shown for grid layer #1. All other grid layers will be shown through tabular calculations at the end of this section.

DETERMINATION OF THE FORCE ACTING ON EACH GRID LAYER



STATIC LOADS, use the subscript "s"

$$a_i := \frac{(H + Sabove + grid_j\cdot h)}{2} \qquad b_i := \frac{(grid_j\cdot h + grid_{j-1}\cdot h)}{2}$$

$a_g = 6.482\,ft$ $\quad H = 6.56\,ft$ $\quad b_g = 5.248\,ft$

$Sabove = 0.5\,ft$ $\quad He\_i = 6.914\,ft$ $\quad www_j := if(a_g < He\_i, a_g - b_g, He\_i - b_g)$

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influence area:

$$Ac_j := if\left[j = 1, if\left(g < 2, He\_i, \frac{grid_{j+1}\cdot h + grid_j\cdot h}{2}\right), if\left[j = g, if\left(Grid\_Above = 1, www_j, He\_i - b_j\right), \frac{(grid_{j+1}\cdot h + grid_j\cdot h)}{2} - b_j\right]\right]$$

$Ac_1 = 1.312\,ft$

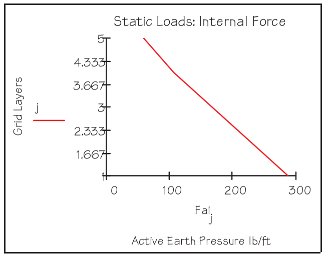
Determine the distance down to each layer of geogrid:

$$G_i := if\left(g < 2, He\_i - \sum Elev\_Grid, He\_i - grid_j\cdot h\right)$$

$G_1 = 6.258\,ft$

active earth pressure per grid layer:

$Fai_j := Kai\cdot\cos(\phi wi)\cdot\gamma i\cdot Ac_j\cdot G_j$ $\quad Fai_1 = 287.423\cdot plf$



surcharge pressure:

$Fqi_j := if(qx > Endg, 0plf, q\cdot Kai\cdot\cos(\phi wi)\cdot Ac_j)$ $\quad Fqi_1 = 0\cdot plf$

point load surcharge pressure:

$FQpti_j := if[x1 > Endg, 0plf, Qpi\cdot(Kai\cdot\cos(\phi wi))\cdot Ac_j]$ $\quad FQpti_1 = 0\cdot plf$

SEISMIC (DYNAMIC) LOADS: use the subscript, "d"

Inclination of Coulomb failure surface for internal stability (αi):

$$\alpha i := atan\left[\frac{-\tan(\phi i - i) + \sqrt{[\tan(\phi i - i)\cdot(\tan(\phi i - i) + \cot(\phi i + \omega))\cdot(1 + \tan(\phi wi - \omega)\cdot\cot(\phi i + \omega))]}}{1 + \tan(\phi wi - \omega)\cdot(\tan(\phi i - i) + \cot(\phi i + \omega))}\right] + \phi i$$

Weight of the active wedge in the infill zone: $\quad \alpha i = 47.955\cdot deg$

$$WAi := \frac{1}{2}\cdot\gamma i\cdot H^2\cdot\left(\frac{\sin(90deg - \omega - \alpha i)}{\sin(\alpha i)\cdot\cos(\omega)}\right)$$

$WAi = 2033.439\cdot plf$

Weight of the active wedge in the backslope:

$$D1 := \frac{H\cdot\sin(90deg - \omega - \alpha i)}{\cos(\omega)\cdot\sin(\alpha i)}$$

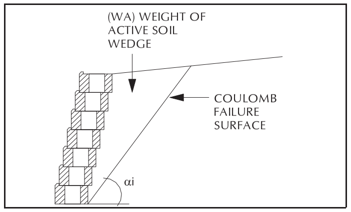
$D1 = 5.166\,ft$

$$D2 := \frac{D1\cdot\sin(i)\cdot\sin(\alpha i)}{\sin(\alpha i - i)}$$

$D2 = 2.455\,ft$

$$WAs := if\left(i > 0, \frac{1}{2}\cdot D1\cdot D2\cdot\gamma i, 0plf\right)$$

$WAs = 761.026\cdot plf$



dynamic earth pressure based on Active Wedge threoy:

$$DFdyni\_SW_j := Khi\cdot(WAi + WAs)\cdot\frac{Ac_j}{He\_i}$$

$DFdyni\_SW_1 = 0\cdot plf$ $\quad \sum DFdyni\_SW = 0\cdot plf$

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dynamic earth pressure based on Trapezoidal theory: $DFdyni\_Trap_j := (0.5) \cdot (Kaei - Kai) \cdot \cos(\phi wi) \cdot \gamma i \cdot He\_i \cdot Ac_j$

Active Wedge threoy:

$DFdyni\_SW_j =$

0
0
0
0
0

$\cdot plf$

Trapezoidal theory:

$DFdyni\_Trap_j =$

-201.622
-158.776
-158.776
-158.776
-158.776

$\cdot plf$

$greater_j := if\left(\sum DFdyni\_Trap > \sum DFdyni\_SW, DFdyni\_Trap_j, DFdyni\_SW_j\right)$

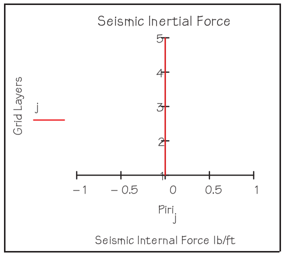
$DFdyni_j := if(SFAM = 1, DFdyni\_Trap_j, if(SFAM = 2, DFdyni\_SW_j, greater_j))$

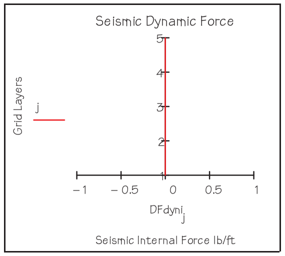
$DFdyni_1 = 0 \cdot plf$

$DynamicTheory_1 = \text{"Active Wedge Theory"}$

seismic inertial force:

$Piri_j := Khi \cdot t \cdot (c \cdot \gamma c + v \cdot \gamma uf) \cdot Ac_j$ $\qquad Piri_1 = 0 \cdot plf$

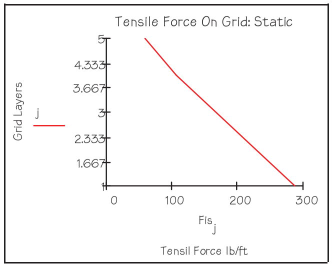




TENSILE FORCE ON EACH GRID:

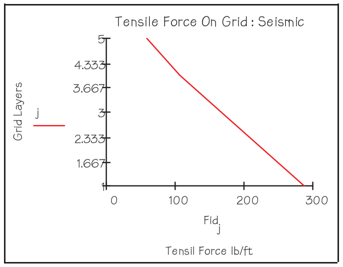
STATIC:

$Fis_j := Fai_j + Fqi_j + FQpti_j$ $\qquad Fis_1 = 287.423 \cdot plf$



SEISMIC:

$Fid_j := Fai_j + Fqi_j + FQpti_j + DFdyni_j + Piri_j$ $\qquad Fid_1 = 287.423 \cdot plf$



GEOGRID TENSILE OVERSTRESS

geogrid tensile strength

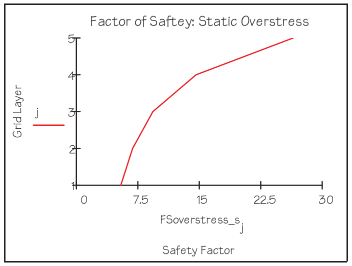
$LTDS_j := if(type_j = A, LTDS\_A, LTDS\_B)$ $\qquad LTDS_1 = 1558 \cdot plf$ $\qquad RFcr_j := if(type_j = A, RFcr\_A, RFcr\_B)$ $\qquad RFcr_1 = 1.67$

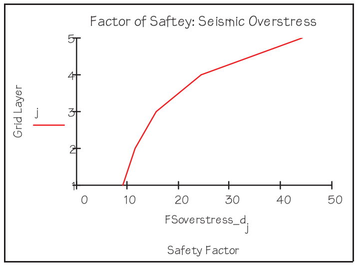
FACTOR OF SAFETY, Static:

$FSoverstress\_s_j := \frac{LTDS_j}{Fis_j}$ $\qquad FSoverstress\_s_1 = 5.421$

FACTOR OF SAFETY, Seismic:

$FSoverstress\_d_j := \frac{LTDS_j \cdot RFcr_j}{Fid_j}$ $\qquad FSoverstress\_d_1 = 9.052$





