Analysis of a 2'-8'' Murata Retaining Wall with No Surcharge and Level Backfill

These calculations are written and derived using a per foot width of retaining wall.

Soil Properties

The following soil values are used for example purposes only and shall NOT be used for individual wall designs without consulting a geotechnical engineer for site conditions and soil values.

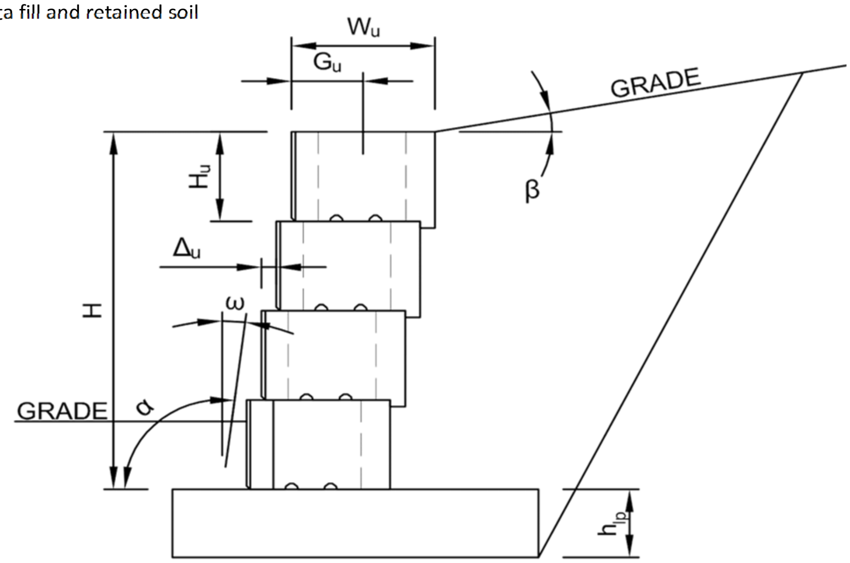
Murata Fill

Φ_i =	36	°	Peak friction angle of the Murata fill
γ_c =	125	pcf	Density of compacted Murata fill

Retained Soil

Φ_r =	26	°	Peak friction angle for the retained soil
γ_r =	110	pcf	Density of the retained soil
Bearing =	1500	psf	Bearing capacity of the retained soil

Calculate the mobilized interface friction factor for the Murata fill and retained soil



Murata Fill

$\delta_c = 2/3\Phi_i$

$= 2/3(36°)$

$= 24.0$ °

Retained Soil

$\delta_r = 2/3\Phi_i$

$= 2/3(26°)$

$= 17.3$ °

Miscellaneous Properties and Loads

PGA_m =	0.427		from USGS detailed printout
K_v =	0	g	Assume 0
q_d =	0	psf	Dead load surcharge
q_l =	0	psf	Live load surcharge

Wall and Block Properties

H =	2.625	ft	Height of wall
H_u =	0.656	ft	Segmental Retaining Wall (SRW) unit height
W_u =	0.968	ft	SRW unit width
D_u =	1.312	ft	SRW unit depth
h_{lp} =	0.5	ft	Leveling pad depth
γ_u =	120.8	pcf	SRW average density of SRW unit and Murata Fill
G_u =	0.484	ft	SRW unit center of gravity from the front face of the unit
Δ_u =	0.101	ft	Setback per course
μ_{SRW} =	0.74		Unfactored coefficient of static friction between SRW units
μ_b =	0.7		Masonry Reduction Factor
β =	0.0	°	Back slope angle
a_u =	449	lbs	Tested shear capacity between SRW units.

Calculate the weight of a 1' wide strip of the wall.

$W_W = \gamma_u W_u H$(1' width)

= (120.8 pcf)(0.968')(2.625')(1')

= 307 lbs

Calculate the SRW wall batter angle from vertical.

$\omega = \text{Arctan}(\Delta_u/H_u)$

= Arctan(0.101'/0.656')

= 8.730 °

Calculate the SRW wall batter angle from the toe horizontal.

$\alpha = 90° + \omega$

$= 90° + 8.73°$

= 98.730 °

Soil Loading Coefficient

Calculate the active soil pressure coefficient induced on the wall by the Murata fill.

$$K_a = \frac{\sin^2(\Phi_i+\omega)}{\sin^2(\alpha)\sin(\alpha-\delta_C)(1+\sqrt{(\sin(\Phi_i+\delta_C)\sin(\Phi_i-\beta))/(\sin(\alpha-\delta_C)\sin(\beta+\alpha))})^2}$$

$$= \frac{\sin^2(36°+8.73°)}{\sin^2(98.73°)\sin(98.73°-24°)\quad [1+\sqrt{\frac{\sin(36°+24°)\sin(36°-0°)}{\sin(98.73°-24°)\sin(0°+98.73°)}}]^2}$$

$= 0.179$

Calculate the resultant active soil force induced on the wall by the Murata fill and its horizontal and vertical components.

$P_s = 0.5K_a\gamma_cH^2$	$P_{sH} = P_s\cos(\delta_i-\omega)$	$P_{sV} = P_s\sin(\delta_c-\omega)$
$= 0.5(0.179)(125\text{ pcf})(2.625')^2$	$= (77\text{ lbs})\cos(24°-8.73°)$	$= (77\text{ lbs})\sin(24°-8.73°)$
= 77.0 lbs	= 74.3 lbs	= 20.3 lbs

Calculate the active soil pressure coefficient induced on the wall by the retained soil.

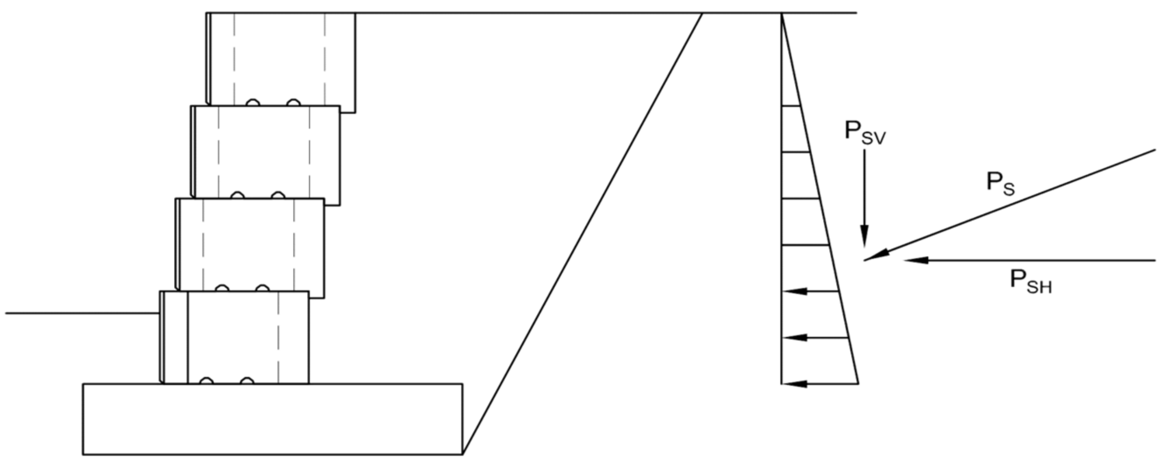
$$K_a = \frac{\sin^2(\Phi_r+\omega)}{\sin^2(\alpha)\sin(\alpha-\delta_r)(1+\sqrt{(\sin(\Phi_r+\delta_r)\sin(\Phi_r-\beta))/(\sin(\alpha-\delta_r)\sin(\beta+\alpha))})^2}$$

$$= \frac{\sin^2(26°+8.73°)}{\sin^2(98.73°)\sin(98.73°-17.3°)\quad [1+\sqrt{\frac{\sin(26°+17.3°)\sin(26°-0°)}{\sin(98.73°-17.3°)\sin(0°+98.73°)}}]^2}$$

$= 0.289$

Calculate the resultant active soil force induced on the wall by the retained soil and its horizontal and vertical components.

$P_s = 0.5K_a\gamma_rH^2$	$P_{sH} = P_s\cos(\delta_r-\omega)$	$P_{sV} = P_s\sin(\delta_r-\omega)$
$= 0.5(0.289)(110\text{ pcf})(2.625')^2$	$= (109.6\text{ lbs})\cos(17.3°-8.73°)$	$= (109.6\text{ lbs})\sin(17.3°-8.73°)$
= 109.6 lbs	= 108.4 lbs	= 16.4 lbs



Seismic Active Earth Force Coefficient

Calculate the variable, K_h and intermediate variable, θ.

$$K_h = (1.45\text{-}PGA_m)PGA_m/2 = 0.427(1.45-0.427)/2 = 0.218\ g$$

$$\theta = \arctan(k_h/(1-k_v)) = \arctan(0.218/(1-0)) = 12.3\ °$$

Calculate the active seismic and soil coefficient induced on the wall by the Murata fill.

$$K_{ae} = \frac{\sin^2(\Phi_i+\alpha-\theta)}{\cos(\theta)\sin^2(\alpha)\sin(\alpha-\theta-\delta_i)(1+\sqrt{((\sin(\Phi_i+\delta_i)\sin(\Phi_i-\theta-\beta))/(\sin(\alpha-\delta_i-\theta)\cos(\beta+\alpha))})^2}$$

$$= \frac{\sin^2(36°+98.73°-12.3°)}{\cos(12.3°)\sin^2(98.73°)\sin(98.73°-12.3°+24°)\quad [1+\sqrt{\frac{\sin(36°+24°)\sin(36°-12.3°-0°)}{\sin(98.73°-24°-12.3°)\sin(0°+98.73°)}}]^2}$$

$$= 0.317$$

Calculate the resultant active seismic and soil force induced on the wall by the Murata fill and its horizontal and vertical components.

$$P_{aE} = 0.5K_{ae}(1-k_v)\gamma_c H^2 = 0.5(0.317)(1-0)(125\ pcf)(2.625')^2 = 136.5\ lbs$$

$$P_{aEH} = P_{aE}\cos(\delta_i-\omega) = (136.5\ lbs)\cos(24°-8.73°) = 131.7\ lbs$$

$$P_{aEV} = P_{aE}\sin(\delta_c-\omega) = (136.5\ lbs)\sin(24°-8.73°) = 36.0\ lbs$$

Recall the resultant active soil force induced on the wall by the Murata fill and its components.

$P_s =$ 77.0 lbs $P_{sH} =$ 74.3 lbs $P_{sV} =$ 20.3 lbs

Calculate the resultant seismic force induced on the wall by the Murata fill and its horizontal and vertical components.

$$\Delta P_{aE} = P_{aE}-P_s = 136.5\ lbs-77\ lbs = 59.5\ lbs$$

$$\Delta P_{aEH} = P_{aE}-P_s = 131.7\ lbs-74.3\ lbs = 57.4\ lbs$$

$$\Delta P_{aEV} = P_{aE}-P_s = 36\ lbs-20.3\ lbs = 15.7\ lbs$$

Calculate the active seismic and soil coefficient induced on the wall by the retained soil. The following equation incorperates a phase shift of 90 degrees in some trigonometric functions as shown in The Principles of Foundation Engineering (1984).

$$K_{ae} = \frac{\sin^2(\Phi_r+\alpha-\theta)}{\cos(\theta)\sin^2(\alpha)\sin(\alpha-\theta-\delta_r)(1+\sqrt{((\sin(\Phi_r+\delta_r)\sin(\Phi_r-\theta-\beta))/(\sin(\alpha-\delta_r-\theta)\cos(\beta+\alpha))})^2}$$

$$= \frac{\sin^2(26°+98.73°-12.3°)}{\cos(12.3°)\sin^2(98.73°)\sin(98.73°-12.3°+17.3°)\quad [1+\sqrt{\frac{\sin(26°+17.3°)\sin(26°-12.3°-0°)}{\sin(98.73°-17.3°-12.3°)\sin(0°+98.73°)}}]^2}$$

$$= 0.476$$

Calculate the resultant active seismic and soil force induced on the wall by the retained soil and its horizontal and vertical components.

$$P_{aE} = 0.5K_{ae}(1-k_v)\gamma_r H^2 = 0.5(0.476)(1-0)(110\ pcf)(2.625')^2 = 180.3\ lbs$$

$$P_{aEH} = P_{aE}\cos(\delta_r-\omega) = (180.3\ lbs)\cos(17.3°-8.73°) = 178.3\ lbs$$

$$P_{aEV} = P_{aE}\sin(\delta_r-\omega) = (180.3\ lbs)\sin(17.3°-8.73°) = 27.0\ lbs$$

Recall the resultant active soil force induced on the wall by the retained soil and its components.

