PanGEO
INCORPORATED
Geotechnical & Earthquake
Engineering Consultants

February 3, 2026
Revised February 24, 2026
File No. 25-466

Artoush Fanaiyan
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Subject: Response to Geotechnical Review Comments – REV01
Proposed SFR
5818 West Mercer Way, Mercer Island, WA

Dear Artoush,

We received Sub 5 geotechnical review comments dated January 23, 2026 from the City of Mercer Island for the above project. Based on the communications/meetings with city reviewers and our additional engineering analyses, the following are our responses to the review comments related to the geotechnical aspect of the project.

PERMANENT ULTRABLOCK WALLS

Based on current design plans, we understand that permanent ultrablock walls are proposed on the south side of the house to retain the cuts and along the driveway to retain the fill, and the walls have the maximum exposed height of 6 feet. We used Ultrablock software to design the walls for 4-foot and 6-foot exposed wall heights. The following soil properties were derived from the subsurface data at the site and were used in the wall design. For the seismic design, a peak ground acceleration (PGA) of 0.627 with F_{PGA} = 1.1 were used in the design.

Table 1. Soil Properties for Ultrablock Wall Design

Soil Type	Unit Weight (pcf)	Cohesion (psf)	Friction (Degree)
Retained Soil	110	0	32
Foundation Soil	130	0	36
Leveling Pad	135	0	40

Based on the calculations, for the 6-foot exposed wall height, a 3-row block configuration with base block 5 feet deep should be used. For the 4-foot exposed wall height, a 2-row block configuration may be used. The detailed calculations are attached in Appendix A at the end of this letter.

Additionally, we recommend adding one soldier pile (E0) to the south of soldier pile E1 to eliminate the most east block wall, and also another soldier pile N1 at the NE corner for excavation transition. All other ultrablock walls will have a level ground behind the walls. As such, there is no slope surcharge for these walls.

SHORING DESIGN RECOMMENDATIONS

1. Soil Properties for Earth Pressures

We used the following soil properties to calculate the earth pressures for the temporary shoring wall design.

Soil Type	Unit Weight (pcf)	Cohesion (psf)	Friction (Degree)
Retained Soil above Excavation Bottom	120	0	32
Native soil below Excavation	130	0	36

We used the following soil properties to calculate the earth pressures for the permanent shoring wall design, to account for the long-term cohesive soil softening.

Soil Type	Unit Weight (pcf)	Cohesion (psf)	Friction (Degree)
Retained Soil above Excavation Bottom	120	0	25
Native soil below Excavation	130	0	36

Assuming the level ground behind the wall, we used Coulomb's earth pressure formula to calculate the earth pressure coefficient, and the active earth pressure coefficient ka is 0.307 for the temporary condition, which yielded an equivalent fluid pressure of 33.8 pcf (less than 35 pcf). The calculated active equivalent fluid pressure for the long term condition is 49 pcf.

To account for the sloping ground surcharge, we used earth pressure factors times the equivalent fluid pressures for the level ground to account for the different backslope ratios, and the earth pressure factors are included in the earth pressure diagram Figures 1 through 4.

The calculated equivalent fluid passive pressure is 462 pcf (allowable value of 308 pcf). These equivalent fluid pressures are used for cantilever soldier pile design.

2. ***Earth Pressure Diagram for Temporary Cantilever Soldier Pile Wall along the south Property line***

The earth pressure diagram for temporary cantilever soldier pile along the south property line S1 – S7 is attached in Figure 1.

3. ***Earth Pressure Diagram for Temporary and Permanent Cantilever Soldier Pile Wall along the East Property line E11 – E14***

The earth pressure diagram for temporary and permanent cantilever soldier piles along the east property line E11 – E14 is attached in Figure 2.

4. ***Earth Pressure Diagram for Temporary Tieback Soldier Piles Wall along the East Property line E1 – E10***

The earth pressure diagram for temporary tieback soldier piles along the east property line E1 – E10 is attached in Figure 3.

5. ***Earth Pressure Diagram for Permanent Tieback Soldier Piles Wall along the East Property line E1 – E10***

The earth pressure diagram for permanent tieback soldier piles along the east property line E1 – E10 is attached in Figure 4. A reduced passive pressure of 35 pcf is used for the basement backfill portion due to the close distance between the basement and the soldier pile wall, and to avoid surcharge the basement wall.

6. ***Reduced Passive Pressure in Front of Shoring Walls***

For the temporary conditions, the passive pressure for sloped cuts in front of Piles E1 through E9 should be disconnected and bottom of the excavations should be assumed at the bottom of basement foundation levels. We will coordinate with the shoring designer to revise the shoring design after the geotechnical design recommendations are approved.

7. ***Other Sub 5 Comments Regarding Shoring Design***

PanGEO reviewed the geotechnical engineering aspects of the latest shoring plans for the above-referenced project. Our review includes the following:

- Revised architectural plan sheet A-1 and A-9 last revised on February 20, 2026 by Centerline Design; and

- Shoring plan sheets SH0.1 through S3.1 and shoring calculations last revised on February 20, 2026 by Atlas Consulting Structural Engineers.

In general, it is our opinion that the plans reviewed had incorporated all substantial geotechnical recommendations presented in our geotechnical letter dated January 6, 2026 and in this letter.

STATEMENT OF MINIMUM RISKS

We understand that the site is mapped as a geologic hazard area. Per Mercer Island City Code Section 19.07.160.B.2, development within geologic hazard areas and critical slopes may occur if the geotechnical engineer provides a statement of risk with supporting documentation indicating that one of the following conditions can be met:

a. The geologic hazard area will be modified, or the development has been designed so that the risk to the lot and adjacent property is eliminated or mitigated such that the site is determined to be safe;

b. Construction practices are proposed for the alteration that would render the development as safe as if it were not located in a geologic hazard area;

c. The alteration is so minor as not to pose a threat to the public health, safety, and welfare;

d. An evaluation of site-specific subsurface conditions demonstrates that the proposed development is not located in a geologic hazard area.

Based on our engineering analyses and our review of the current plans, it is our opinion that Criterion (a) and (b) can be met, provided that the project is properly constructed per the approved plans, current building code and common practice. We recommend that best management practices be implemented during construction, including the proper use of silt fence, minimizing earthwork activities during periods heavy precipitations, minimizing exposed areas in wet season, etc. Permanent erosion control measures including landscape and hardscape installations will effectively mitigate the risk of erosion in the long term and should be applied as soon as the grading is completed.