GEOGRID/BLOCK CONNECTION CAPACITY

normal load: $N_j := (H - grid_j \cdot h) \cdot (c \cdot \gamma c + v \cdot \gamma uf) \cdot t$ $\qquad N_1 = 754 \cdot plf$

peak connection strength: $Fcs_j := if(type_j = A, if(N_j < Ninta, B1a + M1a \cdot N_j, B2a + M2a \cdot N_j), if(N_j < Nintb, B1b + M1b \cdot N_j, B2b + M2b \cdot N_j))$

Does calculated value exceed that maximum tested?: $Fcs_j := if(type_j = A, if(Fcs_j < Max\_A, Fcs_j, Max\_A), if(Fcs_j < Max\_B, Fcs_j, Max\_B))$

TUMBLED REDUCTION FACTOR

$TRF := if(TUMBLED = 1, 0.7, 1.0)$ $\qquad TRF = 1$

ASHLAR REDUCTION FACTOR

$ARF := if(ASHLAR = 1, 0.9, 1.0)$ $\qquad ARF = 1$

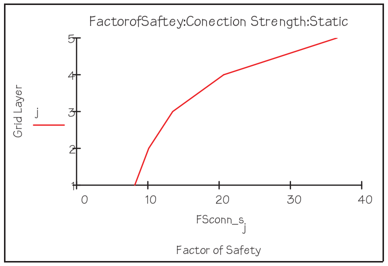
$Fcs_1 = 1566.563 \cdot plf$

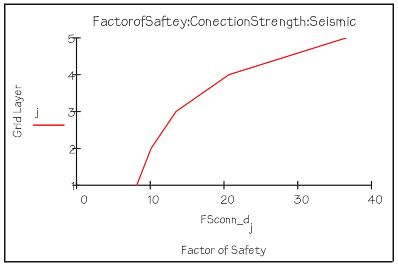
FACTOR OF SAFETY CONNECTION STRENGTH, Static:

$FSconn\_s_j := \frac{(TRF \cdot ARF) \cdot Fcs_j}{Fis_j \cdot 0.667}$ $\qquad FSconn\_s_1 = 8.171$

FACTOR OF SAFETY CONNECTION STRENGTH, Seismic

$FSconn\_d_j := \frac{(TRF \cdot ARF) \cdot Fcs_j}{Fid_j \cdot 0.667}$ $\qquad FSconn\_d_1 = 8.171$





GEOGRID PULLOUT FROM THE SOIL:

Equations for each segment of the line of maximum tension:

segment #1: y1=tan(45*deg+ϕ/2)*(x-t) where: x=distance to the line of maximum tension

segment #2: x=(H)*(0.3+tan(ω)+t)

Setting these two equations equal to each other yields the elevation of their intersection point:

$$y\_int := \tan\left(45\cdot deg + \frac{\phi i}{2}\right)\cdot\left[H\cdot\left(0.3+\tan(\omega)\right)\right] \qquad y\_int = 4.707\,ft$$

Therefore the length of geogrid embedded beyond the line of maximum tension is the following:

End of Geogrid Location

$$EG_j := length_j + s + \tan(\omega)\cdot\left(grid_j\cdot h\right) \qquad EG_1 = 4.258\,ft$$

Line of Maximum Tension for Bi-Linear - Static:

For geogrid elevation < yint

$$S\_MT1_j := \left(\frac{grid_j\cdot h}{\tan\left(45\cdot deg + \frac{\phi i}{2}\right)}\right) + t$$

For geogrid elevations > yint

$$S\_MT2_j := H\cdot\left(0.3+\tan(\omega)\right) + t$$

$$S\_MT_j := \mathrm{if}\left(grid_j\cdot h < y\_int, S\_MT1_j, S\_MT2_j\right) \qquad S\_MT_1 = 1.369\,ft$$

Line of Maximum Tension for Linear Plane - dynamic:

$$D\_MT_j := t + grid_j\cdot h\cdot\tan(90deg - \alpha i) \qquad D\_MT_1 = 1.582\,ft$$

geogrid embedment length - Static:

$$Le\_s_j := EG_j - S\_MT_j \qquad Le\_s_1 = 2.889\,ft$$

geogrid embedment length - dynamic:

$$Le\_d_j := EG_j - D\_MT_j \qquad Le\_d_1 = 2.676\,ft$$

surcharge geogrid length - Static:

$$Lq\_s_j := \mathrm{if}\left(qx < EG_j, \mathrm{if}\left(qx > S\_MT_j, EG_j - qx, S\_MT_j - qx\right), 0ft\right)$$

$$Lq\_s_j := \mathrm{if}\left(xq = 2, Lq\_s_j, 0ft\right) \qquad Lq\_s_1 = 0\,ft$$

surcharge geogrid length - dynamic:

$$Lq\_d_j := \mathrm{if}\left(qx < EG_j, \mathrm{if}\left(qx > D\_MT_j, EG_j - qx, D\_MT_j - qx\right), 0ft\right)$$

$$Lq\_d_j := \mathrm{if}\left(xq = 2, Lq\_d_j, 0ft\right) \qquad Lq\_d_1 = 0\,ft$$

point load geogrid length - Static:

For x1 < the line of maximum tension

$$LQpt1\_s_j := \mathrm{if}\left[x2 < EG_j, \mathrm{if}\left[\left(x2 - S\_MT_j\right) > 0\cdot ft, x2 - S\_MT_j, 0\cdot ft\right], Le\_s_j\right]$$

For x1 is between the line of maximum tension and the end of geogrid

$$LQpt2\_s_j := \mathrm{if}\left(x2 < EG_j, x2 - x1, EG_j - x1\right)$$

For x1 >the end of the geogrid

$$LQpt3\_s_j := 0\cdot ft$$

$$LQpt\_s_j := \mathrm{if}\left(x1 < S\_MT_j, LQpt1\_s_j, \mathrm{if}\left(x1 > EG_j, LQpt3\_s_j, LQpt2\_s_j\right)\right)$$

$$LQpt\_s_j := \mathrm{if}\left(Stype = 1, 0\cdot ft, LQpt\_s_j\right) \qquad LQpt\_s_1 = 0\,ft$$

point load geogrid length - dynamic:

For x1 < the line of maximum tension

$$LQpt1\_d_j := \mathrm{if}\left[x2 < EG_j, \mathrm{if}\left[\left(x2 - D\_MT_j\right) > 0\cdot ft, x2 - D\_MT_j, 0\cdot ft\right], Le\_d_j\right]$$

For x1 is between the line of maximum tension and the end of geogrid

$$LQpt2\_d_j := \mathrm{if}\left(x2 < EG_j, x2 - x1, EG_j - x1\right)$$

For x1 >the end of the geogrid

$$LQpt3\_d_j := 0\cdot ft$$

$$LQpt\_d_j := \mathrm{if}\left(x1 < D\_MT_j, LQpt1\_d_j, \mathrm{if}\left(x1 > EG_j, LQpt3\_d_j, LQpt2\_d_j\right)\right)$$

$$LQpt\_d_j := \mathrm{if}\left(Stype = 1, 0\cdot ft, LQpt\_d_j\right) \qquad LQpt\_d_1 = 0\,ft$$

Preliminary design calculations unless reviewed and certified by a local professional engineer.
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pullout capacity - Static:

$$Fpo\_s_j := 2\cdot Ci\cdot\tan(\phi i)\cdot\left[G_j\cdot\gamma i\cdot Le\_s_j + q\cdot\left(Lq\_s_j\right) + Qpi\cdot LQpt\_s_j\right] \qquad Fpo\_s_1 = 1753.698\cdot plf$$

pullout capacity - dynamic:

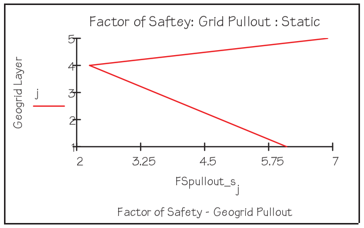
$$Fpo\_d_j := 2\cdot Ci\cdot\tan(\phi i)\cdot\left[G_j\cdot\gamma i\cdot Le\_d_j + q\cdot\left(Lq\_d_j\right) + Qpi\cdot LQpt\_d_j\right] \qquad Fpo\_d_1 = 1624.494\cdot plf$$