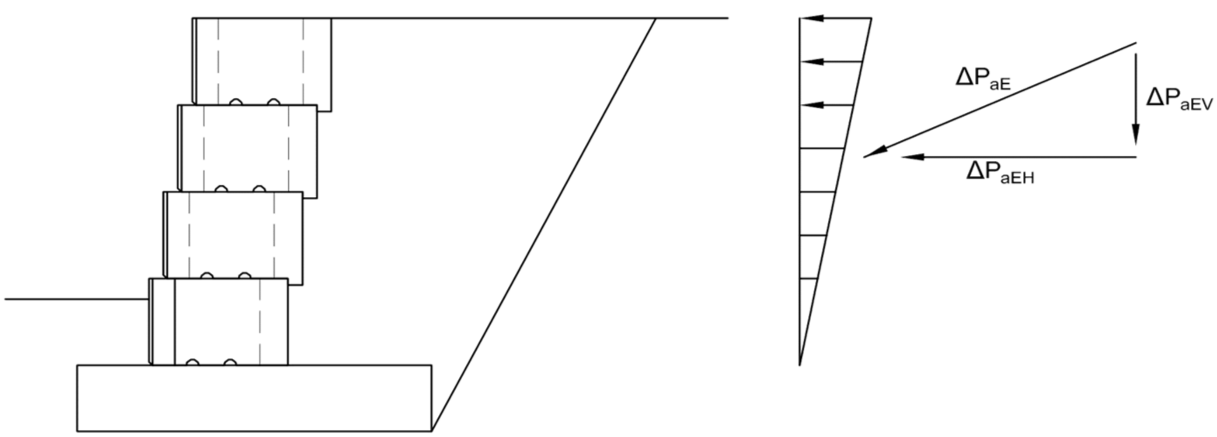
$P_s =$ 109.6 lbs $P_{sH} =$ 108.4 lbs $P_{sV} =$ 16.4 lbs

Calculate the resultant seismic force induced on the wall by the retained soil and its horizontal and vertical components.

$$\Delta P_{aE} = P_{aE}-P_s = 180.3\ lbs-109.6\ lbs = 70.7\ lbs$$

$$\Delta P_{aEH} = P_{aE}-P_s = 178.3\ lbs-108.4\ lbs = 69.9\ lbs$$

$$\Delta P_{aEV} = P_{aE}-P_s = 27\ lbs-16.4\ lbs = 10.6\ lbs$$



Summary of Wall Forces

The maximum resultant forces summarized below are enveloped from the forces induced by both the Murata fill and retained soil.

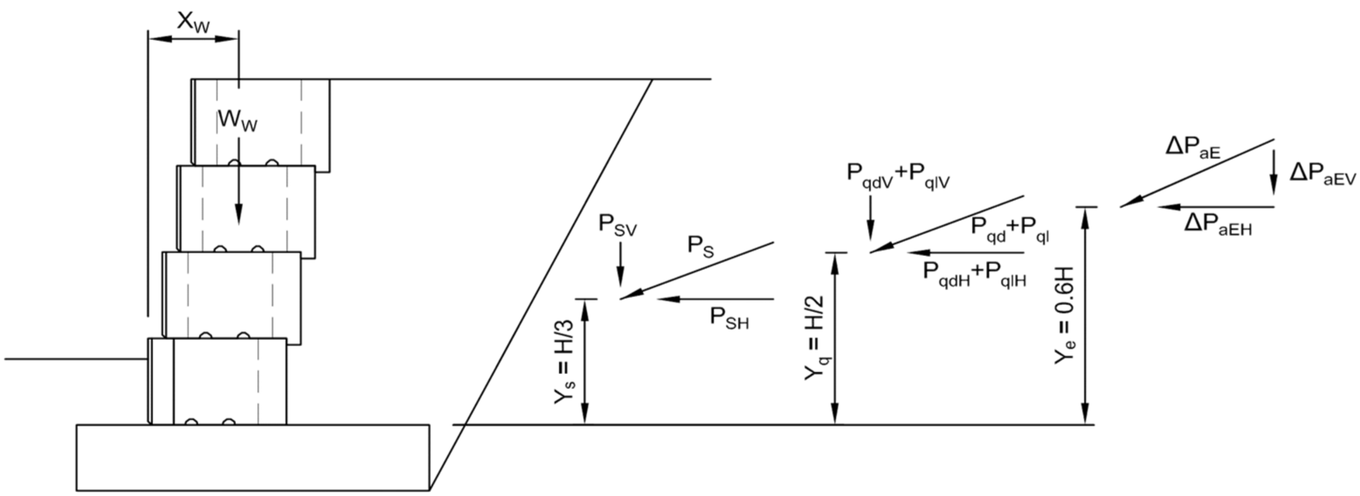
Max P_s =	109.6 lbs	P_{sH} =	108.4 lbs	P_{sV} =	16.4 lbs
Max P_{aE} =	180.3 lbs	P_{aEH} =	178.3 lbs	P_{aEV} =	27.0 lbs
ΔP_{aE} =	70.7 lbs	ΔP_{aEH} =	69.9 lbs	ΔP_{aEV} =	15.7 lbs

Surcharge Loads

Calculate the resultant force on the SRW induced by the surcharge load on the retained soil and its horizontal and vertical components. It is assumed that the surcharge load is uniform and continuous.

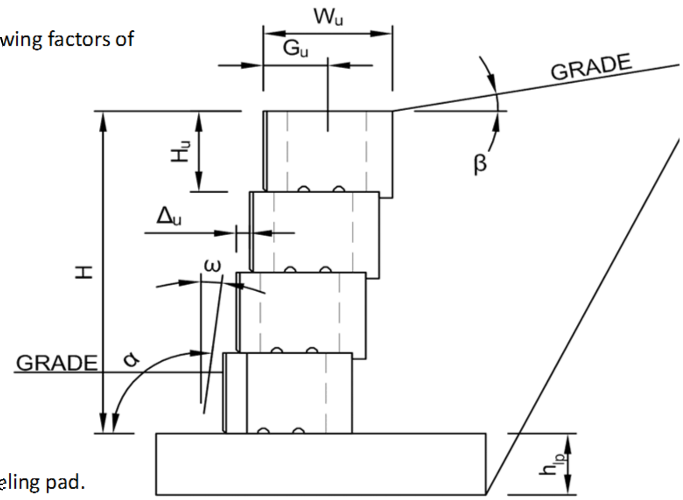
$P_{qd} = q_d K_a H$	$P_{qdH} = P_{qd}\cos(\delta-\omega)$	$P_{qdV} = P_{qd}\sin(\delta-\omega)$
= (0 psf)(0.289)(2.625')	= (0 lbs)cos(17.3°-8.73°)	= (0 lbs)sin(17.3°-8.73°)
= 0.0 lbs	= 0.0 lbs	= 0.0 lbs

$P_{ql} = q_l K_a H$	$P_{qlH} = P_{ql}\cos(\delta-\omega)$	$P_{qlV} = P_{ql}\sin(\delta-\omega)$
= (0 psf)(0.289)(2.625')	= (0 lbs)cos(17.3°-8.73°)	= (0 lbs)sin(17.3°-8.73°)
= 0.0 lbs	= 0.0 lbs	= 0.0 lbs



External Stability Checks

The National Concrete and Masonry Association (NCMA) recommends the following factors of safety for the individual failure modes of a retaining wall (2010).



Failure Mode		Static	Seismic
Base Sliding	FS_{sl}	1.5	1.1
Leveling Pad Sliding	FS_{sl}	1.5	1.1
Internal Sliding	FS_{isl}	1.5	1.1
Internal Overturning	FS_{iot}	1.5	1.1
Overturning	FS_{ot}	1.5	1.1
Allowable Bearing	FS_{be}	1.0	1.0
Global Stability	Consult a Geotechnical Engineer		

Base Block Sliding

Calculate the factor of safety for the base retaining wall block sliding on the leveling pad.

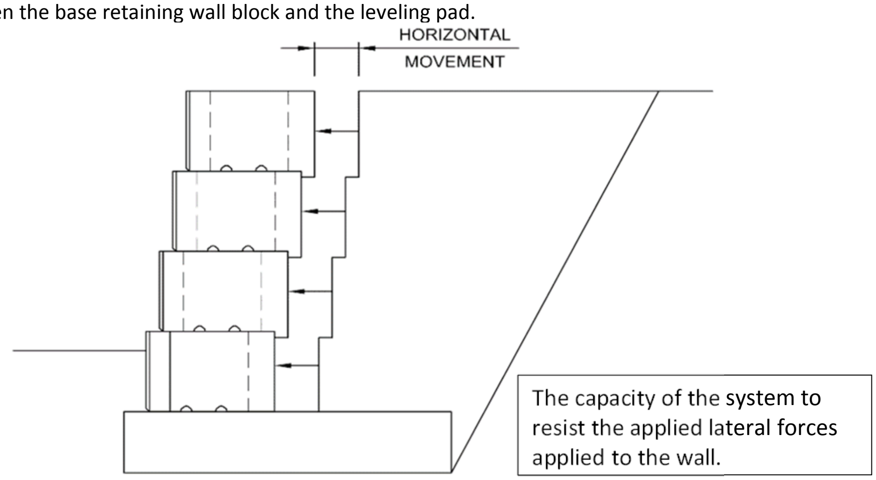
Static Case

Calculate the resistance to sliding due to friction between the base retaining wall block and the leveling pad.

$R_{sc} = (\mu_b)(W_W+P_{sV}+P_{qdV}+P_{qlV})\tan\Phi_i$

$= (0.7)(307\ \text{lbs}+16.4\ \text{lbs}+0\ \text{lbs}+0\ \text{lbs})*\tan(36°)$

$=\ 164\ \text{lbs}$



Calculate the driving forces for a sliding failure.

$P_{aH} = P_{sH}+P_{qdH}+P_{qlH}$

$= 108.4\ \text{lbs}+0\ \text{lbs}+0\ \text{lbs}$

$=\ 108.4\ \text{lbs}$

Calculate the factor of safety for base block sliding.

$FS_{sl} = R_{sc}/P_{aH}$

$= 164\ \text{lbs}/108.4\ \text{lbs}$

$=\ 1.52$

Seismic Case

Calculate the resistance to sliding due to friction between the base retaining wall block and the leveling pad.

$R_{sc} = (\mu_b)(W_W+P_{sV}+P_{qdV}+P_{qlV}+0.5\Delta P_{aEV})\tan\Phi_i$

$= (0.7)(307\ \text{lbs}+16.4\ \text{lbs}+0\ \text{lbs}+0\ \text{lbs}+7.8\ \text{lbs})\tan(36°)$

$=\ 168\ \text{lbs}$

Calculate the driving forces for a sliding failure.

$P_{aEH} = P_{sH}+P_{qdH}+P_{qlH}+0.5\Delta P_{aEH}$

$= 108.4\ \text{lbs}+0\ \text{lbs}+0\ \text{lbs}+35\ \text{lbs}$

$=\ 143.3\ \text{lbs}$

Calculate the factor of safety for base block sliding on the leveling pad.

$FS_{sl} = R_{sc}/P_{aH}$

$= 168\ \text{lbs}/143.3\ \text{lbs}$

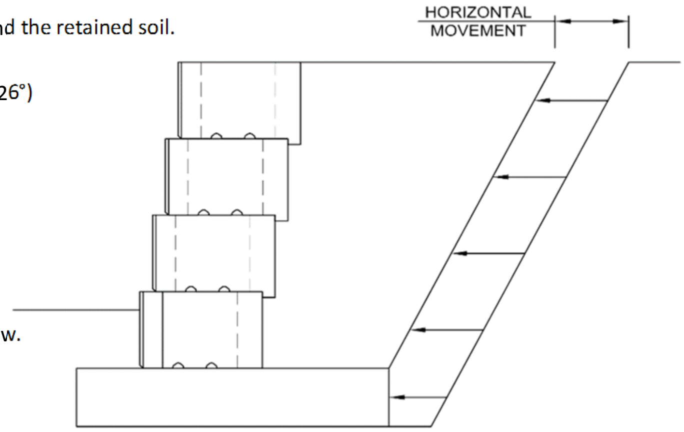
$=\ 1.17$

Leveling Pad Base Sliding

Calculate the factor of safety for the leveling pad sliding on the native foundation soil.