CLOSURE

We appreciate the opportunity to assist you with this project. If you have any questions, please do not hesitate to contact us.

Sincerely,

2/24/2026

Michael H. Xue, P.E.
Principal Geotechnical Engineer

Attachments:

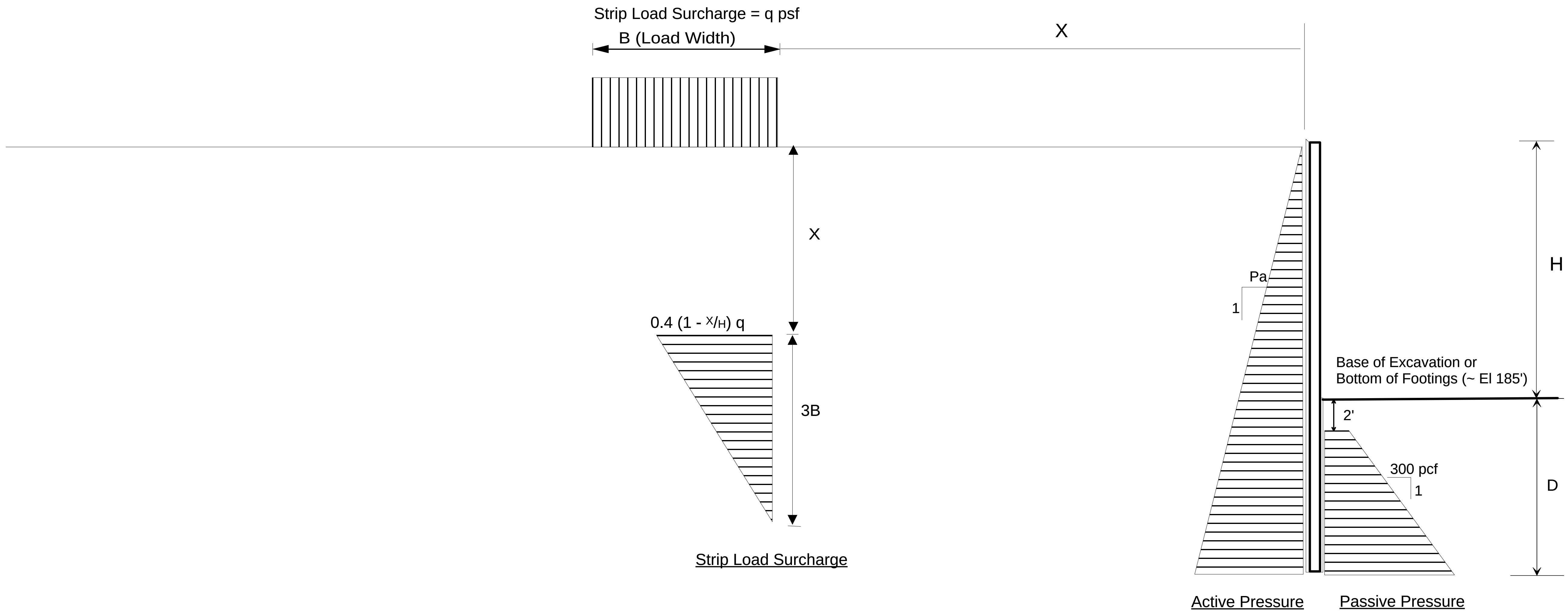
Figure 1 Design Lateral Pressures, Temporary Cantilever Soldier Pile Wall S1 – S7

Figure 2 Design Lateral Pressures, Cantilever Soldier Pile Wall E11-E14

Figure 3 Design Lateral Pressures, Temporary Soldier Pile Wall with One Level of Tiebacks E1-E10

Figure 4 Design Lateral Pressures, Permanent Soldier Pile Wall with One Level of Tiebacks E1-E10

Appendix A – Summary Ultrablock Design Calculations



Temporary Shoring Walls:
Pa = 35 pcf (Level Background)

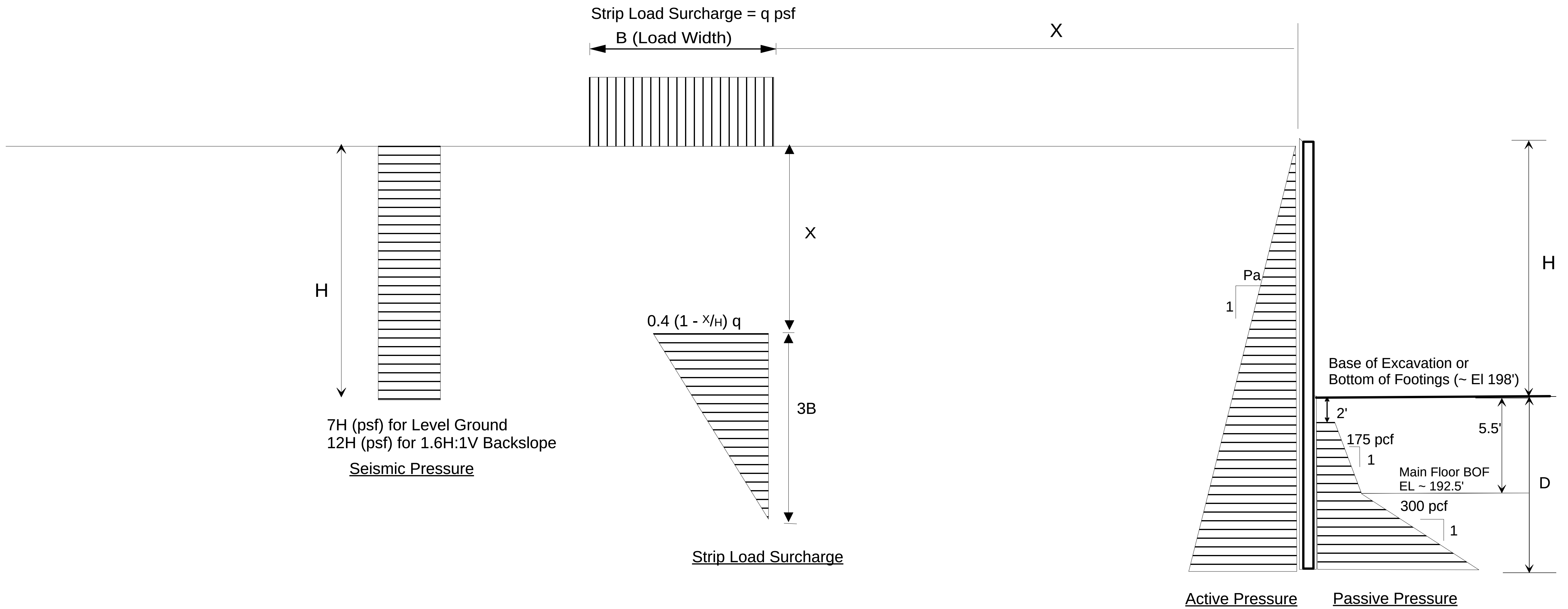
Notes:
1. Minumum embedment should be at least 8 feet below bottom of excavation.
2. A factor of safety of 1.5 has been applied to the recommended passive pressure values. No factor of safety has been applied to the recommended active earth pressure values.
3. Active pressures should be applied over the full width of the pile spacing above the base of the excavation, and over one pile diameter below the base of the excavation.
4. Surcharge pressures should be applied over the entire length of the loaded area.
5. Passive pressure should be applied to 2.5 times the diameter of the soldier piles, or pile center-to-center spacing, whicever is less.
6. For lagging design, refer to report text.