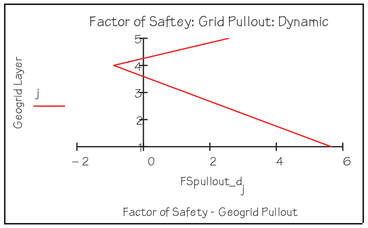
FACTOR OF SAFETY GEOGRID PULLOUT, static:

$$FSpullout\_s_j := \frac{Fpo\_s_j}{Fis_j} \qquad FSpullout\_s_1 = 6.101$$

FACTOR OF SAFETY GEOGRID PULLOUT, dynamic:

$$FSpullout\_d_j := \frac{Fpo\_d_j}{Fid_j} \qquad FSpullout\_d_1 = 5.652$$





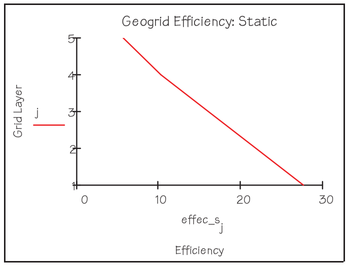
GEOGRID EFFICIENCY

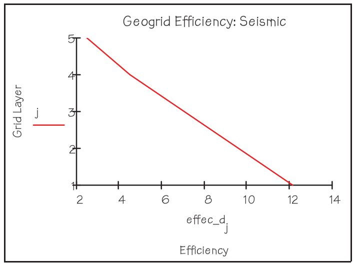
Static Conditions:

$$effec\_s_j := \frac{Fis_j}{LTDS_j\cdot\frac{1}{FSos\_s}}\cdot 100 \qquad effec\_s_1 = 27.672$$

Seismic Conditions:

$$effec\_d_j := \frac{Fid_j}{LTDS_j\cdot\frac{RFcr_j}{FSos\_d}}\cdot 100 \qquad effec\_d_1 = 12.151$$





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LOCALIZED STABILITY, TOP OF THE WALL STABILITY

LOCAL WALL PARAMETERS:

unreinforced height: $\mathrm{H\_top} := \mathrm{H} - \mathrm{grid}_g \cdot \mathrm{h}$ $\qquad \mathrm{H\_top} = 0.656\,\mathrm{ft}$

local weight of facing: $\mathrm{Wt\_top} := \mathrm{H\_top} \cdot \mathrm{t} \cdot (\mathrm{c} \cdot \gamma\mathrm{c} + \mathrm{v} \cdot \gamma\mathrm{uf})$ $\qquad \mathrm{Wt\_top} = 83.778 \cdot \mathrm{plf}$

SOIL AND SURCHARGE FORCES:

active force: $\mathrm{Fa\_top\_s} := \frac{1}{2} \cdot \mathrm{Kai} \cdot \gamma\mathrm{i} \cdot \mathrm{H\_top}^2$ $\qquad \mathrm{Fa\_top\_s} = 8.016 \cdot \mathrm{plf}$

$\mathrm{Fav\_top\_s} := \mathrm{Fa\_top\_s} \cdot \sin(\phi\mathrm{wi})$ $\qquad \mathrm{Fav\_top\_s} = 2.742 \cdot \mathrm{plf}$

$\mathrm{Fah\_top\_s} := \mathrm{Fa\_top\_s} \cdot \cos(\phi\mathrm{wi})$ $\qquad \mathrm{Fah\_top\_s} = 7.532 \cdot \mathrm{plf}$

dynamic force: $\mathrm{Fa\_top\_d} := \frac{1}{2} \cdot (1 + \mathrm{Kv}) \cdot \mathrm{Kaei} \cdot \gamma\mathrm{i} \cdot \mathrm{H\_top}^2$ $\qquad \mathrm{Fa\_top\_d} = 0 \cdot \mathrm{plf}$

$\mathrm{DFdyn\_top} := \mathrm{Fa\_top\_d} - \mathrm{Fa\_top\_s}$ $\qquad \mathrm{DFdyn\_top} = -8.016 \cdot \mathrm{plf}$ $\qquad \mathrm{DFdyn\_top} := \mathrm{if}(\mathrm{Ao} = 0, 0\mathrm{plf}, \mathrm{DFdyn\_top})$

$\mathrm{DFdyn\_top} = 0 \cdot \mathrm{plf}$

$\mathrm{DFdynv\_top} := \mathrm{DFdyn\_top} \cdot \sin(\phi\mathrm{wi})$ $\qquad \mathrm{DFdynv\_top} = 0 \cdot \mathrm{plf}$

$\mathrm{DFdynh\_top} := \mathrm{DFdyn\_top} \cdot \cos(\phi\mathrm{wi})$ $\qquad \mathrm{DFdynh\_top} = 0 \cdot \mathrm{plf}$

seismic inertial force: $\mathrm{Pir\_top} := \mathrm{Khi} \cdot (\mathrm{Wt\_top})$ $\qquad \mathrm{Pir\_top} = 0 \cdot \mathrm{plf}$

Determine the maximum point back where the any surcharge will not effect the wall:

$$\mathrm{ss\_top} := \frac{\mathrm{H\_top}}{\tan\left(45 \cdot \mathrm{deg} + \frac{\phi\mathrm{i}}{2}\right)} \qquad \mathrm{ss\_top} = 0.379\,\mathrm{ft}$$

surcharge force:

$$\mathrm{Fq\_top} := \mathrm{if}\left[\left[\mathrm{qx} - (\mathrm{H} \cdot \tan(\omega) + \mathrm{t})\right] < \mathrm{ss\_top}, \mathrm{q} \cdot \mathrm{Kai} \cdot \mathrm{H\_top}, 0\frac{\mathrm{lb}}{\mathrm{ft}}\right] \qquad \mathrm{Fq\_top} = 0 \cdot \mathrm{plf}$$

$\mathrm{Fqh\_top} := \mathrm{Fq\_top} \cdot \cos(\phi\mathrm{wi})$ $\qquad \mathrm{Fqh\_top} = 0 \cdot \mathrm{plf}$

$\mathrm{Fqv\_top} := \mathrm{if}(\mathrm{xq} = 2, \mathrm{Fq\_top} \cdot \sin(\phi\mathrm{wi}), 0\mathrm{plf})$ $\qquad \mathrm{Fqv\_top} = 0 \cdot \mathrm{plf}$

point load surcharge:

$$\mathrm{FQpt\_top} := \mathrm{if}\left[\left[\mathrm{x1} - (\mathrm{H} \cdot \tan(\omega) + \mathrm{t})\right] < \mathrm{ss\_top}, \mathrm{Qpt} \cdot \mathrm{Kai} \cdot \mathrm{H\_top}, 0\frac{\mathrm{lb}}{\mathrm{ft}}\right] \qquad \mathrm{FQpt\_top} = 0 \cdot \mathrm{plf}$$

$\mathrm{FQpth\_top} := \mathrm{FQpt\_top} \cdot \cos(\phi\mathrm{wi})$ $\qquad \mathrm{FQpth\_top} = 0 \cdot \mathrm{plf}$

$\mathrm{FQptv\_top} := \mathrm{if}(\mathrm{Stype} = 2, \mathrm{FQpt\_top} \cdot \sin(\phi\mathrm{wi}), 0\mathrm{plf})$ $\qquad \mathrm{FQptv\_top} = 0 \cdot \mathrm{plf}$

LOCAL SLIDNG RESISTANCE:

Total weight acting to resist sliding of the top of wall:

$\mathrm{Wtotalstatic} := \mathrm{Wt\_top} + \mathrm{Fav\_top\_s} + \mathrm{Fqv\_top} + \mathrm{FQptv\_top}$ $\qquad \mathrm{Wtotalstatic} = 86.519 \cdot \mathrm{plf}$

$\mathrm{Wtotalseismic} := \mathrm{Wt\_top} + \mathrm{Fav\_top\_s} + \mathrm{DFdynv\_top} + \mathrm{Fqv\_top} + \mathrm{FQptv\_top}$ $\qquad \mathrm{Wtotalseismic} = 86.519 \cdot \mathrm{plf}$

local sliding resistance: $\mathrm{Frt\_static} := \mathrm{if}(\omega < 6\mathrm{deg}, \mathrm{au3} + \mathrm{Wtotalstatic} \cdot \tan(\lambda\mathrm{u3}), \mathrm{au3} + \mathrm{Wtotalstatic} \cdot \tan(\lambda\mathrm{u3}))$ $\qquad \mathrm{Frt\_static} = 1174.085 \cdot \mathrm{plf}$

$\mathrm{Frt\_seismic} := \mathrm{if}(\omega < 6\mathrm{deg}, \mathrm{au3} + \mathrm{Wtotalseismic} \cdot \tan(\lambda\mathrm{u3}), \mathrm{au3} + \mathrm{Wtotalseismic} \cdot \tan(\lambda\mathrm{u3}))$ $\qquad \mathrm{Frt\_seismic} = 1174.085 \cdot \mathrm{p}$

FACTOR OF SAFETY LOCAL SLIDING, Static:

$$\mathrm{FSsliding\_s\_top} := \frac{\mathrm{Frt\_static}}{(\mathrm{Fa\_top\_s} + \mathrm{Fq\_top} + \mathrm{FQpt\_top}) \cdot \cos(\phi\mathrm{wi})} \qquad \mathrm{FSsliding\_s\_top} = 155.874$$