Static Case

Calculate the resistance to sliding due to friction between the leveling pad and the retained soil.



R_{slp} = $(W_W+P_{sV}+P_{qdV}+P_{qlV}+\gamma_c(h_{lp})(W_u+h_{lp})(1' \text{ width}))\tan\Phi_r$

= (307 lbs+16.4 lbs+0 lbs+0 lbs+(125 pcf)(0.5')(0.968'+0.5')(1'))*tan(26°)

= 202 lbs

Calculate the driving forces for a sliding failure.

P_{aH} = $P_{sH}+P_{qdH}+P_{qlH}$

= 108.4 lbs+0 lbs+0 lbs

= 108.4 lbs

Calculate the factor of safety for leveling pad sliding on the retained soil below.

FS_{sl} = R_{slp}/P_{aH}

= 202 lbs/108.4 lbs

= 1.87

The capacity of the system to resist the applied lateral forces applied to the wall.

Seismic Case

Calculate the resistance to sliding due to friction between the leveling pad and the retained soil.

R_{sc} = $(W_W+P_{sV}+P_{qdV}+P_{qlV}+0.5*\Delta P_{aEV}+\gamma_c(h_{lp})(W_u+h_{lp})(1' \text{ width}))\tan\Phi_r$

= (307 lbs+16.4 lbs+0 lbs+0 lbs+7.8 lbs+(125 pcf)(0.5')(0.968'+0.5')(1'))*tan(26°)

= 206 lbs

Calculate the driving forces for a sliding failure.

P_{aH} = $P_{sH}+P_{qdH}+P_{qlH}+0.5\Delta P_{aEH}$

= 108.4 lbs+0 lbs+0 lbs+35 lbs

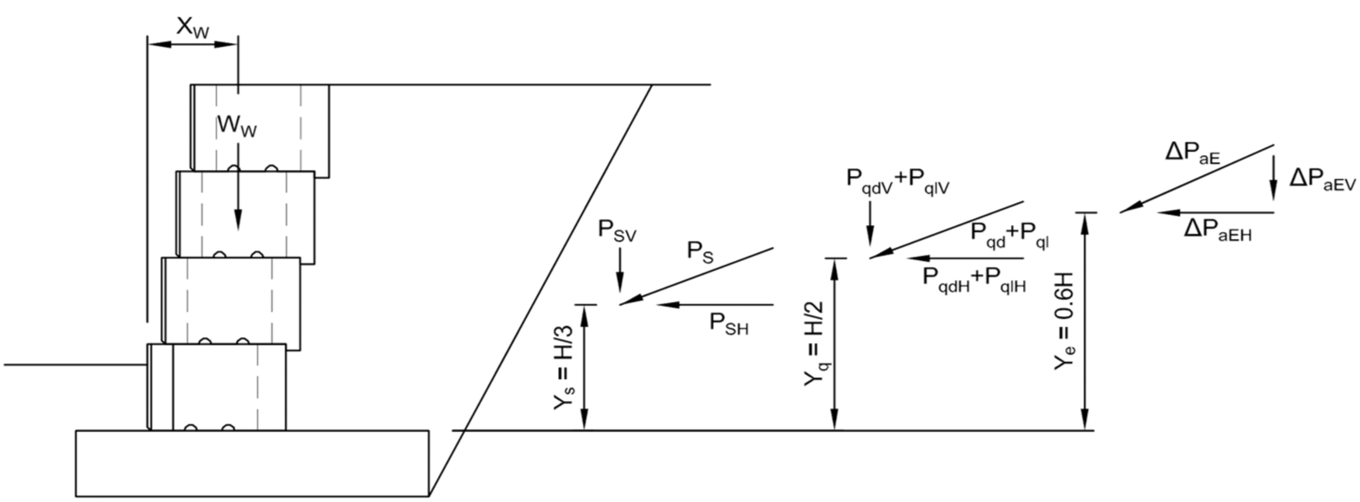
= 143.3 lbs

Calculate the factor of safety for leveling pad sliding on the retained soil below.

FS_{sl} = R_{slp}/P_{aH}

= 206 lbs/143.3 lbs

= 1.44



Global Overturning Check

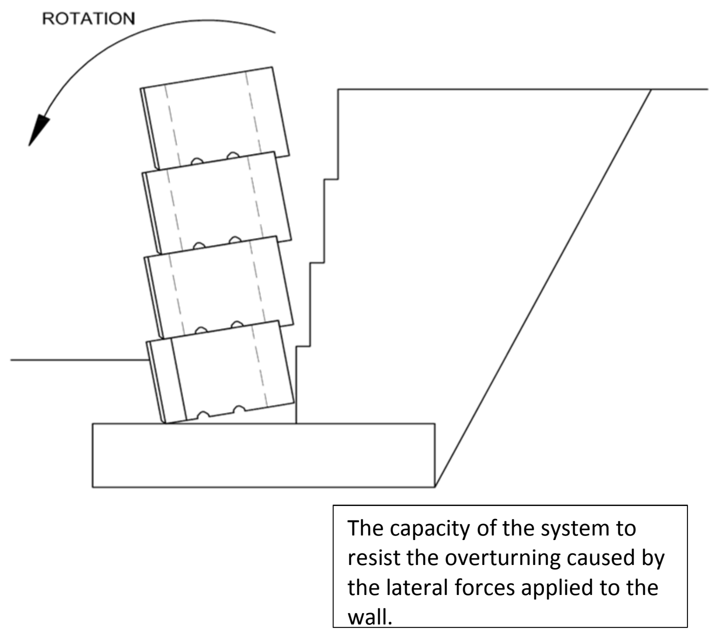
Calculate the factor of safety of the resistive moment versus the overturning moment about the front corner of the base block.

Calculate the resisting moment arm of the wall units.

$X_W = G_u + 0.5H\tan(\omega) - 0.5\Delta_u$

$= 0.484' + 0.5(2.625')\tan(8.73°) - 0.5(0.101')$

$= 0.635$ ft



Calculate the height at which the resultant surcharge force is applied.

$Y_q = H/2$

$= 2.625'/2$

$= 1.312$ ft

Calculate the height at which the resultant active soil force is applied.

$Y_S = H/3$

$= 2.625'/3$

$= 0.875$ ft

Calculate the height at which the resultant seismic force is applied.

$Y_e = 0.6H$

$= 0.6(2.625')$

$= 1.575$ ft

Static Case

Calculate the moment resisting overturning.

$M_r = W_W X_W + P_{sV}[W_u + Y_s\tan(\omega)] + P_{qdV}[W_u + Y_q\tan(\omega)]$

$= (307 \text{ lbs})(0.635') + (16.4 \text{ lbs})[(0.968') + (0.875')\tan(8.73°)] + (0 \text{ lbs})[(0.968')\tan(8.73°)]$

$= 213$ lbs-ft

Calculate the overturning moment.

$M_o = P_{sH}Y_s + P_{dH}Y_q$

$= (108.4 \text{ lbs})(0.875') + (0 \text{ lbs})(1.312')$

$= 95$ lbs-ft

Calculate the factor of safety for the retaining wall overturning about the front corner of the base block.

$FS_{ot} = M_r/M_o$

$= 213 \text{ lbs-ft}/95 \text{ lbs-ft}$

$= 2.25$

Seismic Case

Calculate the moment resisting overturning.

$M_r = W_W X_W + (P_{sV} + 0.5\Delta P_{aEV})[W_u + Y_s\tan(\omega)] + P_{qdV}[W_u + Y_q\tan(\omega)]$

$= (307 \text{ lbs})(0.635') + (16.4 \text{ lbs} + 7.8 \text{ lbs})[(0.968')\tan(8.73°)] + (0 \text{ lbs})[(0.968')\tan(8.73°)]$

$= 222$ lbs-ft

Calculate the overturning moment.

$M_o = P_{sH}Y_s + 0.5\Delta P_{aEH}Y_e + P_{dH}Y_q$

$= (108.4 \text{ lbs})(0.875') + (35 \text{ lbs})(1.575') + (0 \text{ lbs})(1.312')$

$= 150$ lbs-ft

Calculate the factor of safety for the retaining wall overturning about the front corner of the base block.

$FS_{ot} = M_r/M_o$

$= 222 \text{ lbs-ft}/149.9 \text{ lbs-ft}$

$= 1.48$

Bearing Check

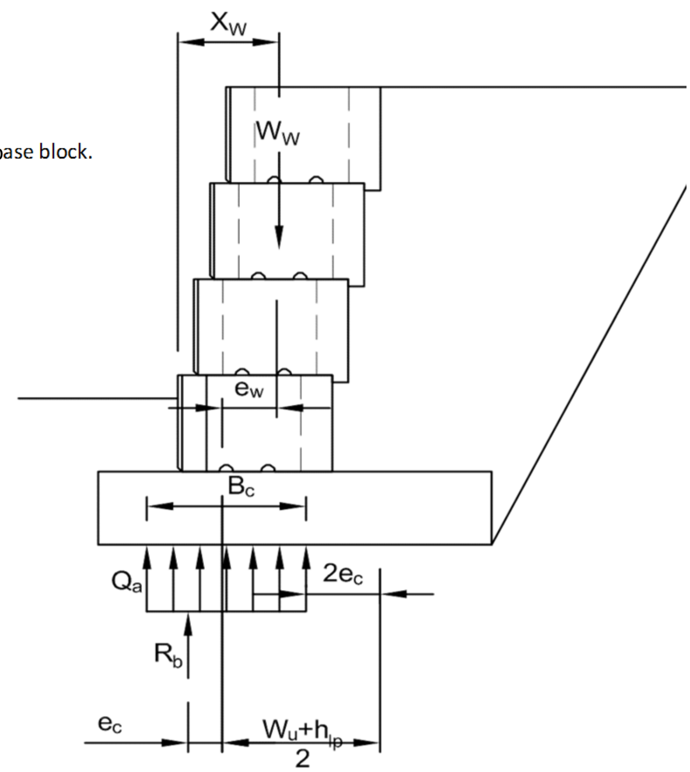
Calculate the factor of safety for the bearing pressure on retained soil versus the bearing capacity of the native foundation soil.

Calculate the eccentricity between the horizontal location of the weight of the wall and the center of the base block.

$e_W = X_W - 0.5W_u$

$= 0.635' - 0.5(0.968')$

$= 0.151$ ft



The capacity of the soil supporting the system to resist the vertical loads.

Static Case

Calculate the eccentricity of the resultant bearing force and the center of the base block.

$e_c = (M_o - W_W e_W)/(W_W + P_{sv} + P_{qdV} + P_{qlV})$

$= [(95 \text{ lbs-ft}) - (307 \text{ lbs})(0.151')]/(306.8 \text{ lbs} + 16.4 \text{ lbs} + 0 \text{ lbs} + 0 \text{ lbs})$

$= 0.150$ ft

Calculate the length of the Meyeroff pressure distribution.

$B_c = W_u + h_{lp} - 2e_c$

$= 0.968' + 0.5' - 2(0.15')$

$= 1.168$ ft

Calculate the uniform Meyeroff bearing pressure.

$Q_a = (W_W + P_{sv} + P_{qdV} + P_{qlV})/B_c$

$= (307 \text{ lbs} + 16.4 \text{ lbs} + 0 \text{ lbs} + 0 \text{ lbs})/1.168'$

$= 277$ psf

Recall the allowable bearing pressure.

Bearing = 1500 psf

Calculate the factor of safety for the leveling pad bearing on retained soil

$FS_{be} = \text{Bearing}/Q_a$

$= 1500 \text{ psf}/277 \text{ psf}$

$= 5.42$

Seismic Case

Calculate the eccentricity of the resultant bearing force and the center of the base block.

$e_c = (M_o - W_W e_W)/(W_W + P_{sv} + P_{qdV} + P_{qlV} + \Delta P_{aEV})$

$= [(150 \text{ lbs-ft}) - (307 \text{ lbs})(0.151')]/(306.8 \text{ lbs} + 16.4 \text{ lbs} + 0 \text{ lbs} + 0 \text{ lbs} + 15.7 \text{ lbs})$

$= 0.305$ ft

Calculate the length of the Meyeroff pressure distribution.

$B_c = W_u + h_{lp} - 2e_c$

$= 0.968' + 0.5' - 2(0.305')$

$= 0.857$ ft

Calculate the uniform Meyeroff bearing pressure.