Earth Pressure Factor for Backslope

Backslope, X:1	Earth Pressure Factor (A)	Pile Locations
Level	1	S1 – S7
3H:1V	1.2	
2H:1V	1.4	E12 – E14
1.6H:1V	1.55	E1 – E11

Note: This Earth Pressure Diagram is for Temporary Cantilever Soldier Pile Wall Design S1 - S7 Only

PanGEO INCORPORATED	Proposed SFR 5818 West Mercer Way Mercer Island, Washington	DESIGN LATERAL PRESSURES TEMPORARY CANTILEVER SOLDIER PILE WALL S1 - S7 Project No. 25-466 — Figure No. 1



Temporary Shoring Walls:
Pa = 35 pcf (Level Background)

Permanent Shoring Walls:
Pa = 50 pcf (Level Background)

Earth Pressure Factor for Backslope

Backslope, X:1	Earth Pressure Factor (A)	Pile Locations
Level	1	S1 – S7
3H:1V	1.2	
2H:1V	1.4	E12 – E14
1.6H:1V	1.55	E1 – E11

Notes:
1. Minumum embedment should be at least 8 feet below bottom of excavation.
2. A factor of safety of 1.5 has been applied to the recommended passive pressure values. No factor of safety has been applied to the recommended active earth pressure values.
3. Active pressures should be applied over the full width of the pile spacing above the base of the excavation, and over one pile diameter below the base of the excavation.
4. Surcharge pressures should be applied over the entire length of the loaded area.
5. Passive pressure should be applied to 2.5 times the diameter of the soldier piles, or pile center-to-center spacing, whicever is less.
6. For lagging design, refer to report text.

Note: This Earth Pressure Diagram is for Cantilever Soldier Pile Wall Design E11 - E14 Only

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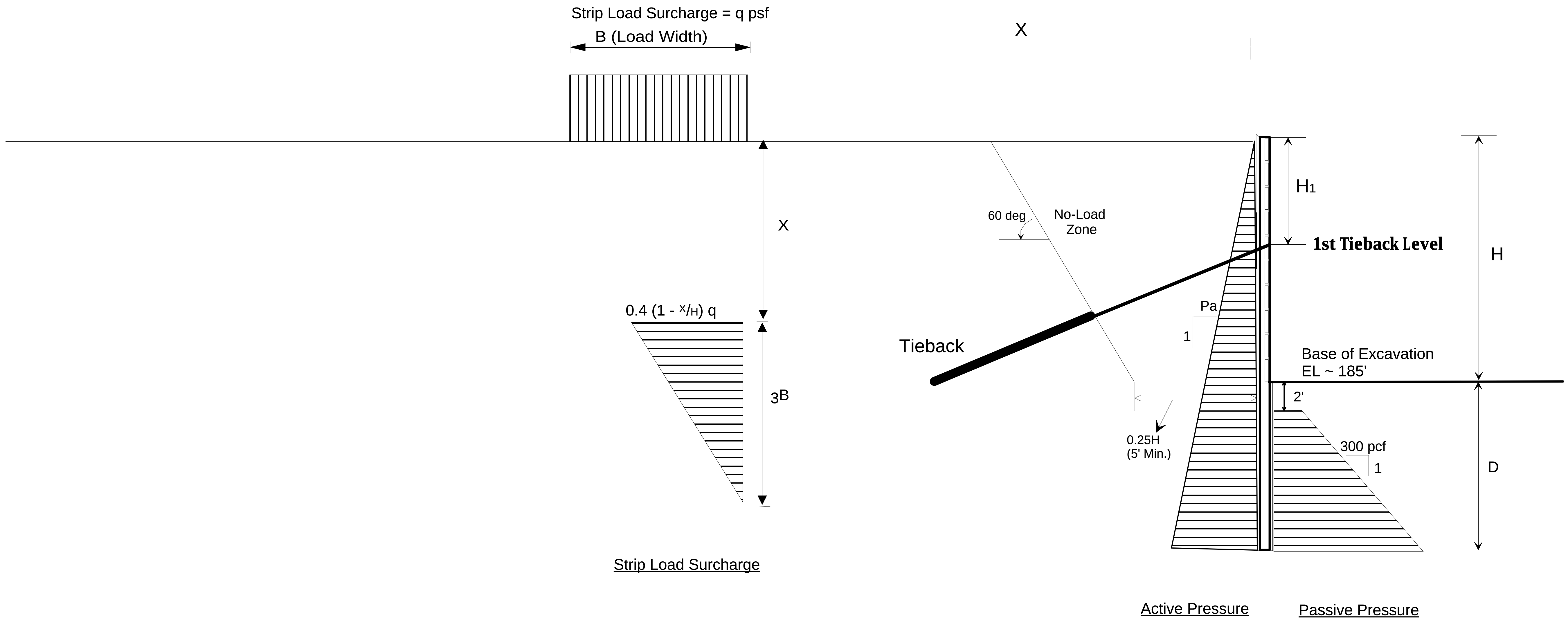
Proposed SFR
5818 West Mercer Way
Mercer Island, Washington

DESIGN LATERAL PRESSURES
CANTILEVER SOLDIER PILE WALL
E11 - E14

Project No. **25-466** Figure No. **2**



Pa = 35H psf (Level Background)

Notes:
1. Minumum embedment should be at least 8 feet below bottom of excavation.
2. A factor of safety of 1.5 has been applied to the recommended passive pressure values. No factor of safety has been applied to the recommended active earth pressure values.
3. Active pressures should be applied over the full width of the pile spacing above the base of the excavation, and over one pile diameter below the base of the excavation.
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6. For lagging design, refer to report text.