FACTOR OF SAFETY LOCAL SLIDING, Seismic:

$$\mathrm{FSsliding\_d\_top} := \frac{\mathrm{Frt\_seismic}}{(\mathrm{Fa\_top\_s} + \mathrm{DFdyn\_top} + \mathrm{Fq\_top} + \mathrm{FQpt\_top} + \mathrm{Pir\_top}) \cdot \cos(\phi\mathrm{wi})} \qquad \mathrm{FSsliding\_d\_top} = 155.874$$

FACTOR OF SAFETY LOCAL OVERTURNING, Static:

$$\mathrm{num1} := \mathrm{Wt\_top} \cdot \left[\frac{(\mathrm{H\_top} \cdot \tan(\omega))}{2} + \frac{\mathrm{t}}{2}\right] + \mathrm{Fav\_top\_s} \cdot \left(\frac{\mathrm{H\_top} \cdot \tan(\omega)}{3} + \mathrm{t}\right) + (\mathrm{Fqv\_top} + \mathrm{FQptv\_top}) \cdot \left(\frac{\mathrm{H\_top} \cdot \tan(\omega)}{2} + \mathrm{t}\right)$$

$$\mathrm{FSoverturning\_s\_top} := \frac{\mathrm{num1}}{\mathrm{Fah\_top\_s} \cdot \left(\frac{\mathrm{H\_top}}{3}\right) + \mathrm{Fqh\_top} \cdot \left(\frac{\mathrm{H\_top}}{2}\right) + \mathrm{FQpth\_top} \cdot \left(\frac{\mathrm{H\_top}}{2}\right)} \qquad \mathrm{FSoverturning\_s\_top} = 28.774$$

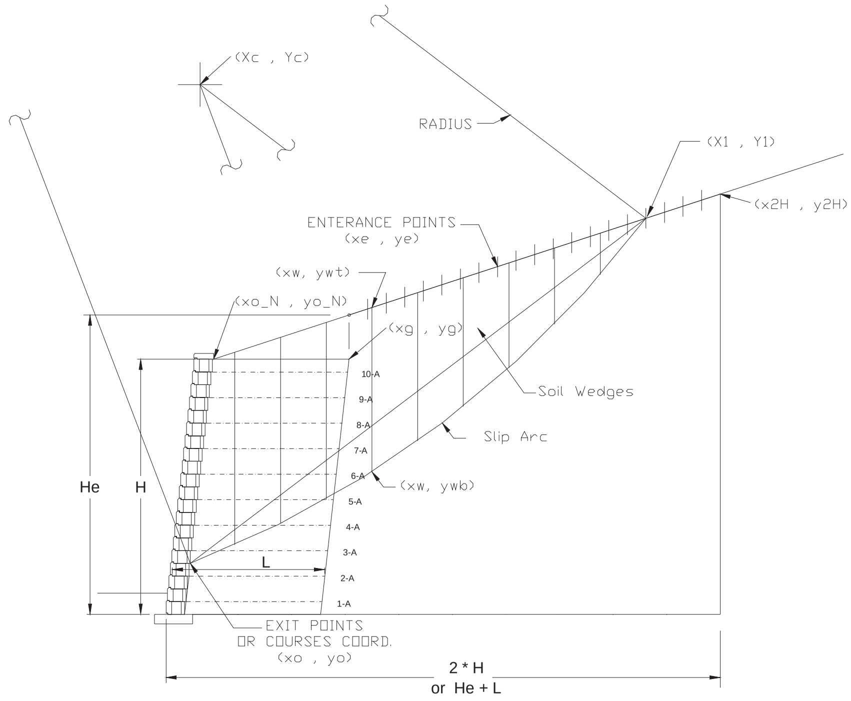
FACTOR OF SAFETY LOCAL OVERTURNING, Siesmic:

$\mathrm{num2} := \mathrm{num1} + \mathrm{DFdynv\_top} \cdot (0.6 \cdot \mathrm{H\_top} + \mathrm{t})$

$$\mathrm{FSoverturning\_d\_top} := \frac{\mathrm{num2}}{\mathrm{Fah\_top\_s} \cdot \left(\frac{\mathrm{H\_top}}{3}\right) + \mathrm{DFdynh\_top} \cdot (0.6 \cdot \mathrm{H\_top}) + \mathrm{Fqh\_top} \cdot \left(\frac{\mathrm{H\_top}}{2}\right) + \mathrm{FQpth\_top} \cdot \left(\frac{\mathrm{H\_top}}{2}\right) + \mathrm{Pir\_top} \cdot \left(\frac{\mathrm{H\_top}}{2}\right)}$$

$\mathrm{FSoverturning\_d\_top} = 28.774$

COMPOUND STABILITY CALCULATIONS



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COURSING COORDINATES

range of courses: $\quad courses := 0..n$

$xo_{courses} := t + courses \cdot h \cdot \tan(\omega) - h \cdot \tan(\omega)$

Block Courses courses =	Course coord. x0 xo = · ft	Course Coord y0 yo = · ft
0	0.915	0.000
1	0.990	0.656
2	1.065	1.312
3	1.140	1.968
4	1.215	2.624
5	1.290	3.280
6	1.365	3.936
7	1.440	4.592
8	1.515	5.248
9	1.590	5.904
10	1.665	6.560

Coordinates of Entrance Points (Equal to # of Courses):

	xe = · ft (0)	ye = · ft (0)
0	13.12	8.560
1	12.294	8.560
2	11.468	8.560
3	10.641	8.560
4	9.815	8.560
5	8.989	8.560
6	8.163	8.560
7	7.336	8.447
8	6.51	8.172
9	5.684	7.897
10	4.858	7.622
11		

Working point at top of Facing (PT):

$yo_{courses} := courses \cdot h$

$xo_n = 1.665\,ft$

$yo_n = 6.56\,ft$

Working point at back of Reinforced Mass (PTG):

$xg := xo_n + (L - t + s)$

$y\_g := yo_n + (L - t + s) \cdot \tan(i)$

$yg := if(y\_g > H + hi, H + hi, y\_g)$

$xg = 4.858\,ft \qquad yg = 7.622\,ft$

Working point at back of influeance zone (2H or H' + grid length - block embedment):

2H :

$x2H1 := 2 \cdot H \qquad x2H1 = 13.12\,ft$

$y2\_H1 := yo_n + (x2H1 - xo_n) \cdot \tan(i)$

$y2H1 := if(y2\_H1 > H + hi, H + hi, y2\_H1) \qquad y2H1 = 8.56\,ft$

He + grid length - block embedment:

$xH\_g := L + He \qquad xH\_g = 11.622\,ft$

$y\_H\_g := yo_n + (xH\_g - xo_n) \cdot \tan(i)$

$yH\_g := if(y\_H\_g > H + hi, H + hi, y\_H\_g) \qquad yH\_g = 8.56\,ft$

$x2H := if(x2H1 < xH\_g, xH\_g, x2H1) \qquad x2H = 13.12\,ft$

$y2H := if(x2H1 < xH\_g, yH\_g, y2H1) \qquad y2H = 8.56\,ft$

Determine twenty equal divisions between back of reinforced mass and the horizontal limit:

$$division := \frac{(x2H - xg)}{n} \qquad division = 0.826\,ft$$

$xe_{courses} := x2H - division \cdot courses$

$y\_e_{courses} := yo_n + (xe_{courses} - xo_n) \cdot \tan(i)$

$ye_{courses} := if(y\_e_{courses} > H + hi, H + hi, y\_e_{courses})$

Input Values from AB Walls:

$course = 0 \qquad FSi = 1.91$

$Xc = 0.75\,ft \qquad Yc = 13.22\,ft \qquad Radius = 13.22\,ft$

$xo_{course} = 0.915\,ft \qquad yo_{course} = 0\,ft$

$X1 = 13.12\,ft \qquad Y1 = 8.56\,ft$

Chord Geometry:

$$chord := \left[(X1 - xo_{course})^2 + (Y1 - yo_{course})^2\right]^{0.5} \qquad chord = 14.908\,ft$$

$$chordslope := \left(\frac{Y1 - yo_{course}}{X1 - xo_{course}}\right) \qquad anglechord := atan(chordslope)$$

$chordslope = 0.701 \qquad anglechord = 35.044 \cdot deg$

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Wedge Thicknesses Relative to Slip Arc:

Note: This calculation fixes the number of soil wedges to 20.