$Q_a = (W_W + P_{sv} + P_{qdV} + P_{qlV} + 0.5\Delta P_{aEV})/B_c$

$= (307 \text{ lbs} + 16.4 \text{ lbs} + 0 \text{ lbs} + 0 \text{ lbs} + 7.8 \text{ lbs})/0.857'$

$= 386$ psf

Calculate the transient bearing capacity. Consult a geotechnical engineer if a third increase in your bearing capacity for transient or short term loads.

Transient Bearing = 4*Bearing/3

$= 4(1500 \text{ psf})/3$

$= 2000$ psf

Calculate the factor of safety for the leveling pad bearing on retained soil.

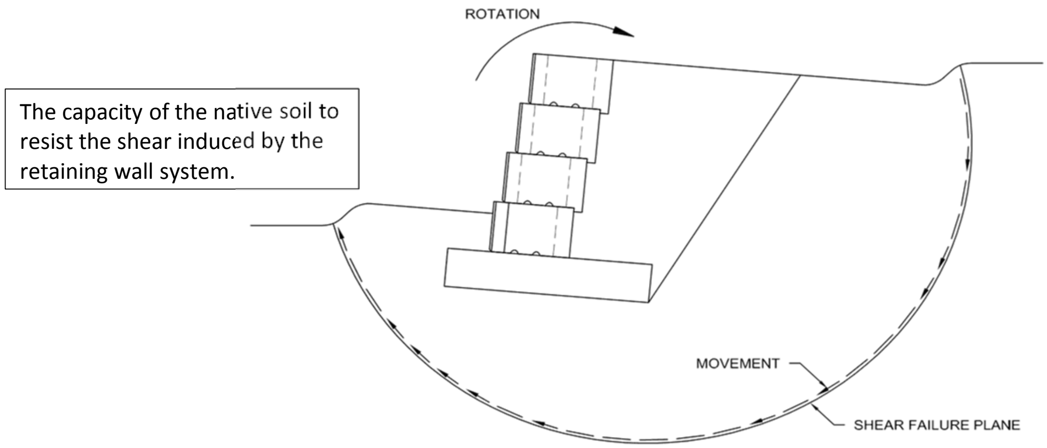
$FS_{be} = \text{Transient Bearing}/Q_a$

$= 2000 \text{ psf}/386 \text{ psf}$

$= 5.18$

Global Stability

Consult a geotechnical engineer for global stability of the site soil around the retaining wall.



Summary

The following is a summary of the recommended factors of safety and the calculated factors of safety.

				Summary		
Failure Mode		Static	Seismic	Static	Seismic	
Base Sliding	FS_{sl}	1.5	1.1	1.52	1.17	PASS
Leveling Pad Sliding	FS_{sl}	1.5	1.1	1.87	1.44	PASS
Internal Sliding	FS_{isl}	1.5	1.1	10.38	10.99	PASS
Internal Overturning	FS_{iot}	1.5	1.1	3.91	1.51	PASS
Overturning	FS_{ot}	1.5	1.1	2.25	1.48	PASS
Allowable Bearing	FS_{be}	1.0	1.0	5.42	5.18	PASS
Global Stability	Consult a Geotechnical Engineer					

Conclusion

A 2'-8'' Murata Retaining Wall (4 blocks tall) is structurally sufficient to resist the given soil pressures and 0 psf of surcharge and a 0 degree backslope.

Internal Stability Checks

Block 3

Block Number 3 h = 1.969 ft = 3(0.656''/block)

Static Loads

Murata Fill	Retained Soil

Recall the previous calculated active soil pressure coefficients.

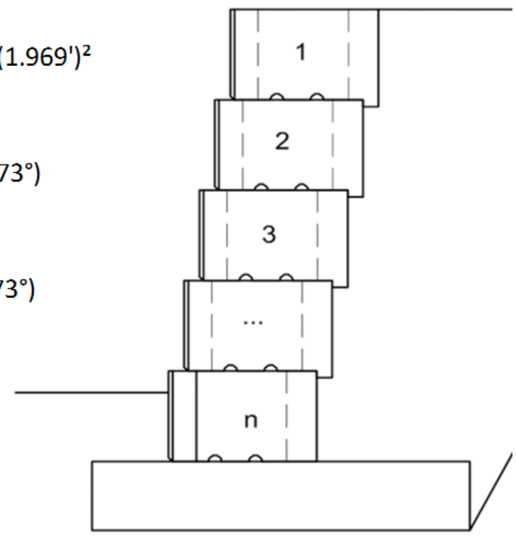
K_a = 0.179 K_a = 0.289

Recall the given soil properties from the geotechnical engineer for the project.

γ_c = 125 pcf γ_r = 110 pcf

δ_c = 24.0 ° δ_r = 17.3 °

Calculate the resultant active soil force induced on the wall and its horizontal and vertical components.



Murata Fill

$P_a = 0.5K_a\gamma_c(1' \text{ wide})h^2$
$= 0.5(0.179)(125 \text{ pcf})(1')(1.969')^2$
$=$ 43.30 lbs

$P_{aH} = P_a\cos(\delta_c-\omega)$
$= (43.3 \text{ lbs})\cos(24°-8.73°)$
$=$ 41.77 lbs

$P_{aV} = P_a\sin(\delta_c-\omega)$
$= (43.3 \text{ lbs})\sin(24°-8.73°)$
$=$ 11.40 lbs

Retained Soil

$P_a = 0.5K_a\gamma_r(1' \text{ wide})h^2$
$= 0.5(0.289)(110 \text{ pcf})(1')(1.969')^2$
$=$ 61.65 lbs

$P_{aH} = P_a\cos(\delta_r-\omega)$
$= (61.65 \text{ lbs})\cos(17.3°-8.73°)$
$=$ 60.95 lbs

$P_{aV} = P_a\sin(\delta_r-\omega)$
$= (61.65 \text{ lbs})\sin(17.3°-8.73°)$
$=$ 9.22 lbs

Seismic Loads

Murata Fill	Retained Soil

Recall the previous calculated active seismic and soil pressure coefficients.

K_{aE} = 0.317 K_{aE} = 0.476

Calculate the active seismic pressure coefficient

K_E = 0.138 $=K_{aE}-K_a$ K_E = 0.187 $=K_{aE}-K_a$

Calculate the resultant active seismic force induced on the wall and its horizontal and vertical components.

Murata Fill

$P_{aE} = 0.5K_E\gamma_c(1' \text{ wide})h^2$
$= 0.5(0.138)(125 \text{ pcf})(1')(1.969')^2$
$=$ 33.49 lbs

$P_{aEH} = P_{aE}\cos(\delta_c-\omega)$
$= (33.49 \text{ lbs})\cos(24°-8.73°)$
$=$ 32.31 lbs

$P_{aEV} = P_{aE}\sin(\delta_c-\omega)$
$= (33.49 \text{ lbs})\sin(24°-8.73°)$
$=$ 8.82 lbs

Retained Soil

$P_{aE} = 0.5K_E\gamma_r(1' \text{ wide})h^2$
$= 0.5(0.187)(110 \text{ pcf})(1')(1.969')^2$
$=$ 39.79 lbs

$P_{aEH} = P_{aE}\cos(\delta_r-\omega)$
$= (39.79 \text{ lbs})\cos(17.3°-8.73°)$
$=$ 39.34 lbs

$P_{aEV} = P_{aE}\sin(\delta_r-\omega)$
$= (39.79 \text{ lbs})\sin(17.3°-8.73°)$
$=$ 5.95 lbs

Surcharge Loads

Calculate the resultant force on the SRW induced by the surcharge load on the retained soil and its horizontal and vertical components. It is assumed that the surcharge load is uniform and continuous.

$P_{qd} = q_dK_a(1' \text{ wide})h$
$= (0 \text{ psf})(0.179)(1')(1.969')$
$=$ 0.00 lbs

$P_{qdH} = P_{qd}\cos(\delta-\omega)$
$= (0 \text{ lbs})\cos(24°-8.73°)$
$=$ 0.00 lbs

$P_{qdV} = P_{qd}\sin(\delta-\omega)$
$= (0 \text{ lbs})\sin(24°-8.73°)$
$=$ 0.00 lbs

$P_{ql} = q_lK_a(1' \text{ wide})$
$= (0 \text{ psf})(0.289)(1')(1.969')$
$=$ 0.00 lbs

$P_{qlH} = P_{ql}\cos(\delta-\omega)$
$= (0 \text{ lbs})\cos(17.3°-8.73°)$
$=$ 0.00 lbs

$P_{qlV} = P_{ql}\sin(\delta-\omega)$
$= (0 \text{ lbs})\sin(17.3°-8.73°)$
$=$ 0.00 lbs

Static Load Application

Calculate the applied distributed load to the retaining wall and the resultant location from the bottom of block (3).

Horizontal Load at the Top of the (3) Block Wall

$w_{HT} = q_d K_a (1')\cos(\delta\text{-}\omega) + q_l K_a (1')\cos(\delta\text{-}\omega)$

$= (0\text{ psf})(0.289)(1')\cos(17.3°\text{-}8.73°) + (0\text{ psf})(0.289)(1')\cos(17.3°\text{-}8.73°)$

$= 0.0\text{ plf}$

Horizontal Load at the Bottom of the (3) Block Wall

$w_{HB} = w_{HT} + K_a \gamma_c h(1')\cos(\delta\text{-}\omega) + q_d K_a (1')\cos(\delta\text{-}\omega) + q_l K_a (1')\cos(\delta\text{-}\omega)$

$= 0\text{ plf} + (0.289)(110\text{ pcf})(1.969')(1')\cos(17.3°\text{-}8.73°)$

$+ (0\text{ psf})(0.289)(1')\cos(17.3°\text{-}8.73°) + (0\text{ psf})(0.289)(1')\cos(17.3°\text{-}8.73°)$

$= 61.9\text{ plf}$

Calculate the location of the active soil pressure.

$c_y = h - [h(2 * w_{HB} + w_{HT})]/[3(w_{HB} + w_{HT})]$

$= 1.969' - [(1.969')(2(61.93\text{ plf}) + 0\text{ plf})]/[3(61.93\text{ plf} + 0\text{ plf})]$

$= 0.656\text{ ft}$

Calculate horizontal resultant active soil force.

$P_{aH} = h(w_{HT} + w_{HB})/2$

$= (1.969')(0\text{ plf} + 61.93\text{ plf})/2$

$= 61.0\text{ lbs @ } c_y$

Vertical Load at the Top of the (3) Block Wall

$w_{VT} = q_d K_a (1')\sin(\delta\text{-}\omega) + q_l K_a (1')\sin(\delta\text{-}\omega)$

$= (0\text{ psf})(0.289)(1')\sin(17.3°\text{-}8.73°) + (0\text{ psf})(0.289)(1')\sin(17.3°\text{-}8.73°)$

$= 0.0\text{ plf}$

Vertical Load at the Bottom of the (3) Block Wall

$w_{VB} = w_{VT} + K_a \gamma_c h(1')\sin(\delta\text{-}\omega) + q_d K_a (1')\sin(\delta\text{-}\omega) + q_l K_a (1')\sin(\delta\text{-}\omega)$

$= 0\text{ plf} + (0.289)(110\text{ pcf})(1.969')(1')\sin(17.3°\text{-}8.73°)$

$+ (0\text{ psf})(0.289)(1')\sin(17.3°\text{-}8.73°) + (0\text{ psf})(0.289)(1')\sin(17.3°\text{-}8.73°)$

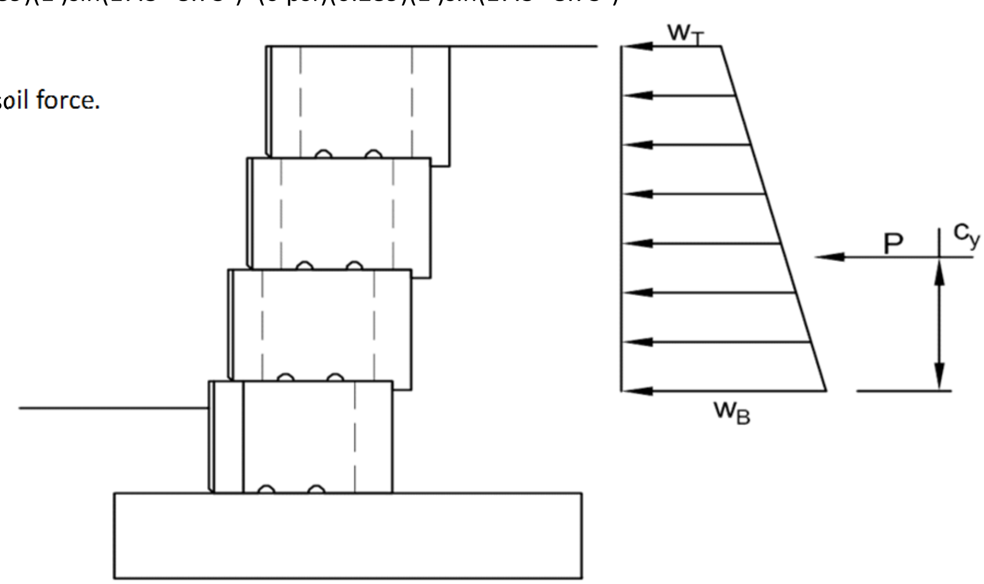
$= 9.4\text{ plf}$

Calculate vertical resultant active soil force.