Earth Pressure Factor for Backslope

Backslope, X:1	Earth Pressure Factor (A)	Pile Locations
Level	1	S1 – S7
3H:1V	1.2	
2H:1V	1.4	E12 – E14
1.6H:1V	1.55	E1 – E11

Tiebacks:

Minimum Bond Length: 12 feet
Assume Maximum Allowable Capacity:
2.5 kip / foot

Note: This Earth Pressure Diagram is for Temporary Tiebacked Soldier Pile Wall Design E1 - E10 Only

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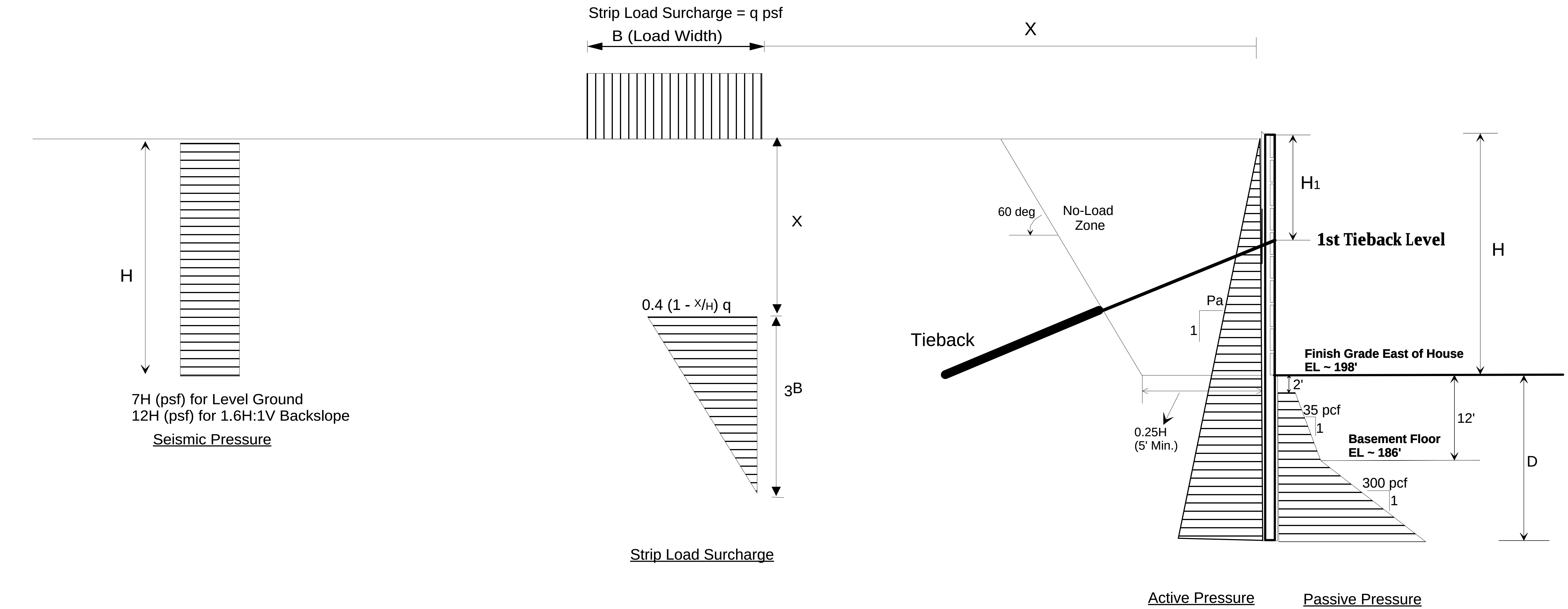
Proposed SFR
5818 West Mercer Way
Mercer Island, Washington

DESIGN LATERAL PRESSURES
TEMPORARY SOLDIER PILE WALL WITH
ONE OR MULTIPLE LEVELS OF TIEBACKS

Project No. **25-466** Figure No. **3**



Pa = 49H psf (Level Background)

Notes:
1. Minumum embedment should be at least 8 feet below bottom of excavation.
2. A factor of safety of 1.5 has been applied to the recommended passive pressure values. No factor of safety has been applied to the recommended active earth pressure values.
3. Active pressures should be applied over the full width of the pile spacing above the base of the excavation, and over one pile diameter below the base of the excavation.
4. Surcharge pressures should be applied over the entire length of the loaded area.
5. Passive pressure should be applied to 2.5 times the diameter of the soldier piles, or pile center-to-center spacing, whicever is less.
6. For lagging design, refer to report text.

Earth Pressure Factor for Backslope

Backslope, X:1	Earth Pressure Factor (A)	Pile Locations
Level	1	S1 – S7
3H:1V	1.2	
2H:1V	1.4	E12 – E14
1.6H:1V	1.55	E1 – E11

Tiebacks:

Minimum Bond Length: 12 feet
Assume Maximum Allowable Capacity:
2.5 kip / foot

Note: This Earth Pressure Diagram is for Permanent Tiebacked Soldier Pile Wall Design E1 - E10 Only

PanGEO INCORPORATED

Proposed SFR
5818 West Mercer Way
Mercer Island, Washington

DESIGN LATERAL PRESSURES
PERMANENET SOLDIER PILE WALL WITH
ONE OR MULTIPLE LEVELS OF TIEBACKS
E1 - E10

Project No. **25-466**
Figure No. **4**

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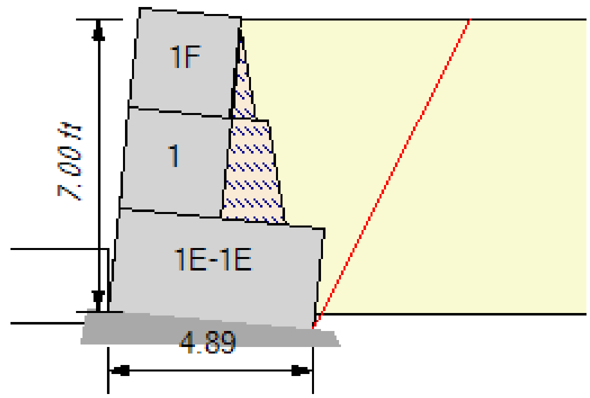
APPENDIX A
SUMMARY ULTRABLOCK DESIGN CALCULATIONS