$w := 20$

$NoWedges := 0 .. w$

$$wedge\_thick := \frac{(X1 - xo_{course})}{w}$$

This is the thickness of each wedge Relative to the selected Slip Arc length:

$wedge\_thick = 0.61\,ft$

$Elev_{course} = 0\,ft$

$wedge\_thick = 0.61\,ft$

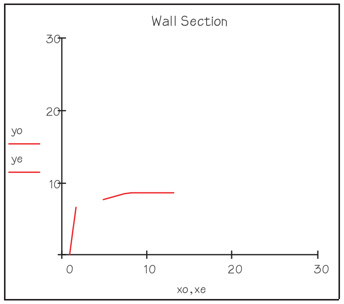
$xw_{NoWedges} := (wedge\_thick \cdot NoWedges) + xo_{course}$

$Radius = 13.22\,ft$

$$ywb_{NoWedges} := Yc - \left[Radius^2 - (xw_{NoWedges} - Xc)^2\right]^{0.5}$$

$yw\_t_{NoWedges} := yo_n + (xw_{NoWedges} - xo_n) \cdot \tan(i)$

$ywt_{NoWedges} := if(yw\_t_{NoWedges} > H + hi, H + hi, yw\_t_{NoWedges})$



$xo_{course-1} = ▮$

Coordinates of intersection points of Arcs and Vertical Wedges:

$ywb_{NoWedges} =$ (ft)
0.001
0.023
0.073
0.152
0.259
0.397
0.566
0.767
1.001
1.272
1.58
1.93
2.325
2.771
3.274
...

$ywt_{NoWedges} =$ (ft)
6.311
6.514
6.717
6.92
7.123
7.326
7.529
7.732
7.935
8.138
8.341
8.544
8.56
8.56
8.56
...

$xw_{NoWedges} =$ (ft)
0.915
1.525
2.136
2.746
3.356
3.966
4.577
5.187
5.797
6.407
7.018
7.628
8.238
8.848
9.459
10.069
...

Area of each of the 10 Wedges Relative to the chosen Arc Number:

$Area\_Wedge1 = 1.623\,ft^2$ $Area\_Wedge6 = 4.239\,ft^2$ $Area\_Wedge11 = 4.081\,ft^2$ $Area\_Wedge16 = 2.681\,ft^2$

$Area\_Wedge2 = 3.926\,ft^2$ $Area\_Wedge7 = 4.25\,ft^2$ $Area\_Wedge12 = 3.92\,ft^2$ $Area\_Wedge17 = 2.255\,ft^2$

$Area\_Wedge3 = 4.092\,ft^2$ $Area\_Wedge8 = 4.241\,ft^2$ $Area\_Wedge13 = 3.669\,ft^2$ $Area\_Wedge18 = 1.759\,ft^2$

$Area\_Wedge4 = 4.159\,ft^2$ $Area\_Wedge9 = 4.21\,ft^2$ $Area\_Wedge14 = 3.379\,ft^2$ $Area\_Wedge19 = 1.166\,ft^2$

$Area\_Wedge5 = 4.208\,ft^2$ $Area\_Wedge10 = 4.158\,ft^2$ $Area\_Wedge15 = 3.052\,ft^2$ $Area\_Wedge20 = 0.422\,ft^2$

$$\sum Area\_Wedge = 65.489\,ft^2$$

Wedge Properties:

α = Angle from Horizontal to bottom of each wedge.

θ = Angle from Horizontal to relitive Geogrid placment. Assumed to always be 0 degrees.

ϕ = Internal friction angle of either infill or retained soils.

γi = Unit weight of infill soil will be used for all Wedge weights.

Where : $m\_\alpha = \cos(\alpha) + [\,\sin(\alpha) * \tan(\phi)\,] / FS$

SURCHARGE PARAMETERS

Note: For Internal Compound Stability calculations, there will be no distinction between live and dead load surcharges. Both act on the sliding wedge in a similar way. The weight of all surcharges will be added to the weight of each particular soil wedge resulting in an addition to the resisting and sliding forces.

SQUARE FOOT SURCHARGE PARAMETERS

$q = 100 \cdot psf$

Weight of square foot surcharge per wedge:

$qx = 8\,ft$

$Wt\_Sf = q * wedge\_thick$

$Wt\_Sf_3 = 0 \cdot plf$

POINT LOAD SURCHARGE PARAMETERS

$P = 0 \cdot psf$

$x1 = 0$

$x2 = 3.5\,ft$

Weight of point load surcharge per wedge:

$Wt\_pt = Qpi * wedge\_thick$

$Wt\_pt_3 = 0 \cdot plf$

Total weight of surcharges:

$Wt\_Sur := Wt\_Sf + Wt\_pt$

SOIL WEDGE PARAMETERS

NoWedges =	Area_Wedge = (ft^2)	γ_{bbb} = (· pcf)	$Weight\_Wedge_{bbb}$ = (· plf)	Wt_Sur = (· plf)	α_{bbb} = (· deg)	θ = (· deg)	ϕ_{bbb} = (· deg)	$m\_\alpha1_{bbb}$ =
0	1.623	120	194.71	0	2.039	0	30	1.010
1	3.926	120	471.098	0	4.689	0	30	1.021
2	4.092	120	491.075	0	7.349	0	30	1.030
3	4.159	120	499.109	0	10.026	0	30	1.037
4	4.208	120	504.979	0	12.725	0	30	1.042
5	4.239	120	508.622	0	15.453	0	30	1.044
6	4.25	120	509.957	0	18.217	0	30	1.044
7	4.241	120	508.88	0	21.027	0	30	1.042
8	4.21	120	505.26	0	23.89	0	30	1.037
9	4.158	120	498.933	0	26.818	0	30	1.029
10	4.081	120	489.694	0	29.825	0	30	1.018
11	3.92	120	470.448	24	32.925	0	30	1.004
12	3.669	120	440.262	61	36.138	0	30	0.986
13	3.379	120	405.533	61	39.49	0	30	0.964
14	3.052	120	366.275	61	43.012	0	30	0.937
...	...	...	...	...	...	...	...	...

$\sum Weight\_Wedge = 7858.738 \cdot plf$ $\sum Wt\_Sur = 512 \cdot plf$

Sliding Resistance Due to Soil Weight, Surcharges and Soil Frictional Interaction:

$$Fr_{bbb} := \left(\frac{Weight\_Wedge_{bbb} + Wt\_Sur_{bbb-1}}{m\_\alpha1_{bbb}}\right) \cdot \tan(\phi_{bbb})$$

Fr_{bbb} = (· plf)
111.29
266.30
275.14
277.78
279.79
281.17
281.91
281.99
281.37
279.99
277.76
...

<u>Sum of Resisting Forces:</u>

$\sum Fr = 4919.04 \cdot plf$

<u>Lateral Sliding Force:</u>

$$Fs_{bbb} := (Weight\_Wedge_{bbb} + Wt\_Sur_{bbb-1}) \cdot \sin(\alpha_{bbb})$$

Fs_{bbb} = (· plf)
6.926
38.511
62.818
86.892
111.231
135.52
159.424
182.586
204.621
225.1
243.549
268.644
295.627
296.703
291.486
...

$\sum Fs = 3645.051 \cdot plf$

SEISMIC PARAMETERS

$Dyn\_CS := \sum Fs \cdot Khr$ $Dyn\_CS = 0 \cdot plf$

<u>Sum of Lateral Sliding Forces:</u>

$\sum Fs + Dyn\_CS = 3645.05 \cdot plf$

<u>GEOGRID INTERACTION</u>

$$xgrid1_k := if\left[Elev\_Grid_k \le Elev_{course}, 0ft, Xc + \left[\left[(Radius)^2 - (Elev_k - Yc)^2\right]\right]^{0.5}\right]$$

<u>Note:</u> geo course #0 represents the top of leveling pad.

$$ygrid1_k := if(geo_k > 0, if(xgrid1_k \le 0ft, 0ft, Elev_k), 0ft)$$

$$xgrid2_k := if(geo_k > 0, if(xgrid1_k \le 0ft, 0ft, xgrid1_k), 0ft)$$

<u>Coordinates of intersection points between Grid Layer elevation and Slip Arc:</u>

courses =	geo =	Course Elevation: Elev = (· ft)	ygrid1 = (· ft)	xgrid2 = (· ft)
0	0	0	0	0
1	1	0.656	0.656	4.863
2	0	1.312	0	0
3	2	1.968	1.968	7.69
4	0	2.624	0	0
5	3	3.28	3.28	9.466
6	0	3.936	0	0
7	4	4.592	4.592	10.766
8	0	5.248	0	0
9	5	5.904	5.904	11.761
10	0	6.56	0	0

Horizontal resistance Forces due to Geogrid layers at intersection with Slip Arc:

Note: The designer should determine the least amount of resisting force provided by each grid layer by calculating the resistance from both sides of the Slip Arc. The resisting force from the retained side is the embedment length (Le) combined with the confining pressure of the soil above. Simalarly, the sliding wedge side is figured by combining the connection strength of that layer with the confining soil pressure above the effected grid length.