$P_{aV} = h(w_{VT} + w_{VB})/2$

$= (1.969')(0\text{ plf} + 9.4\text{ plf})/2$

$= 9.2\text{ lbs}$



Seismic Load Application

Calculate the applied distributed load to the retaining wall and the resultant location from the bottom of the base block.

Horizontal Load at the Top of the (3) Block Wall

$w_{HTE} = K_E\gamma_c H(1')\cos(\delta-\omega)+w_{HT}$

$= (0.187)(110\ psf)(2.625')(1')\cos(17.3°-8.73°)+ 0plf$

$=$ 40.0 plf

Horizontal Load at the Bottom of the (3) Block Wall

$w_{HBE} = K_E\gamma_c(H-h)(1')\cos(\delta-\omega)+w_{HB}$

$= (0.187)(110\ psf)(2.625'-1.969')(1')\cos(17.3°-8.73°)+ 61.9plf$

$=$ 75.2 plf

Calculate the location of the active seismic and soil pressure.

$c_{yE} = h-[h(2*w_{HBE}+w_{HTE})]/[3(w_{HBE}+w_{HTE})]$

$= 1.969'-[(1.969')(2(75.2\ plf)+40\ plf)]/[3(75.2\ plf+40\ plf)]$

$=$ 0.884 ft

Calculate vertical resultant active soil force.

$P_{aEH} =$ h(Horizontal Load @ Top+Horizontal Load @ Bottom)/2

$= (1.969')(39.97\ plf+75.25\ plf)/2$

$=$ 113.4 lbs @ c_{yE}

Vertical Load at the Top of the (3) Block Wall

$w_{VTE} = K_E\gamma_c H(1')\cos(\delta-\omega)+w_{VT}$

$= (0.187)(110\ psf)(2.625')(1')\cos(17.3°-8.73°)+ 0plf$

$=$ 6.0 plf

Vertical Load at the Bottom of the (3) Block Wall

$w_{VBE} = K_E\gamma_c(H-h)(1')\sin(\delta-\omega)+w_{VB}$

$= (0.187)(110\ psf)(2.625'-1.969')(1')\sin(17.3°-8.73°)+ 9.4plf$

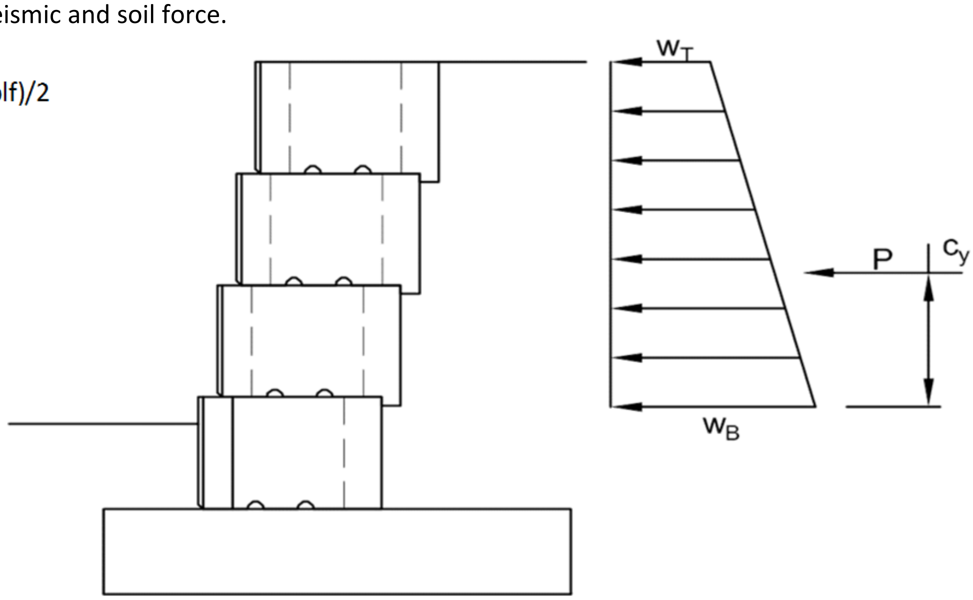
$=$ 11.4 plf

Calculate vertical resultant active seismic and soil force.

$P_{aEV} = h(w_{VTE}+w_{VBE})/2$

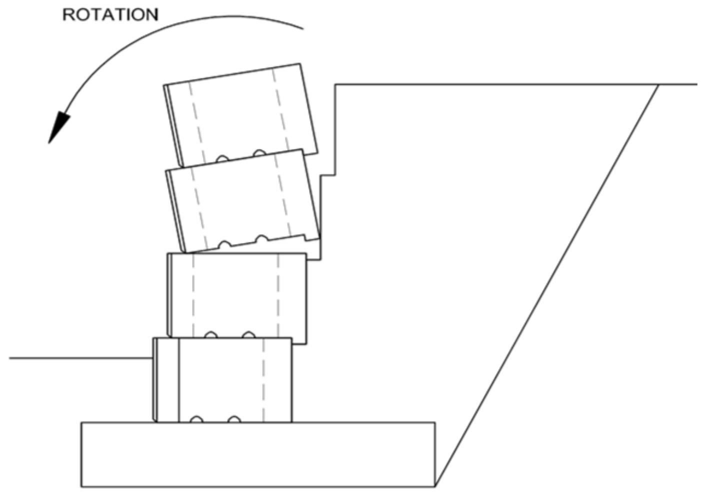
$= (1.969')(6.05\ plf+11.39\ plf)/2$

$=$ 17.2 lbs



Internal Overturning Stability

Calculate the factor of safety of the resistive moment versus the overturning moment of the block (3) overturning about the front corner.



The capacity of the system to resist the overturning caused by the lateral forces applied to the wall.

Static

Calculate the overturning moment.

$M_o = P_{aH}c_y$
$= (61\text{ lbs})(0.656')$
$= 40.0\text{ lbs-ft}$

Calculate the weight of a 1' wide strip of the wall (3) blocks tall.

$w_W = \gamma_u W_u h(1'\text{wide})$
$= (120.8\text{ pcf})(0.968')(1.969')(1')$
$= 230\text{ lbs}$

Recall the resisting moment arm.

$x_W = 0.635\text{ ft}$

Calculate the moment resisting overturning.

$M_r = w_W x_W + P_{aV}[W_u + h*\tan(\omega)/2]$
$= (230\text{ lbs})(0.635') + (9.2\text{ lbs})[(0.968') + (0.656')\tan(8.73°)]$
$= 156\text{ lbs-ft}$

Calculate the factor of safety for the retaining wall overturning about the front corner of the (3) block.

$FS_{ot} = M_r/M_o$
$= 156\text{ lbs-ft}/40\text{ lbs-ft}$
$= 3.91$

Seismic

Calculate the overturning moment.

$M_o = P_{aEH}c_{yE}$
$= (113.4\text{ lbs})(0.884')$
$= 100.2\text{ lbs-ft}$

Calculate the moment resisting overturning.

$M_r = w_W x_W + 0.5P_{aEV}[W_u + h*\tan(\omega)/2]$
$= (230\text{ lbs})(0.635') + (4.6\text{ lbs})[(0.968') + (0.656')\tan(8.73°)]$
$= 151\text{ lbs-ft}$

Calculate the factor of safety for the retaining wall overturning about the front corner of the (3) block.

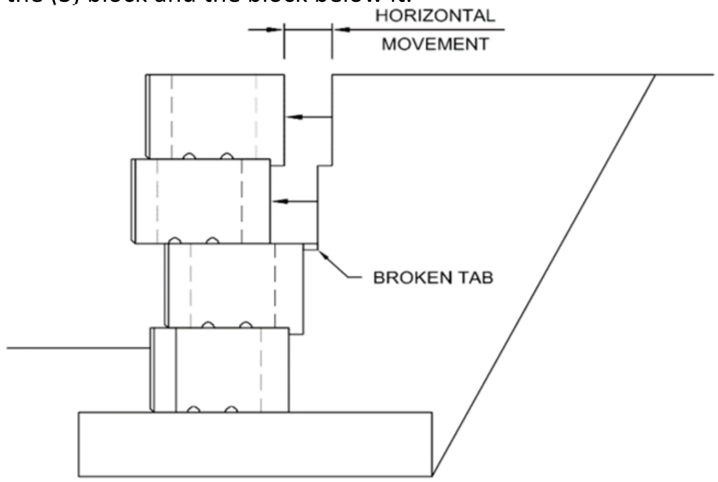
$FS_{ot} = M_r/M_o$
$= 151\text{ lbs-ft}/100.2\text{ lbs-ft}$
$= 1.51$

Internal Sliding Stability

Calculate the factor of safety of block (3) sliding on block (4).

Static

Calculate the resistance to sliding due to friction between the (3) block and the block below it.



$R_{sc} = (\mu_{SRW})(w_W+P_{aV})+a_u$

$= (0.74)(230.1 \text{ lbs}+17.2 \text{ lbs})+(449 \text{ lbs})$

$= 632 \text{ lbs}$

Recall the resultant horizontal active soil force.

$P_{aH} = 61.0 \text{ lbs}$

Calculate the factor of safety for block sliding.

$FS_{sl} = R_{sc}/P_{aH}$

$= 632 \text{ lbs}/61 \text{ lbs}$

$= 10.38$

Seismic

Calculate the resistance to sliding due to friction between the (3) block and the block below it.

$R_{sc} = (\mu_{SRW})(w_W+0.5P_{aEV})+a_u$

$= (0.74)(230.1 \text{ lbs}+4.6 \text{ lbs})+(449 \text{ lbs})$

$= 623 \text{ lbs}$

The capacity of the system to resist the overturning caused by the lateral forces applied to the wall.

Recall the resultant horizontal active seismic and soil force.

$P_{aEH} = 113.4 \text{ lbs}$

Calculate the factor of safety for block sliding.

$FS_{sl} = R_{sc}/0.5P_{aEH}$

$= 623 \text{ lbs}/56.7 \text{ lbs}$

$= 10.99$

Internal Stability Checks

Block 2

Block Number: 2 | h = 1.312 ft | = 2(0.656''/block)

Static Loads

Murata Fill	Retained Soil

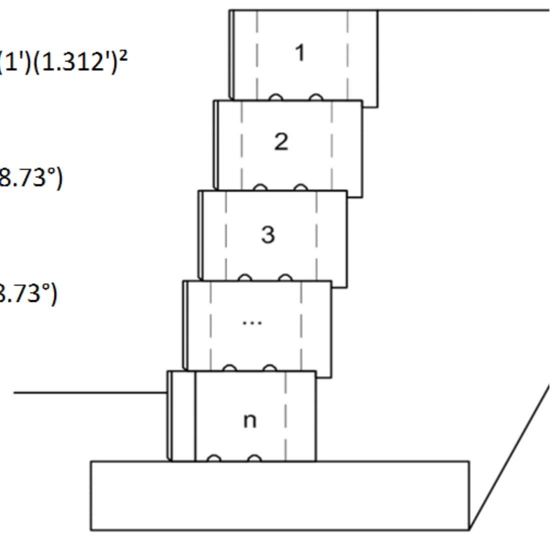
Recall the previous calculated active soil pressure coefficients.

$K_a = 0.179$	$K_a = 0.289$

Recall the given soil properties from the geotechnical engineer for the project.

$\gamma_c =$ 125 pcf	$\gamma_r =$ 110 pcf
$\delta_c =$ 24.0 °	$\delta_r =$ 17.3 °

Calculate the resultant active soil force induced on the wall and its horizontal and vertical components.