UltraWall

Project: 5818 W Mercer Way SFR
Location: 5818 W Mercer Way, MI
Designer: HMX
Date: 2/2/2026
Section: Section 1
Design Method: NCMA_09_3rd_Ed
Design Unit: UltraBlock: 1

Seismic Acc: 0.690g
Design Method: AASHTO 2020, Kavazanjian
Design Equation: AASHTO 2020, A11.5.1-1



SOIL PARAMETERS	Φ	coh	γ
Drainage Zone:	34 deg	0 lbf/ft2	120 lbf/ft3
Retained Soil:	32 deg	0 lbf/ft2	110 lbf/ft3
Foundation Soil:	36 deg	0 lbf/ft2	130 lbf/ft3
Leveling Pad:	40 deg	0 lbf/ft2	135 lbf/ft3
Crushed Stone Lvlng Pad			

GEOMETRY

Design Height:	7.00 ft	Live Load:	0.00 lbf/ft2
Wall Batter/Tilt:	0.00/ 5.70 deg	Live Load Offset:	0.00 ft
Embedment:	1.50 ft*	Live Load Width:	0.00 ft
Leveling Pad Depth:	0.30 ft		
Slope Angle:	0.0 deg	Dead Load:	0.0 lbf/ft2
Slope Length:	0.0 ft	Dead Load Offset:	0.0 ft
Slope Toe Offset:	0.0 ft	Dead Load Width:	0.00 ft
Leveling Pad Width:	5.92 ft	D.L. Embedment:	0.00 ft

Vert δ on Single Dpth

* Note: For all designs the passive resistance in front of the wall units is ignored for sliding calculations.

FACTORS OF SAFETY (Static / Seismic)

Sliding:	1.50 / 1.125	Overturning:	1.50 / 1.125
Bearing:	3.00 / 1.5		

RESULTS (Static / Seismic)

FoS Sliding: 4.46 (lvlpd) / 2.76 FoS Overturning: 8.56 / 2.47

Bearing: 1961.69 / 1050.88 FoS Bearing: 9.56 / 26.63

Name	Elev.	ka	kae	Pa	Pae	Pif	PaT	PaTs	FSsl	seisFSsl	FoS OT	FoS SeisOT
1F	4.84	0.237	0.479	60	122	251	60	374	73.78	35.72	24.43	3.04
1	2.42	0.237	0.479	273	552	503	273	1054	18.94	9.09	5.88	1.21
1E-1E	0.00	0.407	0.741	1096	1997	1005	1096	3003	4.46	2.76	8.56	2.47

Design Approach:

The design is a 'top down' approach. The values shown in the table[ka, kae, Pa, etc.] are the values from the top of wall to the base of that row. For trial wedge analysis, the ka and kae are back-calculated from the Pa, Pae values.

Column Descriptions:

ka: active earth pressure coefficient
kae: active seismic earth pressure coefficient
Pa: active earth pressure
Pae: dynamic earth pressure
Pir: inertia force
Paq: live surcharge earth pressure
Paq2: live load 2 surcharge earth pressure
Paqd: dead surcharge earth pressure
(PaC): reduction in load due to cohesion
PaT: sum of all earth pressures
FSsl(lvl Pad): factor of safety for sliding at each layer. (FS sliding below the leveling pad)
FSot: factor of safety of overturning about the toe.

DESIGN DATA

TARGET DESIGN VALUES (Factors of Safety - Static / Seismic)

Minimum Factor of Safety for the sliding along the base	FSsl = 1.50 /1.125
Minimum Factor of Safety for overturning about the toe	FSot = 1.50 /1.125
Minimum Factor of Safety for bearing (foundation shear failure)	FSbr = 2.00 /1.500

MINIMUM DESIGN REQUIREMENTS

Minimum embedment depth	Min_emb = 1.50 ft

INPUT DATA

Geometry

Wall Geometry

Design Height, top of leveling pad to top of wall	H = 7.00 ft
Design Height External, top of leveling pad to finished grade at top of wall	he = 7.00 ft
Embedment, measured from top of leveling pad to finished grade	emb = 1.50 ft
Leveling Pad Depth	Thickness = 0.30 ft
Face Batter, measured from vertical	i = 0.00 deg

Slope Geometry

Back Slope Angle, measured from horizontal	β = 0.00 deg
Back Slope Toe Offset, measured from back of the face unit	STL_offset = 0.00 ft
Back Slope Length, measured from toe to crest	SL_Length = 0.00 ft

NOTE: If the back slope toe is offset or the slope breaks within three times the wall height, a Coulomb Trial Wedge method of analysis is used.

Toe Slope Angle, measured from horizontal	β = 0.00 deg
Toe Slope Crest Offset, measured from front of the face unit	STL_offset = 0.00 ft
Toe Slope Length, measured from crest to toe	SL_Length = 0.00 ft

Surcharge Loading

Live Load, assumed transient loading (e.g. traffic)	LL = 0.00 lbf/ft2
Live Load Offset, measured from back face of wall	LL_offset = 0.00 ft
Live Load Width, assumed strip loading	LL_width = 0.00 ft

Soil Parameters

Retained Zone

Angle of Internal Friction	Φ = 32.00 deg
Cohesion	coh = 0.00 lbf/ft2
Moist Unit Weight	γ = 110.00 lbf/ft3

Foundation

Angle of Internal Friction	Φ = 36.00 deg
Cohesion	coh = 0.00 lbf/ft2
Moist Unit Weight	γ = 130.00 lbf/ft3

Leveling Pad

Angle of Internal Friction	Φ = 40.00 deg
Cohesion	coh = 0.00 lbf/ft2
Moist Unit Weight	γ = 135.00 lbf/ft3

RETAINING WALL UNITS

STRUCTURAL PROPERTIES:

N is the normal force [or factored normal load] on the base unit

The default leveling pad to base unit shear is 0.8 tan(Φ) [AASHTO 10.6.3.4] or may be the manufacturer supplied data. Φ is assumed to be 40 degrees for a stone leveling pad.