Retained side of Slip Arc Calculation:

ygrid = Elevation of Geogrid Layer at intersection with Slip Arc

Le_grid_b = Length of Geogrid beyond intersection with Slip Arc (the "_b" indicates "beyond" the Slip Arc)

Ngrid_b = The weight or confining pressure from soil above Le_grid_b

$$Le\_grid1 := Glength - (xgrid2 - ygrid1 \cdot \tan(\omega)) \qquad Le\_grid\_b_k := if(xgrid2_k = 0 \cdot ft, 0 \cdot ft, if(Le\_grid1_k \le 0, 0 \cdot ft, Le\_grid1_k))$$

$$ygrid_k := if(Le\_grid\_b_k \le 0ft, 0ft, ygrid1_k) \qquad xgrid_k := if(ygrid_k = 0ft, 0ft, xgrid2_k)$$

Normal load above grid:

$$Ngrid\_b_k := if\left[ygrid_k \le 0 \cdot ft, 0 \cdot plf, \gamma i \cdot \left[\left[\left[yo_n + (xgrid1_k - xo_n) \cdot \tan(i\_int)\right] - ygrid_k\right] + \frac{\left[(xgrid1_k + Le\_grid\_b_k) \cdot \tan(i\_int)\right]}{2}\right] \cdot Le\_grid\_b_k\right]$$

$$Tgrid1_k := if\left(ygrid_k \le 0ft, 0 \cdot plf, \alpha pullout \cdot 2 \cdot Le\_grid\_b_k \cdot Ci \cdot \frac{Ngrid\_b_k}{1ft} \cdot \frac{\tan(\phi i)}{1.5}\right)$$

where: $\phi i = 30 \cdot deg$

Geogrid Layer strength is limited to it's LTDS:

$$Tgrid\_b_k := if\left(Tgrid1_k \le 0plf, 0plf, if\left(Tgrid1_k \ge LTDS_{geo_k}, LTDS_{geo_k}, Tgrid1_k\right)\right)$$

Allowable geogrid strength:

courses =	xgrid = (·ft)	ygrid = (·ft)	Le_grid_b = (·ft)	Ngrid_b = (·plf)	Tgrid_b = (·plf)
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0

Sum of Allowable grid strengths based on embedment depth beyond the Slip Arc:

$$Fg\_b := Tgrid\_b \cdot \cos(\alpha\_grid_w)$$

$$Fg\_b = 0 \cdot plf$$

Failure Wedge side of Slip Arc Calculation:

Soil resistance portion:

ygrid = Elevation of Geogrid Layer at intersection with Slip Arc

Le_grid_f = Length of Geogrid beyond intersection with Slip Arc (the "_f" indicates "in front" of the Slip Arc)

Ngrid_f = The weight or confining pressure from soil above Le_grid_b

$$Le\_grid2 := L - (t - s) - Le\_grid1 \qquad Le\_grid\_f_k := if(xgrid2_k = 0ft, 0ft, if(Le\_grid1_k \le 0.01ft, 0ft, Le\_grid2_k))$$

Normal load above grid:

$$Ngrid\_f_k := if\left[ygrid_k = 0 \cdot ft, 0 \cdot plf, \gamma i \cdot \left[\left[\left[yo_n + (xgrid2_k - xo_n) \cdot \tan(i\_int)\right] - ygrid_k\right] - \frac{\left[(xgrid2_k - xo_n) \cdot \tan(i\_int)\right]}{2}\right] \cdot Le\_grid\_f_k\right]$$

$$Tgrid2_k := if\left(ygrid_k \le 0ft, 0 \cdot plf, \alpha pullout \cdot 2 \cdot Le\_grid\_f_k \cdot Ci \cdot \frac{Ngrid\_f_k}{1ft} \cdot \frac{\tan(\phi i)}{1.5}\right)$$

where: $\phi i = 30 \cdot deg$

Geogrid Layer strength is limited to it's LTDS:

$$Tgrid\_f_k := if\left(Tgrid2_k \le 0plf, 0plf, if\left(Tgrid2_k \ge LTDS_{geo_k}, LTDS_{geo_k}, Tgrid2_k\right)\right)$$

Connection Capacity Portion:

$$Fcon\_f_k := if\left[Le\_grid\_f_k > 0ft, Fcs_{geo_k} \cdot (TRF \cdot ARF), 0plf\right]$$

Note: TRF and ARF are connection reductions for pattern walls and tumbled product.

Connection capacity:

courses =	xgrid = (ft)	ygrid = (ft)	Le_grid_f = (ft)	Ngrid_f = (·plf)	Tgrid_f = (·plf)	Fcon_f = (·plf)
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0

Allowable geogrid strength:

$$Fg\_f := Tgrid\_f \cdot \cos(\alpha\_grid_w)$$

$$Fg\_f = 0 \cdot plf$$

$$\sum Fcon\_f = 0 \cdot plf$$

Sum of Allowable resistance on Wedge side:

$$Fg\_f + \sum Fcon\_f = 0 \cdot plf$$

$$Fg := if\left(Fg\_b \le Fg\_f + \sum Fcon\_f, Fg\_b, \sum Fg\_f + \sum Fcon\_f\right)$$

Allowable Resisting force from Geogrid: $Fg = 0 \cdot plf$

GEOGRID LAYERS ABOVE THE WALL

Are there Geogrid layers above the wall? $Grid\_Above = 2$ 1 for Yes 2 for No

How far above the top block to the first layer of grid: $Sabove = 0.5\,ft$

$$Lga_{ga} = \begin{pmatrix} 12 \\ 12 \\ 12 \end{pmatrix} ft$$

$$type\_GA_{ga} = \begin{pmatrix} \text{"Miragrid 3XT"} \\ \text{"Miragrid 3XT"} \\ \text{"Miragrid 3XT"} \end{pmatrix}$$

How many layers above wall are required: $Gabove = 3$

Spacing between layers: $Spacing = 0.5\,ft$

Length of Grid and Type:

Starting and ending grid coordinates:

$$Elev\_GA_{ga} := if\left(Grid\_Above = 1, if\left(i\_int \le 0deg, 0ft, yo_n + Sabove + ga \cdot Spacing\right), 0ft\right)$$

$$Xga1_{ga} := if\left(Grid\_Above = 1, if\left(i\_int \le 0deg, 0ft, xo_n + \frac{Elev\_GA_{ga} - yo_n}{tan(i\_int)}\right), 0ft\right)$$

$$Xga2_{ga} := if\left(Grid\_Above = 1, if\left(i\_int \le 0deg, 0ft, Xga1_{ga} + Lga_{ga}\right), 0ft\right)$$

Geogrid intersection point with Slip-Arc: $xgrid\_ga_{ga} := if\left[Grid\_Above = 1, Xc + \left[\left|(Radius)^2 - \left(Elev\_GA_{ga} - Yc\right)^2\right|\right]^{0.5}, 0ft\right]$

Start of grid: End of grid:

$$Elev\_GA_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} ft \quad Xga1_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} ft \quad Xga2_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} ft \quad xgrid\_ga_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} ft$$

Grid Length in front of Slip-Arc:

$$Le\_GA\_f_{ga} := if\left(Xga1_{ga} \ge xgrid\_ga_{ga}, 0ft, if\left(Xga2_{ga} \le xgrid\_ga_{ga}, 0ft, xgrid\_ga_{ga} - Xga1_{ga}\right)\right)$$

Grid Length behind Slip-Arc:

$$Le\_GA\_b_{ga} := if\left(Xga1_{ga} \ge xgrid\_ga_{ga}, 0ft, if\left(Xga2_{ga} \le xgrid\_ga_{ga}, 0ft, Xga2_{ga} - xgrid\_ga_{ga}\right)\right)$$

Normal load above grid:

$$N\_GA\_f_{ga} := if\left[Le\_GA\_f_{ga} \le 0ft, 0plf, \frac{\gamma i \cdot \left[\left(xgrid\_ga_{ga} - Xga1_{ga}\right) \cdot Le\_GA\_f_{ga} \cdot tan(i\_int)\right]}{2}\right]$$

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$$Tgrid2\_GA\_f_{ga} := if\left(Le\_GA\_f_{ga} \le 0ft, 0 \cdot plf, \alpha pullout \cdot 2 \cdot Le\_GA\_f_{ga} \cdot Ci \cdot \frac{N\_GA\_f_{ga}}{1ft} \cdot \frac{tan(\phi i)}{1.5}\right)$$