$P_a = 0.5K_a\gamma_c(1' \text{ wide})h^2$	$P_a = 0.5K_a\gamma_r(1' \text{ wide})h^2$
$= 0.5(0.179)(125 \text{ pcf})(1')(1.312')^2$	$= 0.5(0.289)(110 \text{ pcf})(1')(1.312')^2$
= 19.25 lbs	= 27.40 lbs
$P_{aH} = P_a\cos(\delta_c-\omega)$	$P_{aH} = P_a\cos(\delta_r-\omega)$
= (19.25 lbs)cos(24°-8.73°)	= (27.4 lbs)cos(17.3°-8.73°)
= 18.57 lbs	= 27.09 lbs
$P_{aV} = P_a\sin(\delta_c-\omega)$	$P_{aV} = P_a\sin(\delta_r-\omega)$
= (19.25 lbs)sin(24°-8.73°)	= (27.4 lbs)sin(17.3°-8.73°)
= 5.07 lbs	= 4.10 lbs

Seismic Loads

Murata Fill	Retained Soil

Recall the previous calculated active seismic and soil pressure coefficients.

$K_{aE} = 0.317$	$K_{aE} = 0.476$

Calculate the active seismic pressure coefficient

$K_E = 0.138$ $=K_{aE}-K_a$	$K_E = 0.187$ $=K_{aE}-K_a$

Calculate the resultant active seismic force induced on the wall and its horizontal and vertical components.

$P_{aE} = 0.5K_E\gamma_c(1' \text{ wide})h^2$	$P_{aE} = 0.5K_E\gamma_r(1' \text{ wide})h^2$
$= 0.5(0.138)(125 \text{ pcf})(1')(1.312')^2$	$= 0.5(0.187)(110 \text{ pcf})(1')(1.312')^2$
= 14.88 lbs	= 17.68 lbs
$P_{aEH} = P_{aE}\cos(\delta_c-\omega)$	$P_{aEH} = P_{aE}\cos(\delta_r-\omega)$
= (14.88 lbs)cos(24°-8.73°)	= (17.68 lbs)cos(17.3°-8.73°)
= 14.36 lbs	= 17.48 lbs
$P_{aEV} = P_{aE}\sin(\delta_c-\omega)$	$P_{aEV} = P_{aE}\sin(\delta_r-\omega)$
= (14.88 lbs)sin(24°-8.73°)	= (17.68 lbs)sin(17.3°-8.73°)
= 3.92 lbs	= 2.65 lbs

Surcharge Loads

Calculate the resultant force on the SRW induced by the surcharge load on the retained soil and its horizontal and vertical components. It is assumed that the surcharge load is uniform and continuous.

$P_{qd} = q_dK_a(1' \text{ wide})h$	$P_{ql} = q_lK_a(1' \text{ wide})$
= (0 psf)(0.179)(1')(1.312')	= (0 psf)(0.289)(1')(1.312')
= 0.00 lbs	= 0.00 lbs
$P_{qdH} = P_{qd}\cos(\delta-\omega)$	$P_{qlH} = P_{ql}\cos(\delta-\omega)$
= (0 lbs)cos(24°-8.73°)	= (0 lbs)cos(17.3°-8.73°)
= 0.00 lbs	= 0.00 lbs
$P_{qdV} = P_{qd}\sin(\delta-\omega)$	$P_{qlV} = P_{ql}\sin(\delta-\omega)$
= (0 lbs)sin(24°-8.73°)	= (0 lbs)sin(17.3°-8.73°)
= 0.00 lbs	= 0.00 lbs

Static Load Application

Calculate the applied distributed load to the retaining wall and the resultant location from the bottom of block (2).

Horizontal Load at the Top of the (2) Block Wall

$w_{HT} = q_d K_a(1')\cos(\delta-\omega)+q_l K_a(1')\cos(\delta-\omega)$

$= (0\text{ psf})(0.289)(1')\cos(17.3°-8.73°)+(0\text{ psf})(0.289)(1')\cos(17.3°-8.73°)$

$= 0.0\text{ plf}$

Horizontal Load at the Bottom of the (2) Block Wall

$w_{HB} = w_{HT}+K_a\gamma_c h(1')\cos(\delta-\omega)+q_d K_a(1')\cos(\delta-\omega)+q_l K_a(1')\cos(\delta-\omega)$

$= 0\text{ plf}+(0.289)(110\text{ pcf})(1.312')(1')\cos(17.3°-8.73°)$
$+(0\text{ psf})(0.289)(1')\cos(17.3°-8.73°)+(0\text{ psf})(0.289)(1')\cos(17.3°-8.73°)$

$= 41.3\text{ plf}$

Calculate the location of the active soil pressure.

$c_y = h-[h(2*w_{HB}+w_{HT})]/[3(w_{HB}+w_{HT})]$

$= 1.312'-[(1.312')(2(41.28\text{ plf})+0\text{ plf})]/[3(41.28\text{ plf}+0\text{ plf})]$

$= 0.437\text{ ft}$

Calculate horizontal resultant active soil force.

$P_{aH} = h(w_{HT}+w_{HB})/2$

$= (1.312')(0\text{ plf}+41.28\text{ plf})/2$

$= 27.1\text{ lbs @ } c_y$

Vertical Load at the Top of the (2) Block Wall

$w_{VT} = q_d K_a(1')\sin(\delta-\omega)+q_l K_a(1')\sin(\delta-\omega)$

$= (0\text{ psf})(0.289)(1')\sin(17.3°-8.73°)+(0\text{ psf})(0.289)(1')\sin(17.3°-8.73°)$

$= 0.0\text{ plf}$

Vertical Load at the Bottom of the (2) Block Wall

$w_{VB} = w_{VT}+K_a\gamma_c h(1')\sin(\delta-\omega)+q_d K_a(1')\sin(\delta-\omega)+q_l K_a(1')\sin(\delta-\omega)$

$= 0\text{ plf}+(0.289)(110\text{ pcf})(1.312')(1')\sin(17.3°-8.73°)$
$+(0\text{ psf})(0.289)(1')\sin(17.3°-8.73°)+(0\text{ psf})(0.289)(1')\sin(17.3°-8.73°)$

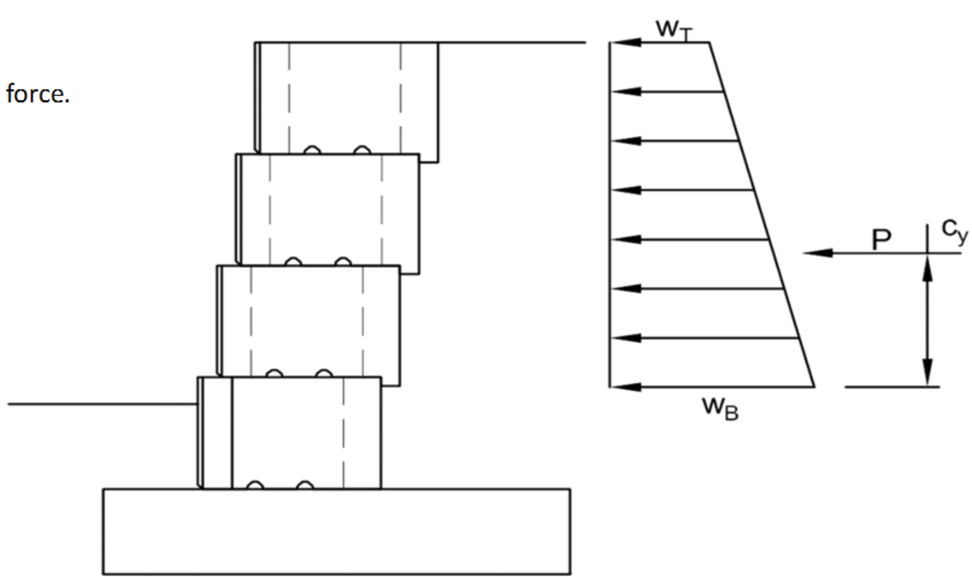
$= 6.2\text{ plf}$

Calculate vertical resultant active soil force.

$P_{aV} = h(w_{VT}+w_{VB})/2$

$= (1.312')(0\text{ plf}+6.2\text{ plf})/2$

$= 4.1\text{ lbs}$



Seismic Load Application

Calculate the applied distributed load to the retaining wall and the resultant location from the bottom of the base block.

Horizontal Load at the Top of the (2) Block Wall

$w_{HTE} = K_E\gamma_c H(1')\cos(\delta-\omega)+w_{HT}$

$= (0.187)(110\ psf)(2.625')(1')\cos(17.3°-8.73°)+ 0plf$

$=$ 26.6 plf

Horizontal Load at the Bottom of the (2) Block Wall

$w_{HBE} = K_E\gamma_c(H-h)(1')\cos(\delta-\omega)+w_{HB}$

$= (0.187)(110\ psf)(2.625'-1.312')(1')\cos(17.3°-8.73°)+ 41.3plf$

$=$ 67.9 plf

Calculate the location of the active seismic and soil pressure.

$c_{yE} = h-[h(2*w_{HBE}+w_{HTE})]/[3(w_{HBE}+w_{HTE})]$

$= 1.312'-[(1.312')(2(67.9\ plf)+26.6\ plf)]/[3(67.9\ plf+26.6\ plf)]$

$=$ 0.561 ft

Calculate vertical resultant active soil force.

P_{aEH} = h(Horizontal Load @ Top+Horizontal Load @ Bottom)/2

$= (1.312')(26.65\ plf+67.93\ plf)/2$

$=$ 62.1 lbs @ c_{yE}

Vertical Load at the Top of the (2) Block Wall

$w_{VTE} = K_E\gamma_c H(1')\cos(\delta-\omega)+w_{VT}$

$= (0.187)(110\ psf)(2.625')(1')\cos(17.3°-8.73°)+ 0plf$

$=$ 4.0 plf

Vertical Load at the Bottom of the (2) Block Wall

$w_{VBE} = K_E\gamma_c(H-h)(1')\sin(\delta-\omega)+w_{VB}$

$= (0.187)(110\ psf)(2.625'-1.312')(1')\sin(17.3°-8.73°)+ 6.2plf$

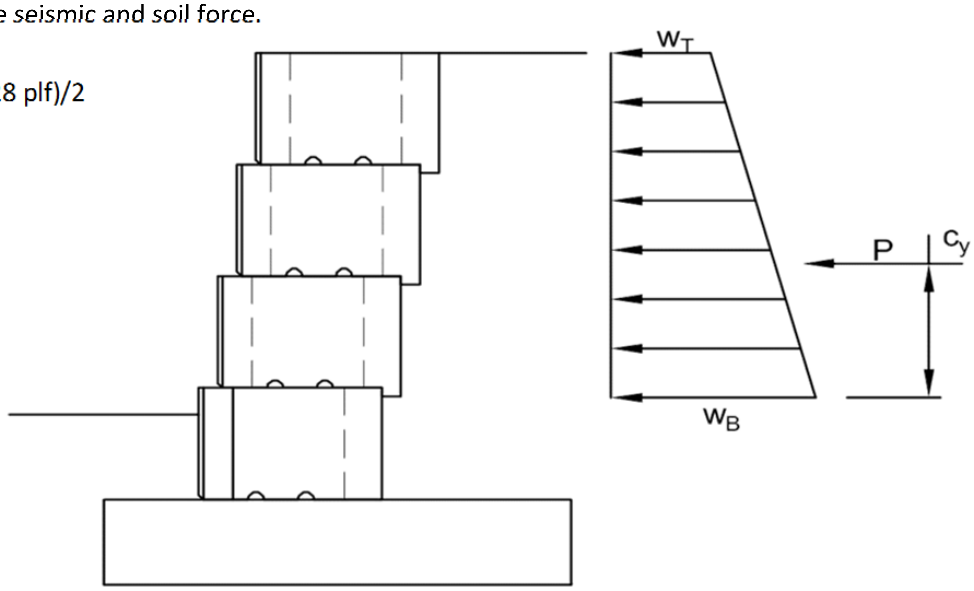
$=$ 10.3 plf

Calculate vertical resultant active seismic and soil force.