Unit	Aggr_Vol (cf)	Aggr_Density (pcf)	Aggr_CG (in)	Equiv_Density (pcf)	Equiv_CG (in)
Cap	0.00	105	14.75, 7.37	0	NaN
Full Cap	0.00	105	14.75, 14.75	0	NaN
Full	0.00	105	14.75, 14.75	0	NaN
Double	0.00	105	29.50, 14.75	0	NaN

CALCULATION RESULTS

OVERVIEW

UltraWall calculates stability assuming the wall is a rigid body. Forces and moments are calculated about the base and the front toe of the wall. The base block width is used in the calculations. The concrete units and granular fill over the blocks are used as resisting forces.

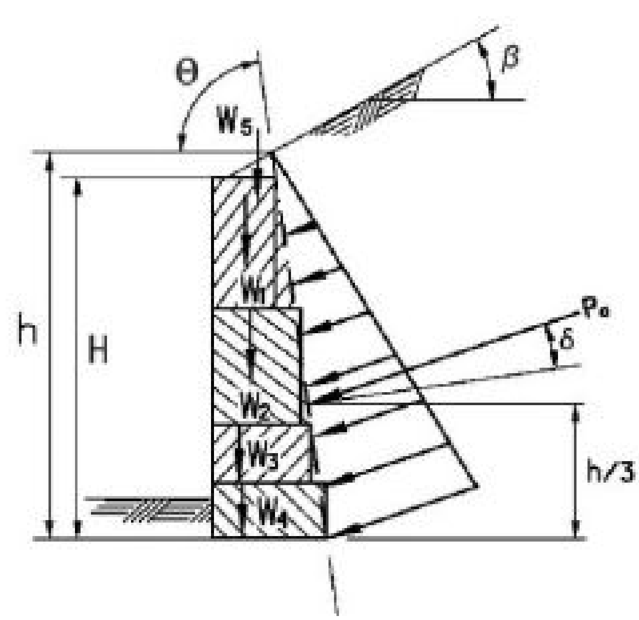
EARTH PRESSURES

The method of analysis uses the Coulomb Earth Pressure equation (below) to calculate active earth pressures. Wall friction is assumed to act at the back of the wall face. The component of earth pressure is assumed to act perpendicular to the boundary surface. The effective δ angle is δ minus the wall batter at the back face. If the slope breaks within the failure zone, a trial wedge method of analysis is used.

EXTERNAL EARTH PRESSURES

Effective δ angle (3/4 retained phi)	δ = 24.0 deg
Coefficient of active earth pressure	ka = 0.407
External failure plane	ρ = 62 deg
Effective Angle from horizontal	θ = 74.84 deg
Coefficient of passive earth pressure: kp = (1 + sin(Φ)) / (1 - sin(Φ))	kp = 0.00

$$Ka := \frac{\cos(\phi_i + i)^2}{\cos(i)^2 \cdot \cos(\delta_i - i)\left(1 + \sqrt{\dfrac{\sin(\phi_i + \delta_i)\cdot \sin(\phi_i - \beta)}{\cos(\delta_i - i)\cdot \cos(i + \beta)}}\right)^2}$$



where:

- δ = friction angle between fill and wall (degrees)
- β = angle of fill to the horizontal (degrees)
- θ = angle of back face of wall to the horizontal (degrees)
- ω = angle of wall batter (degrees) = θ - 90
- Φ' = effective angle of internal friction (degrees)

FORCE DETAILS

The details below shown how the forces are calculated for each force component. The values shown are not factored. All loads are based on a unit width (lbf/ft or kN/m).

Layer	Block Wt lbf	Soil Infill Wt lbf	Soil Wedge Wt lbf
1	846.08	0	83
2	846.08	0	357
3	1692.15	0	

Block Weight = 3384.31 lbf/ft X-Arm = 4.02 ft
Soil Infill Weight = 0.00 lbf/ft X-Arm = 0.00 ft
Soils Wedge Weight = volume x Drain rock density
3.67 * 120.00 = 439.87 lbf/ft X-Arm = 3.66 ft

Active Earth Pressure Pa = 1095.69 lbf/ft
Pa_h (W9) = Pa cos(δ - ω) = 1095.69 x cos(24.00 - (-15.16)) = 850 lbf/ft
Y-Arm = 2.50 ft
Pa_v (W9) = Pa sin(δ - ω) = 1095.69 x sin(24.00 - (-15.16)) = 692 lbf/ft
X-Arm = 4.24 ft

FORCES AND MOMENTS

The program resolves all the geometry into simple geometric shapes to make checking easier. All x and y coordinates are referenced to a zero point at the toe of the bottom unit.

LOADS FOR OVERTURNING ABOUT THE TOE

Name	Force(V) lbf	Force(H) lbf	X-len ft	Y-len ft	Mo ft-lbf	Mr ft-lbf
Face Blocks (W1)	3384.31		4.024			13617.82
Soil Wedge (W2)	439.87		3.663			1611.16
Pa_h (W9)		849.57		2.496	2120.61	
Pa_v (W9)	691.94		4.240			2934.01
Sum V / H	4,516	850		Sum Mom	2,121	18,163

W0: stone within units

W1: facing units

W2: soil wedge behind the face

X-Len: is measured from the front of the base block (+) Driving, (-) Resisting.

Pa_h (W9): horizontal earth pressure

Pa_v (W9): vertical earth pressure

Pq_h: horizontal surcharge pressure

Pq_v: vertical surcharge pressure

BEARING LOADS: NCMA

All x and y coordinates are referenced to a zero point at the middle of the base block for eccentricity calculations.

Name	Force(V) lbf	Force(H) lbf	X-len ft	Y-len ft	Mo ft-lbf	Mr ft-lbf
Face Blocks (W1)	3384.31		-1.578			-6515.65
Soil Wedge (W2)	439.87		-1.217			-535.50
Pa_h (W9)		849.57		2.496	2120.61	
Pa_v (W9)	691.94		-1.796			-1414.40
Sum V / H	4516	850		Sum Mom	2121	-8466

BASE SLIDING

Sliding at the base is checked at the block to leveling pad interface between the base block and the leveling pad. Sliding is also checked between the leveling pad and the foundation soils.