Determine if the pullout of grid from soil is greater than the LTDS of the grid:

$$Tgrid\_GA\_f_{ga} := if\left(Le\_GA\_f_{ga} \le 0ft, 0plf, if\left(Tgrid2\_GA\_f_{ga} \ge LTDS_{Gabove}, LTDS_{Gabove}, Tgrid2\_GA\_f_{ga}\right)\right)$$

$$Le\_GA\_f_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} ft \quad N\_GA\_f_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf \quad Tgrid2\_GA\_f_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf \quad Tgrid\_GA\_f_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf \quad \alpha\_grid\_GA_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot deg$$

Allowable geogrid strength:

$$Fg\_GA\_f_{ga} := Tgrid\_GA\_f_{ga} \cdot cos\left(\alpha\_grid\_GA_{ga}\right)$$

$$Fg\_GA\_f_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf$$

Normal load above grid:

$$N\_GA\_b_{ga} := if\left[Le\_GA\_b_{ga} \le 0ft, 0plf, \gamma i \cdot \left[\frac{\left(Le\_GA\_f_{ga} \cdot tan(i\_int) + Lga_{ga} \cdot tan(i\_int)\right)}{2}\right] \cdot Le\_GA\_b_{ga}\right]$$

$$Tgrid2\_GA\_b_{ga} := if\left(Le\_GA\_b_{ga} \le 0ft, 0 \cdot plf, \alpha pullout \cdot 2 \cdot Le\_GA\_b_{ga} \cdot Ci \cdot \frac{N\_GA\_b_{ga}}{1ft} \cdot \frac{tan(\phi i)}{1.5}\right)$$

Determine if the pullout of grid from soil is greater than the LTDS of the grid:

$$Tgrid\_GA\_b_{ga} := if\left(Le\_GA\_b_{ga} \le 0ft, 0plf, if\left(Tgrid2\_GA\_b_{ga} \ge LTDS_{Gabove}, LTDS_{Gabove}, Tgrid2\_GA\_b_{ga}\right)\right)$$

$$Le\_GA\_b_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} ft \quad N\_GA\_b_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf \quad Tgrid2\_GA\_b_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf \quad Tgrid\_GA\_b_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf \quad \alpha\_grid\_GA_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot deg$$

Allowable geogrid strength:

$$Fg\_GA\_b_{ga} := Tgrid\_GA\_b_{ga} \cdot cos\left(\alpha\_grid\_GA_{ga}\right)$$

$$Fg\_GA\_b_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf$$

$$Fg\_GA_{ga} := if\left(Fg\_GA\_f_{ga} < Fg\_GA\_b_{ga}, Fg\_GA\_f_{ga}, Fg\_GA\_b_{ga}\right)$$

$$Fg\_GA_{ga} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \cdot plf$$

Allowable Resisting force from Geogrids placed above the wall:

$$\sum Fg\_GA = 0 \cdot plf$$

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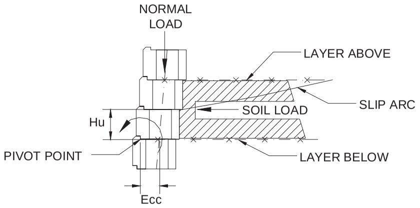
WALL FACING CONTRIBUTION

The Wall facing is subject to lateral forces from the soil load and a vertical normal load from the block facing. If the Slip Arc passes through the facing at a grid layer the shear strength of the Block-Grid-Block shear tests will be considered. If the Slip Arc passes between grid layers, we will determine the applied force on the back of the wall facing from the soil preasure between the upper and lower grid layers relative to the Slip Arc position. The combination of the Normal Load and Connection Strength will help form the resisting loads.

course = 0



NORMAL LOAD REQUIRED = (SOIL LOAD * Hu) / Ecc

Determine if the driving forces due to soil weight and surcharges exceed the resisting forced due to the soil friction and geogrid:

$Drg\_Frc := \sum Fs - \left(\sum Fr + Fg + \sum Fg\_GA\right)$ $\quad Drg\_Frc = -1273.989 \cdot plf$

If this value is POSITIVE the driving force has exceeded the resisting force and the sliding wedge has been mobilized. Then this net driving force should be applied to the back of the wall facing in the Wall Facing Contribution Section.

BLOCK SHEAR TEST RESULTS

Results are based on independent test lab findings.

NOTE: Block - Grid - Block AND Block - Block Shear Results are the same for AB Classic and AB Stones and slightly lower for AB Three, due to top lip configuration. Test values are on page 3:

User defined Shear Capacity: $Shear\_Capacity = 100 \cdot \%$

Block - Grid - Block SHEAR:

$Vu\_BGB_{course} := if\left(\omega < 6 \cdot deg, au3' + N\_CS_{course} \cdot tan(\lambda u3'), au' + N\_CS_{course} \cdot tan(\lambda u')\right)$

$Vu\_BGB_{course} = 3325.544 \cdot plf$ $\quad N\_CS_{course} = 837.778 \cdot plf$

NOTE: Arc Number zero exits between the bottom block and the base material, therefore the shear value will be the shear interaction between the block and base material soil.

$N\_CS_{courses} := (H - courses \cdot h) \cdot (c \cdot \gamma c + v \cdot \gamma uf) \cdot t$

Shear at Arc Number Zero:

$N\_CS_0 = 837.778 \cdot plf$

$Vo := N\_CS_0 \cdot tan(\phi lp)$

$Vo = 608.681 \cdot plf$

Determine if the calculated shear is greater than the allowed shear:

$Vu\_BGB_{course} := if\left(\omega < 6deg, if\left(Vu\_BGB_{course} > au3'\_max, au3'\_max, Vu\_BGB_{course}\right), if\left(Vu\_BGB_{course} > au'\_max, au'\_max, Vu\_BGB_{course}\right)\right)$

$Vu\_BGB_{course} := Vu\_BGB_{course} \cdot Shear\_Capacity$

$Vu\_BGB_{course} = 3325.544 \cdot plf$

Block - Block SHEAR:

$Vu\_BB_{course} := if\left(\omega < 6deg, au3 + N\_CS_{course} \cdot tan(\lambda u3), au + N\_CS_{course} \cdot tan(\lambda u)\right)$

$Vu\_BB_{course} = 3325.544 \cdot plf$

Note:
These equations are based on the Allan Block shear strength. The equations were developed through empirical test data and is a function of the normal load acting at that point.

Determine if the calculated shear is greater than the allowed shear:

$Vu\_BB_{course} := if\left(\omega < 6deg, if\left(Vu\_BB_{course} > au3\_max, au3\_max, Vu\_BB_{course}\right), if\left(Vu\_BB_{course} > au\_max, au\_max, Vu\_BB_{course}\right)\right)$

$Vu\_BB_{course} := Vu\_BB_{course} \cdot Shear\_Capacity$ $\quad Vu\_BB_{course} = 3325.544 \cdot plf$

Determine if the Slip Arc passes thought the facing at a grid layer:

$Grid\_Layer := if\left(Elev\_Grid_{course} = 0ft, "NO", "YES"\right)$ $\quad Grid\_Layer = "NO"$

$Vu := if\left(Grid\_Layer = "YES", Vu\_BGB_{course}, Vu\_BB_{course}\right)$

$Vu = 3325.544 \cdot plf$

Determine the applied force due to soil forces:

Elevation of Slip Arc above leveling pad: $Elev_{course} = 0\,ft$ $\quad course = 0$ $\quad Grid\_Layer = "NO"$

Elevation of grid layer above Slip Arc: Distance Below grade:

$Layer\_Above = 0.656\,ft$ $\quad H\_Above := H - Layer\_Above$ $\quad H\_Above = 5.904\,ft$

$h = 0.656\,ft$ $\quad grid\_crs\_num\_Above := \dfrac{Layer\_Above}{h}$ $\quad grid\_crs\_num\_Above = 1$

Elevation of grid layer below Slip Arc: Distance Below grade:

$Layer\_Below = 0\,ft$ $\quad H\_Below := H - Layer\_Below$ $\quad H\_Below = 6.56\,ft$

$grid\_crs\_num\_Below := \dfrac{Layer\_Below}{h}$ $\quad grid\_crs\_num\_Below = 0$

Soil Load between grid layers or driving from above if applicable:

$$Soil\_Load := if\left[Grid\_Layer = "YES", 0 \cdot plf, if\left[Drg\_Frc > 0 \cdot plf, Drg\_Frc, \gamma i \cdot Kai \cdot \frac{H\_Above + H\_Below}{2} \cdot (H\_Below - H\_Above)\right]\right]$$

$Soil\_Load = 152.298 \cdot plf$

Geogrid / Block Connection Capacity at Grid layer above Slip-Arc:

$N_{grid\_crs\_num\_Above} := (H - grid\_crs\_num\_Above \cdot h) \cdot (c \cdot \gamma c + v \cdot \gamma uf) \cdot t$ $\quad N_{grid\_crs\_num\_Above} = 754 \cdot plf$