$P_{aEV} = h(w_{VTE}+w_{VBE})/2$

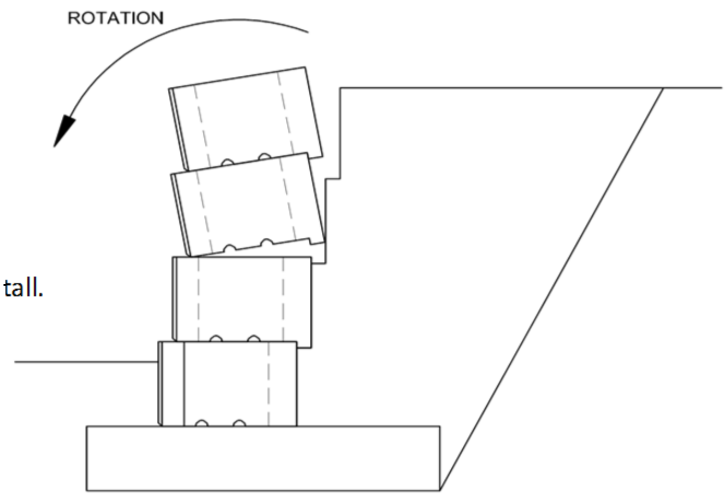
$= (1.312')(4.03\ plf+10.28\ plf)/2$

$=$ 9.4 lbs



Internal Overturning Stability

Calculate the factor of safety of the resistive moment versus the overturning moment of the block (2) overturning about the front corner.



The capacity of the system to resist the overturning caused by the lateral forces applied to the wall.

Static

Calculate the overturning moment.

$M_o = P_{aH}c_y$
$= (27.1 \text{ lbs})(0.437')$
$= 11.9 \text{ lbs-ft}$

Calculate the weight of a 1' wide strip of the wall (2) blocks tall.

$w_W = \gamma_u W_u h(1'\text{wide})$
$= (120.8 \text{ pcf})(0.968')(1.312')(1')$
$= 153 \text{ lbs}$

Recall the resisting moment arm.

$x_W = 0.635 \text{ ft}$

Calculate the moment resisting overturning.

$M_r = w_W x_W + P_{aV}[W_u + h*\tan(\omega)/2]$
$= (153 \text{ lbs})(0.635') + (4.1 \text{ lbs})[(0.968') + (0.437')\tan(8.73°)]$
$= 102 \text{ lbs-ft}$

Calculate the factor of safety for the retaining wall overturning about the front corner of the (2) block.

$FS_{ot} = M_r/M_o$
$= 102 \text{ lbs-ft}/11.9 \text{ lbs-ft}$
$= 8.59$

Seismic

Calculate the overturning moment.

$M_o = P_{aEH}c_{yE}$
$= (62.1 \text{ lbs})(0.561')$
$= 34.8 \text{ lbs-ft}$

Calculate the moment resisting overturning.

$M_r = w_W x_W + 0.5P_{aEV}[W_u + h*\tan(\omega)/2]$
$= (153 \text{ lbs})(0.635') + (2 \text{ lbs})[(0.968') + (0.437')\tan(8.73°)]$
$= 100 \text{ lbs-ft}$

Calculate the factor of safety for the retaining wall overturning about the front corner of the (2) block.

$FS_{ot} = M_r/M_o$
$= 100 \text{ lbs-ft}/34.8 \text{ lbs-ft}$
$= 2.86$

Internal Sliding Stability

Calculate the factor of safety of block (2) sliding on block (3).

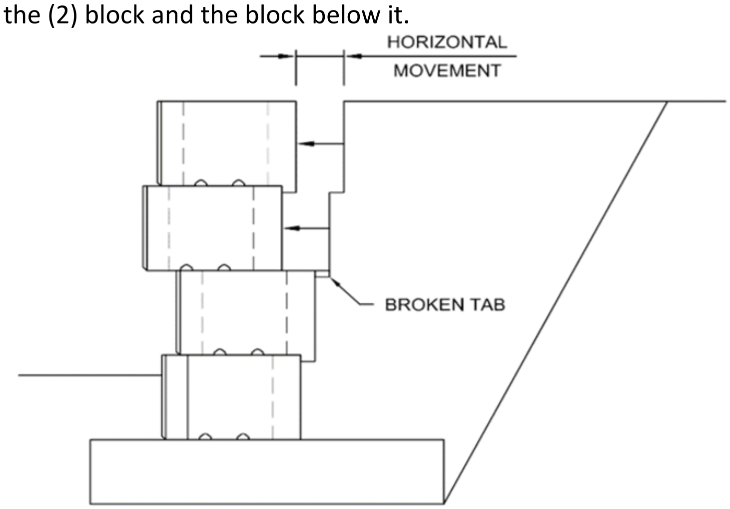
Static

Calculate the resistance to sliding due to friction between the (2) block and the block below it.

$R_{sc} = (\mu_{SRW})(w_W+P_{aV})+a_u$

$= (0.74)(153.4 \text{ lbs}+9.4 \text{ lbs})+(449 \text{ lbs})$

$= 570 \text{ lbs}$



Recall the resultant horizontal active soil force.

$P_{aH} = 27.1 \text{ lbs}$

Calculate the factor of safety for block sliding.

$FS_{sl} = R_{sc}/P_{aH}$

$= 570 \text{ lbs}/27.1 \text{ lbs}$

$= 21.04$

Seismic

Calculate the resistance to sliding due to friction between the (2) block and the block below it.

$R_{sc} = (\mu_{SRW})(w_W+0.5P_{aEV})+a_u$

$= (0.74)(153.4 \text{ lbs}+2 \text{ lbs})+(449 \text{ lbs})$

$= 564 \text{ lbs}$

The capacity of the system to resist the overturning caused by the lateral forces applied to the wall.

Recall the resultant horizontal active seismic and soil force.

$P_{aEH} = 62.1 \text{ lbs}$

Calculate the factor of safety for block sliding.

$FS_{sl} = R_{sc}/0.5P_{aEH}$

$= 564 \text{ lbs}/31 \text{ lbs}$

$= 18.19$

Internal Stability Checks

Block 1

Block Number 1 $h =$ 0.656 ft = 1(0.656''/block)

Static Loads

Murata Fill	Retained Soil

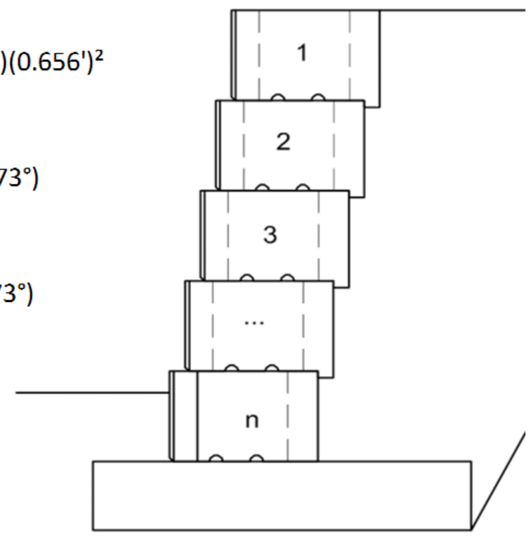
Recall the previous calculated active soil pressure coefficients.

Murata Fill	Retained Soil
$K_a = 0.179$	$K_a = 0.289$

Recall the given soil properties from the geotechnical engineer for the project.

Murata Fill	Retained Soil
$\gamma_c =$ 125 pcf	$\gamma_r =$ 110 pcf
$\delta_c =$ 24.0 °	$\delta_r =$ 17.3 °

Calculate the resultant active soil force induced on the wall and its horizontal and vertical components.



Murata Fill	Retained Soil
$P_a = 0.5K_a\gamma_c(1' \text{ wide})h^2$	$P_a = 0.5K_a\gamma_r(1' \text{ wide})h^2$
$= 0.5(0.179)(125 \text{ pcf})(1')(0.656')^2$	$= 0.5(0.289)(110 \text{ pcf})(1')(0.656')^2$
= 4.81 lbs	= 6.85 lbs
$P_{aH} = P_a\cos(\delta_c-\omega)$	$P_{aH} = P_a\cos(\delta_r-\omega)$
= (4.81 lbs)cos(24°-8.73°)	= (6.85 lbs)cos(17.3°-8.73°)
= 4.64 lbs	= 6.77 lbs
$P_{aV} = P_a\sin(\delta_c-\omega)$	$P_{aV} = P_a\sin(\delta_r-\omega)$
= (4.81 lbs)sin(24°-8.73°)	= (6.85 lbs)sin(17.3°-8.73°)
= 1.27 lbs	= 1.02 lbs

Seismic Loads

Murata Fill	Retained Soil

Recall the previous calculated active seismic and soil pressure coefficients.

Murata Fill	Retained Soil
$K_{aE} = 0.317$	$K_{aE} = 0.476$

Calculate the active seismic pressure coefficient

Murata Fill	Retained Soil
$K_E = 0.138$ $=K_{aE}-K_a$	$K_E = 0.187$ $=K_{aE}-K_a$

Calculate the resultant active seismic force induced on the wall and its horizontal and vertical components.

Murata Fill	Retained Soil
$P_{aE} = 0.5K_E\gamma_c(1' \text{ wide})h^2$	$P_{aE} = 0.5K_E\gamma_r(1' \text{ wide})h^2$
$= 0.5(0.138)(125 \text{ pcf})(1')(0.656')^2$	$= 0.5(0.187)(110 \text{ pcf})(1')(0.656')^2$
= 3.72 lbs	= 4.42 lbs
$P_{aEH} = P_{aE}\cos(\delta_c-\omega)$	$P_{aEH} = P_{aE}\cos(\delta_r-\omega)$
= (3.72 lbs)cos(24°-8.73°)	= (4.42 lbs)cos(17.3°-8.73°)
= 3.59 lbs	= 4.37 lbs
$P_{aEV} = P_{aE}\sin(\delta_c-\omega)$	$P_{aEV} = P_{aE}\sin(\delta_r-\omega)$
= (3.72 lbs)sin(24°-8.73°)	= (4.42 lbs)sin(17.3°-8.73°)
= 0.98 lbs	= 0.66 lbs

Surcharge Loads

Calculate the resultant force on the SRW induced by the surcharge load on the retained soil and its horizontal and vertical components. It is assumed that the surcharge load is uniform and continuous.

$P_{qd} = q_dK_a(1' \text{ wide})h$	$P_{ql} = q_lK_a(1' \text{ wide})$
= (0 psf)(0.179)(1')(0.656')	= (0 psf)(0.289)(1')(0.656')
= 0.00 lbs	= 0.00 lbs
$P_{qdH} = P_{qd}\cos(\delta-\omega)$	$P_{qlH} = P_{ql}\cos(\delta-\omega)$
= (0 lbs)cos(24°-8.73°)	= (0 lbs)cos(17.3°-8.73°)
= 0.00 lbs	= 0.00 lbs
$P_{qdV} = P_{qd}\sin(\delta-\omega)$	$P_{qlV} = P_{ql}\sin(\delta-\omega)$
= (0 lbs)sin(24°-8.73°)	= (0 lbs)sin(17.3°-8.73°)
= 0.00 lbs	= 0.00 lbs

Static Load Application

Calculate the applied distributed load to the retaining wall and the resultant location from the bottom of block (1).

Horizontal Load at the Top of the (1) Block Wall

$w_{HT} = q_d K_a (1')\cos(\delta-\omega) + q_l K_a (1')\cos(\delta-\omega)$

$= (0\ psf)(0.289)(1')\cos(17.3°-8.73°) + (0\ psf)(0.289)(1')\cos(17.3°-8.73°)$

$= 0.0\ plf$

Horizontal Load at the Bottom of the (1) Block Wall

$w_{HB} = w_{HT} + K_a \gamma_c h(1')\cos(\delta-\omega) + q_d K_a (1')\cos(\delta-\omega) + q_l K_a (1')\cos(\delta-\omega)$

$= 0\ plf + (0.289)(110\ pcf)(0.656')(1')\cos(17.3°-8.73°)$

$+ (0\ psf)(0.289)(1')\cos(17.3°-8.73°) + (0\ psf)(0.289)(1')\cos(17.3°-8.73°)$

$= 20.6\ plf$

Calculate the location of the active soil pressure.

$c_y = h - [h(2*w_{HB} + w_{HT})]/[3(w_{HB} + w_{HT})]$

$= 0.656' - [(0.656')(2(20.64\ plf) + 0\ plf)]/[3(20.64\ plf + 0\ plf)]$

$= 0.219\ ft$

Calculate horizontal resultant active soil force.

$P_{aH} = h(w_{HT} + w_{HB})/2$

$= (0.656')(0\ plf + 20.64\ plf)/2$

$= 6.8\ lbs\ @\ c_y$

Vertical Load at the Top of the (1) Block Wall

$w_{VT} = q_d K_a (1')\sin(\delta-\omega) + q_l K_a (1')\sin(\delta-\omega)$

$= (0\ psf)(0.289)(1')\sin(17.3°-8.73°) + (0\ psf)(0.289)(1')\sin(17.3°-8.73°)$

$= 0.0\ plf$

Vertical Load at the Bottom of the (1) Block Wall

$w_{VB} = w_{VT} + K_a \gamma_c h(1')\sin(\delta-\omega) + q_d K_a (1')\sin(\delta-\omega) + q_l K_a (1')\sin(\delta-\omega)$

$= 0\ plf + (0.289)(110\ pcf)(0.656')(1')\sin(17.3°-8.73°)$

$+ (0\ psf)(0.289)(1')\sin(17.3°-8.73°) + (0\ psf)(0.289)(1')\sin(17.3°-8.73°)$

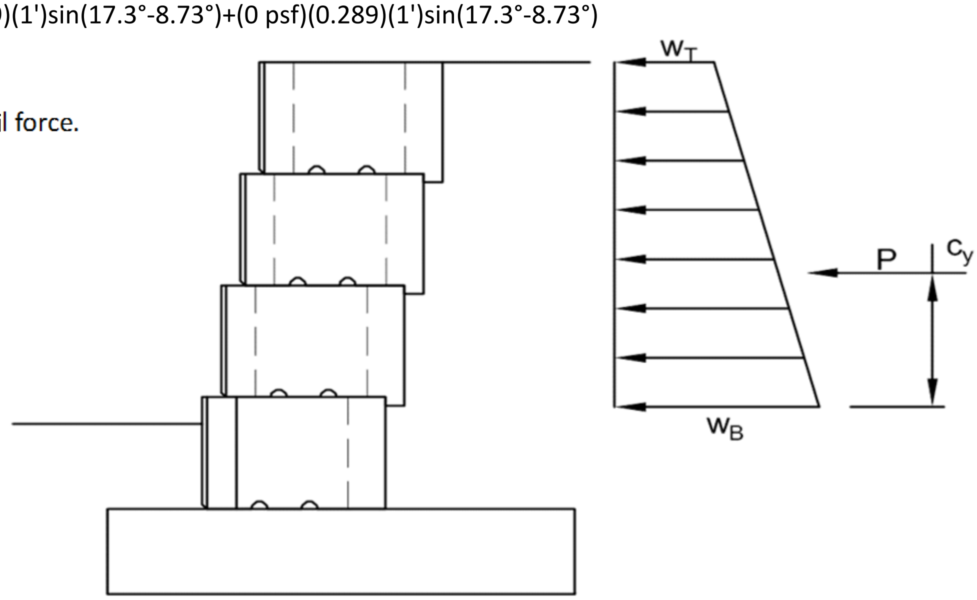
$= 3.1\ plf$

Calculate vertical resultant active soil force.

$P_{aV} = h(w_{VT} + w_{VB})/2$

$= (0.656')(0\ plf + 3.1\ plf)/2$

$= 1.0\ lbs$



Seismic Load Application

Calculate the applied distributed load to the retaining wall and the resultant location from the bottom of the base block.

Horizontal Load at the Top of the (1) Block Wall

$w_{HTE} = K_E \gamma_c H(1')\cos(\delta-\omega)+w_{HT}$

$= (0.187)(110\ psf)(2.625')(1')\cos(17.3°-8.73°)+ 0plf$

$=$ 13.3 plf

Horizontal Load at the Bottom of the (1) Block Wall

$w_{HBE} = K_E \gamma_c (H-h)(1')\cos(\delta-\omega)+w_{HB}$

$= (0.187)(110\ psf)(2.625'-0.656')(1')\cos(17.3°-8.73°)+ 20.6plf$

$=$ 60.6 plf

Calculate the location of the active seismic and soil pressure.

$c_{yE} = h-[h(2*w_{HBE}+w_{HTE})]/[3(w_{HBE}+w_{HTE})]$

$= 0.656'-[(0.656')(2(60.6\ plf)+13.3\ plf)]/[3(60.6\ plf+13.3\ plf)]$

$=$ 0.258 ft

Calculate vertical resultant active soil force.

P_{aEH} = h(Horizontal Load @ Top+Horizontal Load @ Bottom)/2

= (0.656')(13.32 plf+60.61 plf)/2

= 24.3 lbs @ c_{yE}

Vertical Load at the Top of the (1) Block Wall

$w_{VTE} = K_E \gamma_c H(1')\cos(\delta-\omega)+w_{VT}$

$= (0.187)(110\ psf)(2.625')(1')\cos(17.3°-8.73°)+ 0plf$

$=$ 2.0 plf

Vertical Load at the Bottom of the (1) Block Wall

$w_{VBE} = K_E \gamma_c (H-h)(1')\sin(\delta-\omega)+w_{VB}$

$= (0.187)(110\ psf)(2.625'-0.656')(1')\sin(17.3°-8.73°)+ 3.1plf$

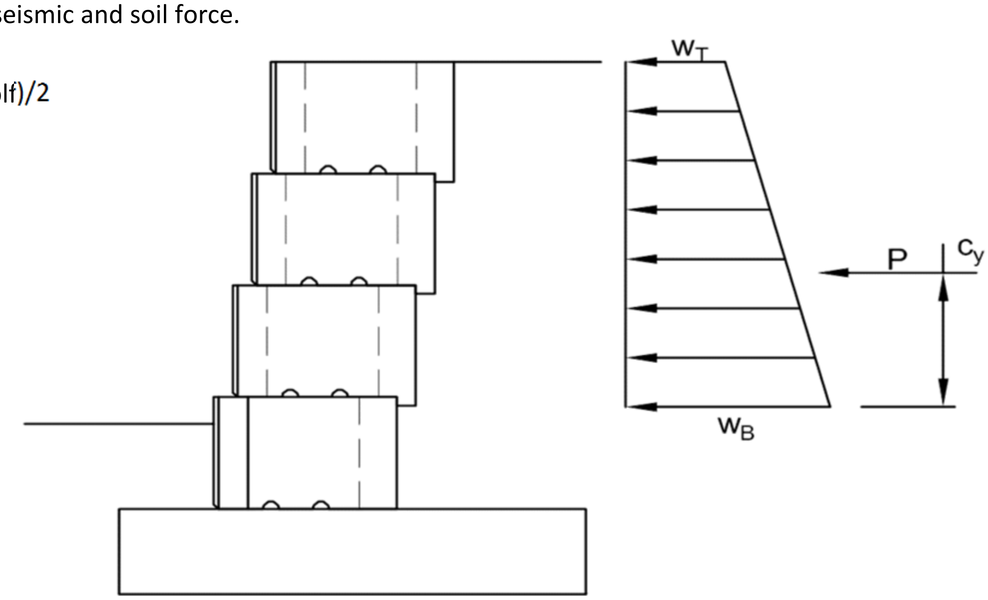
$=$ 9.2 plf

Calculate vertical resultant active seismic and soil force.

$P_{aEV} = h(w_{VTE}+w_{VBE})/2$

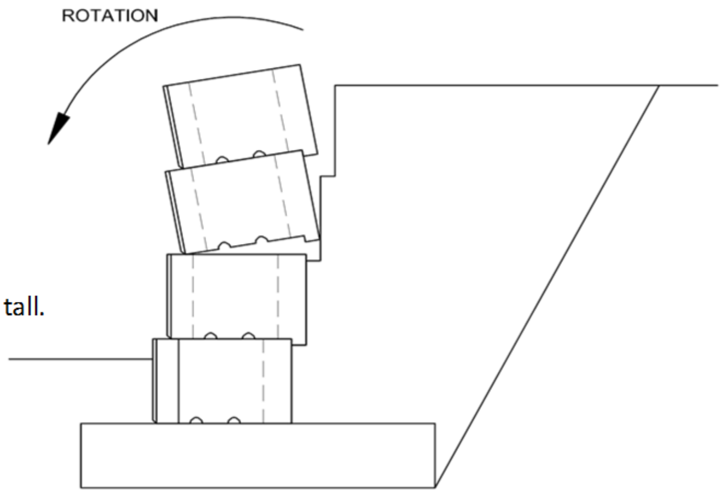
= (0.656')(2.02 plf+9.17 plf)/2

= 3.7 lbs



Internal Overturning Stability

Calculate the factor of safety of the resistive moment versus the overturning moment of the block (1) overturning about the front corner.



The capacity of the system to resist the overturning caused by the lateral forces applied to the wall.

Static

Calculate the overturning moment.

$M_o = P_{aH}c_y$

$= (6.8 \text{ lbs})(0.219')$

$= 1.5$ lbs-ft

Calculate the weight of a 1' wide strip of the wall (1) blocks tall.

$w_W = \gamma_u W_u h(1'\text{wide})$

$= (120.8 \text{ pcf})(0.968')(0.656')(1')$

$= 77$ lbs

Recall the resisting moment arm.

$x_W = 0.635$ ft

Calculate the moment resisting overturning.

$M_r = w_W x_W + P_{aV}[W_u + h^*\tan(\omega)/2]$

$= (77 \text{ lbs})(0.635') + (1 \text{ lbs})[(0.968') + (0.219')\tan(8.73°)]$

$= 50$ lbs-ft

Calculate the factor of safety for the retaining wall overturning about the front corner of the (1) block.

$FS_{ot} = M_r/M_o$

$= 50 \text{ lbs-ft}/1.5 \text{ lbs-ft}$

$= 33.59$

Seismic

Calculate the overturning moment.

$M_o = P_{aEH}c_{yE}$

$= (24.3 \text{ lbs})(0.258')$

$= 6.3$ lbs-ft

Calculate the moment resisting overturning.

$M_r = w_W x_W + 0.5P_{aEV}[W_u + h^*\tan(\omega)/2]$

$= (77 \text{ lbs})(0.635') + (0.5 \text{ lbs})[(0.968') + (0.219')\tan(8.73°)]$

$= 49$ lbs-ft

Calculate the factor of safety for the retaining wall overturning about the front corner of the (1) block.

$FS_{ot} = M_r/M_o$

$= 49 \text{ lbs-ft}/6.3 \text{ lbs-ft}$

$= 7.86$

Internal Sliding Stability

Calculate the factor of safety of block (1) sliding on block (2).

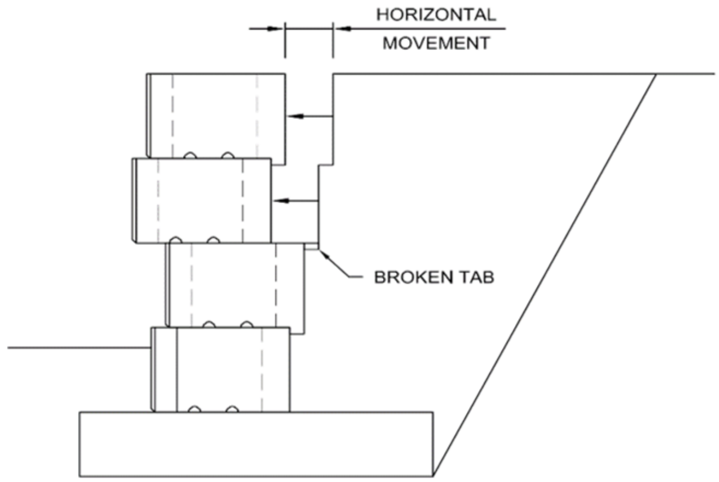
Static

Calculate the resistance to sliding due to friction between the (1) block and the block below it.

$R_{sc} = (\mu_{SRW})(w_W+P_{aV})+a_u$

$= (0.74)(76.7\ lbs+3.7\ lbs)+(449\ lbs)$

$= 509\ lbs$



Recall the resultant horizontal active soil force.

$P_{aH} = 6.8\ lbs$

Calculate the factor of safety for block sliding.

$FS_{sl} = R_{sc}/P_{aH}$

$= 509\ lbs/6.8\ lbs$

$= 75.15$

Seismic

Calculate the resistance to sliding due to friction between the (1) block and the block below it.

$R_{sc} = (\mu_{SRW})(w_W+0.5P_{aEV})+a_u$

$= (0.74)(76.7\ lbs+0.5\ lbs)+(449\ lbs)$

$= 507\ lbs$

The capacity of the system to resist the overturning caused by the lateral forces applied to the wall.

Recall the resultant horizontal active seismic and soil force.

$P_{aEH} = 24.3\ lbs$

Calculate the factor of safety for block sliding.

$FS_{sl} = R_{sc}/0.5P_{aEH}$

$= 507\ lbs/12.1\ lbs$

$= 41.77$