$na := N_{grid\_crs\_num\_Above}$

$Fcs_{grid\_crs\_num\_Above, j} := if\left(type_j = A, if\left(na < Ninta, B1a + M1a \cdot na, B2a + M2a \cdot na\right), if\left(na < Nintb, B1b + M1b \cdot na, B2b + M2b \cdot na\right)\right)$

$Fcon := Fcs_{grid\_crs\_num\_Above, 1} \cdot TRF \cdot ARF$ $\quad Fcon = 1566.563 \cdot plf$ $\quad course = 0$

Normal load required to prevent overturning:

$$Nreq := \frac{\left[Soil\_Load \cdot \left(Elev_{course} - Layer\_Below\right) - \left(\frac{Fcon}{1.5}\right) \cdot (Layer\_Above - Layer\_Below)\right]}{\frac{t}{2}}$$

$Nreq = -1384.061 \cdot plf$ $\quad N\_CS_{course} = 837.778 \cdot plf$

aaa = "Actual normal load exceeds the required, therefore the Block Shear can be used"

Therefore : $Vu := if\left(N\_CS_{course} \ge Nreq, Vu, 0plf\right)$ $\quad Vu = 3325.544 \cdot plf$

Distribution of Connection Strength at facing:

Above Slip Arc: $p := 0 .. \frac{32in}{h}$

$$G1_p := if\left[Elev\_Grid_{course+p} > 0 \cdot ft, \frac{(32 \cdot in - p \cdot h)}{32in} \cdot qqq_{course+p}, 0plf\right]$$

$$G1 = \begin{bmatrix} 0 \\ 1181.188 \\ 0 \\ 401.906 \\ 0 \end{bmatrix} \cdot plf$$

$$\sum G1 = 1583.095 \cdot plf$$

Below Slip Arc: $p1 := 1 .. \frac{32in}{h}$

$$G2_{p1} := if\left[Elev_{course} - p1 \cdot h \le 0 \cdot ft, 0 \cdot plf, if\left[Elev\_Grid_{course-p1} > 0 \cdot ft, \frac{(32 \cdot in - p1 \cdot h)}{32 \cdot in} \cdot qqq_{course-p1}, 0plf\right]\right]$$

$$G2_{p1} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \cdot plf \qquad \sum G2 = 0 \cdot plf$$

Frictional portion of base material (Vo): $Vo = 608.681 \cdot plf$

$$B\_Vo := if\left[Elev_{course} \ge 32 \cdot in, 0 \cdot plf, \frac{(32 \cdot in - course \cdot h)}{32 \cdot in} \cdot Vo\right]$$

$B\_Vo = 608.681 \cdot plf$

Sum of Connection Contribution: $Conn := \sum G1 + \sum G2 + B\_Vo$ $Conn = 2191.776 \cdot plf$

Determine the lesser of bock Shear OR Connection Contribution:

$Facing := if(Vu > Conn, Conn, Vu)$ $Facing = 2191.776 \cdot plf$

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Safety Factor againest Compound Failure for Arc Number:

Note: All resisting forces are summed in the numerator and the sliding forces are summed in the denominator. This ratio is the Safety Factor for internal Compound Stability.

$$SF\_slip\_Arc := \frac{\sum Fr + Facing + Fg + \sum Fg\_GA}{\sum Fs + Dyn\_CS}$$

Initial input Safety Factor from AB Walls 2010:

$FSi = 1.91$

$SF\_slip\_Arc = 1.951$

$\sum Fr = 4919.04 \cdot plf$ $Facing = 2191.776 \cdot plf$

$\sum Fs = 3645.051 \cdot plf$ $Fg = 0 \cdot plf$ $\sum Fg\_GA = 0 \cdot plf$ $Dyn\_CS = 0 \cdot plf$

Compound Stability Summary:

Relative data for analyzed Slip Arc:

$course = 0$

Exit elevation above Base Material:

$Elev_{course} = 0 ft$

Initial Safety Factor for instability:

$FSi = 1.91$

Iterated Safety Factor for instability:

$SF\_slip\_Arc = 1.951$

Enterance coordinates:

$X1 = 13.12 ft$ $Y1 = 8.56 ft$

Coordinates for center of Slip Arc Circle:

$Xc = 0.75 ft$ $Yc = 13.22 ft$

Radius of Slip Arc Circle:

$Radius = 13.22 ft$

$\sum Weight\_Wedge = 7858.738 \cdot plf$

$\sum Wt\_Sur = 512 \cdot plf$

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SUMMARY OF RESULTS

DESIGN PARAMETERS:

Wall Height: $H = 6.56$ ft

Block Setback: $\omega = 6.52 \cdot$ deg

Backslope Angle: $i = 18.4 \cdot$ deg

Backslope Height: $hi = 2$ ft

Surcharge Load: $q = 100 \cdot$ psf

Point Load Surcharge: $P = 0 \cdot$ plf

Point Load Location: $x1 = 0$

$x2 = 3.5$ ft

Seismic Coefficient: $Ao = 0$

Allowable Deflection: $di = 0.25$ ft $dr = 0.25$ ft

SOIL PARAMETERS:

Infill Soil: $\phi i = 30 \cdot$ deg Retained Soil: $\phi r = 30 \cdot$ deg Foundation Soil: $\phi f = 30 \cdot$ deg

$\gamma i = 120 \cdot$ pcf $\gamma r = 120 \cdot$ pcf $\gamma f = 120 \cdot$ pcf

$cf = 0 \cdot$ psf

SurType = "Retained Soil Dead Load"

SurTypePoint = "Live Load"

Controlling Dynamic Earth Pressure Theory:

$DynamicTheory_1$ = "Active Wedge Theory"

BLOCK TYPE AND PATTERN:

BlockType = "AB COLLECTION"

BlendType = "NO PATTERN"

GEOGRID PARAMETERS:

Geogrid Type A: A = "Miragrid 3XT"

Geogrid Type B: B = "Miragrid 5XT"

Number of Layers: $g = 5$ Layers

Geogrid Length: $L = 4$ ft

$Ltop = 7$ ft

EXTERNAL STABILITY:

Static Conditions:

Factor of Safety for Sliding: FSstaticsliding = 2.48

Factor of Safety for Overturning: FSstaticoverturning = 4.587

Seismic Conditions:

Factor of Safety for Sliding: FSseismicsliding = 2.48

Factor of Safety for Overturning: FSseismicoverturning = 4.587

Bearing Capacity:

Ultimate Bearing Capacity: $\sigma ult = 5060 \cdot$ psf

Bearing pressure: $\sigma max = 928.368 \cdot$ psf

Factor of Safety: FSbearing = 5.45

Leveling Pad Dimensions:

Width of pad: $Lwidth = 2.0 \cdot$ ft

Toe Extension: $Ltoe = 0.5 \cdot$ ft

Depth of pad: $Ldepth = 0.5 \cdot$ ft

Width of Reinforcement:

$Lgrid = 0 \cdot$ ft

When reinforcement is present it shall always be placed 6in from the bottom of the pad.

Note:
The minimum pad dimensions are 6in deep by 24in wide. If the values specifying the pad dimensions are not greater than 6in X 24in, the minimum size should be used. When geogrid reinforcement is present the minimum pad depth shall be 12in to provide 6in of minimum cover above and below the geogrid.

INTERNAL STABILITY: Local Top of the Wall Stability

Static Conditions:

Factor of Safety for Sliding: FSsliding_s_top = 155.87

Factor of Safety for Overturning: FSoverturning_s_top = 28.77

Seismic Conditions:

Factor of Safety for Sliding: FSsliding_d_top = 155.87

Factor of Safety for Overturning: FSoverturning_d_top = 28.77

INTERNAL STABILITY:

Static Conditions:

Geogrid Length: $L = 4$ ft $Ltop = 7$ ft

Geogrid Number $j =$	Geogrid Elev. $Ee_j =$ (ft)	Tensile Force $Fis_j =$ ($\cdot$ plf)	Allowable Load $\frac{LTDS_j}{FSos\_s} =$ ($\cdot$ plf)	Factor Safety Overstress $FSoverstress\_s_j =$	Factor Safety Pullout Block: $FSconn\_s_j =$	Factor Safety Pullout, Soil: $FSpullout\_s_j =$	Geogrid Efficiency, % $effec\_s_j =$
5	5.904	58.908	1038.667	26.448	36.554	6.902	5.672
4	4.592	106.648	1038.667	14.609	20.649	2.252	10.268
3	3.28	166.906	1038.667	9.335	13.487	3.535	16.069
2	1.968	227.164	1038.667	6.858	10.124	4.818	21.871
1	0.656	287.423	1038.667	5.421	8.171	6.101	27.672