Forces Resisting sliding = W1 + W2 + Pav
3384.31 + 439.87 + 691.94 N = 4516.12 lbf/ft

Sliding between Concrete Units and Leveling Pad/Drain Mat (Rf1)
Resisting force at pad = (N x φ x tan(slope) + intercept)
(4516 x 0.8 + tan(40.00) + 0.0) RF(lvlPd) = 3789 lbf

Driving force is the horizontal component of Pah
849.57 Df = 849.57

FSsl = Rf / Df FSsl = 4.46 lbf

FSslfndn = Rf1 / Df FSslfndn = 100.00

ROW TO ROW SLIDING

Sliding between rows is checked at the interface between two adjacent rows.

Details of the calculation are shown on the previous page. The leveling pad interaction is now replaced with the unit/unit interaction.

Resisting Force = Normal Force x 0.8 + intercept)
Units: All units are in lbf/ft or ft-lbf/ft of wall.

RESULTS TABLE

Elev[ft]	Normal[lbf/ft]	RF Concrete	Shear Intcpt	Resisting Force	Driving Force[lbf/ft]	FS Sliding/Shear
4.84	846.08	676.86	3619.55	4296.41	58.24	73.78
2.42	1692.15	1353.72	3619.55	4973.27	262.58	18.94

OVERTURNING ABOUT THE TOE

Overturning at the base is checked by assuming rotation about the front toe by the block mass and the soil retained on the blocks. Allowable overturning can be defined by factor of safety of overturning. For concrete leveling pads overturning is checked at the base of the pad.

Moments Resisting Overturning = M1 + M2 + MPav
13617.82 + 1611.16 + 2934.01 — Mr = 18163.00 ft-lbs

Moments causing Overturning = MPah
2120.61 — Mo = 2120.61 ft-lbs

FSot = Mr / Mo
FSot = 18163.00 / 2120.61 — FSot = 8.56

OVERTURNING ABOUT THE ROW BELOW

Overturning at the row below is checked by assuming rotation about the front toe by the block mass and the soil retained on the blocks. Allowable overturning can be defined by Factor of safety of Overturning. For concrete leveling pads overturning is checked at the base of the pad.

Factor of Safety Overturning = Moment Resisting / Moment Driving

RESULTS TABLE

Elev[ft]	Mr[ft-lbf]	Mo[lbf/ft]	FS Overturning
4.84	1138.12	46.59	24.43
2.42	2480.01	422.06	5.88

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant measured from the centroid of base. In wall design the eccentricity is used to calculate an effective footing width and bearing pressure.

Calculation of Eccentricity

SumV = + W1 + W2 + Pav

+ 3384.31 + 439.87 + 691.94 — SumV = 4516.12 lbf

Moment Resisting — Mr = 8465.55 ft-lbf

Moment Driving — Md = 2120.61 ft-lbf

e = (SumMr + SumMd)/(SumV)

e = (8465.55 - 2120.61) /4516.12 — e = 1.405 ft

BEARING

Bearing Capacity Factors [Foundation]

Nc = 50.59 Myerhoff Eqn
Nq = 37.75 Myerhoff Eqn
Ng = 56.31 Vesic Eqn

Shape Factors [Foundation]

Sc = 1.07
Sq = 1.07
Sg = 0.96

Depth Correction Factor

df = 1.09

Modified Bearing Capacity Factors [Foundation]

Ncm = Nc x Sc = 54.36
Nqm = Nq x Sq x df = 44.00
Ngm = Ng x Sg = 54.06

Water Correction Factor

Cwq = 1.00
Cwg = 1.00

Base width at foundation, B'f
B'f = B - 2e + lvlPad Thickness (Bearing area at foundation)
4.92 - 2 x 1.40 + 0.30 B'f = 2.41 ft

q = embedment * γ
= 1.50 x 130.00 q = 195.00 lbf/ft2

Calculation of Bearing Pressures on Foundation
qr = (c * Ncm) + (q * Nqm * Cwq) + 0.5 * γ * B'f * Ngm * Cwg)
[(0.00 x 54.36) + (195.00 x 44.00 x 1.00) + (0.5 x 130.00 x 2.41 x 54.06 x 1.00)]
qult = 18753.85 lbf/ft2

Nbrg = Bearing at Foundation Level NBrg = 4721 lbf/ft2

Calculate Ultimate Bearing, qult qult = 18753.85 lbf/ft2
Bearing Pressures (σ) Nbrg/Bf' = 1961.69 lbf/ft2
Calculated Factor of safety for bearing qult/σ = 9.56

SEISMIC CALCULATIONS

The loads considered under seismic loading are primarily inertial loadings. The wave passes the structure putting the mass into motion and then the mass will try to continue in the direction of the initial wave. In the calculations you see the one dynamic earth pressure from the wedge of the soil behind the reinforced mass, and then all the other forces come from inertia calculations of the face put into motion and then trying to be held in place.

kmax = PGA x Fpga = 0.627 x 1.1	kmax = 0.690g
Displacment (d)	d = 6.0 in
khint = khext = 0.74 A (A/d)^0.25	kh(ext) = 0.297
Vertical Acceleration	kv = 0.000

EXTERNAL Kae_ext

Kae_ext	Kae_ext = 0.741
D_Kae_ext = Kae_ext - Ka = (0.741 - 0.407)	D_Kae_ext = 0.335
Pae_ext = 0.5 x gamma*(H)² x D_Kae_ext	Pae = 902 lbf/ft
Pae_h/2 = Pae x cos(delta)/2	Pae_h/2 = 412 lbf/ft
Pae_v/2 = Pae*sin(delta)/2	Pae_v/2 = 183 lbf/ft

INERTIA FORCES OF THE STRUCTURE

Face (Pir) = (W0 + W1) x kh(ext) = (0 + 3,384) x 0.297	Pir = 1,005 lbf/ft

MONONOBE-OKABE EQ (REF AASHTO A11.3.1.1)

$$K_{AE} = \frac{\cos^2(\phi - \theta_{MO} - \beta)}{\cos\theta_{MO}\cos^2\beta\cos(\delta+\beta+\theta_{MO})} \times \left[1 + \sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\theta_{MO}-i)}{\cos(\delta+\beta+\theta_{MO})\cos(i-\beta)}}\right]^{-2} \qquad \text{(A11.3.1-1)}$$

where:

K_{AE} = seismic active earth pressure coefficient (dim)
γ = unit weight of soil (kcf)
H = height of wall (ft)
h = vertical distance between ground surface and wall base at the back of wall heel (ft)
ϕ_f = friction angle of soil (degrees)
θ_{MO} = arc tan $[k_h/(1 - k_v)]$ (degrees)
δ = wall backfill interface friction angle (degrees)
k_h = horizontal seismic acceleration coefficient (dim.)
k_v = vertical seismic acceleration coefficient (dim.)
i = backfill slope angle (degrees)
β = slope of wall to the vertical, negative as shown (degrees)

SEISMIC SLIDING

The target factor of safety for seismic is 75% of the static value. Live loads are ignored in these analysis based on the basic premise that the probability of the maximum acceleration occuring at the exact same instant as the maximum live load is small.

Details are only shown for sliding at the base of blocks, a check is made at the foundation level with the answer only shown.

The vertical resisting forces is W1 + W2 + Pav + Paev	
3384 + 440 + 692 + 569	SumVs = 5085.58
Resisting force = SumVs * tan(phi) + intercept x L	FRe = 4267.31 lbf/ft
Driving force = Pa_h + Pae_h + Pir	
= 849.57 +699.19 +1005.14	FDr = 1548.76 lbf/ft
FOS = FRe/FDr [leveling pad / foundation]	FoS = 2.76 / 2.48

SEISMIC OVERTURNING

Overturning is rotation about the front toe of the wall. Eccentricity is also a check on overturning

Resisting Moment = M1 + M2 + MPav + MPaev	
13618 + 1611 + 2934 + 2260	SumMrS = 20422.78 ft lbf/ft
Driving Moment = MPah + MPaeh + MPif	
2121 + 2618 + 3518	SumMoS = 8256.49 ft lbf/ft
Factor of Safety = SumMrS/SumMoS	FoS = 2.47

SEISMIC BEARING

Bearing is the ability of the foundation to support the mass of the structure.

Qult = c*Nc + q*Nq + 0.5*gamma*(B')*Ng

where:

Nc = 50.59 Myerhoff Eqn

Nq = 37.75 Myerhoff Eqn

Ng = 56.31 Vesic Eqn

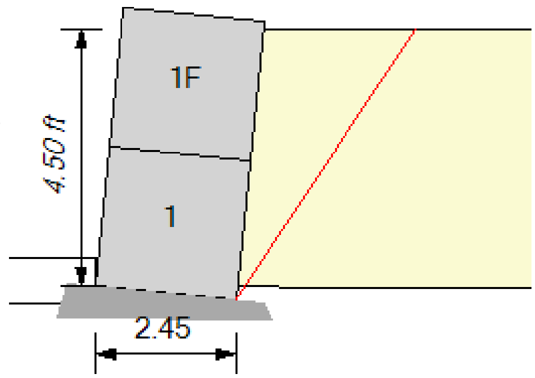
c = 0.00 lbf/ft2

q = 234.00 lbf/ft2

Calculate Ultimate Bearing, Qult (seismic)	Qult = 27987.56 lbf/ft2
eccentricity (e)	e = 0.091
Equivalent Footing Width, B' = L - 2e + lvl pad	B' = 5.03 ft
Bearing Pressure = sumVs/B'	sigma = 1050.88 lbf/ft2
Factor of Safety for Bearing = Qult/Bearing	FoS = 26.63

UltraWall

Project:	5818 W Mercer Way SFR
Location:	5818 W Mercer Way, MI
Designer:	HMX
Date:	2/2/2026
Section:	Section 2
Design Method:	NCMA_09_3rd_Ed, Ignore Vert. Force
Design Unit:	UltraBlock: 1



Seismic Acc:	0.690g
Design Method:	AASHTO 2020, Kavazanjian
Design Equation:	AASHTO 2020, A11.5.1-1

SOIL PARAMETERS	Φ	coh	γ
Drainage Zone:	34 deg	0 lbf/ft2	120 lbf/ft3
Retained Soil:	32 deg	0 lbf/ft2	110 lbf/ft3
Foundation Soil:	36 deg	0 lbf/ft2	130 lbf/ft3
Leveling Pad:	40 deg	0 lbf/ft2	135 lbf/ft3
Crushed Stone Lvlng Pad			

GEOMETRY

Design Height:	4.50 ft	Live Load:	0.00 lbf/ft2
Wall Batter/Tilt:	0.00/ 5.70 deg	Live Load Offset:	0.00 ft
Embedment:	0.50 ft*	Live Load Width:	0.00 ft
Leveling Pad Depth:	0.30 ft		
Slope Angle:	0.0 deg	Dead Load:	0.0 lbf/ft2
Slope Length:	0.0 ft	Dead Load Offset:	0.0 ft
Slope Toe Offset:	0.0 ft	Dead Load Width:	0.00 ft
Leveling Pad Width:	3.46 ft	D.L. Embedment:	0.00 ft

Vert δ on Single Dpth

* Note: For all designs the passive resistance in front of the wall units is ignored for sliding calculations.

FACTORS OF SAFETY (Static / Seismic)

Sliding:	1.50 / 1.125	Overturning:	1.50 / 1.125
Bearing:	3.00 / 1.5		

RESULTS (Static / Seismic)

FoS Sliding:	5.60 (lvlpd) / 2.88	FoS Overturning:	6.18 / 1.25
Bearing:	781.45 / 1675.76	FoS Bearing:	16.15 / 5.05

Name	*Elev.*	*ka*	*kae*	*Pa*	*Pae*	*Pif*	*PaT*	*PaTs*	*FSsl*	*seisFSsl*	*FoS OT*	*FoS SeisOT*
1F	*2.42*	*0.237*	*0.479*	*56*	*114*	*251*	*56*	*365*	*79.42*	*38.45*	*27.18*	*3.21*
1	*0.00*	*0.237*	*0.479*	*263*	*533*	*503*	*263*	*1036*	*5.60*	*2.88*	*6.18*	*1.25*

Design Approach:

The design is a 'top down' approach. The values shown in the table[ka, kae, Pa, etc.] are the values from the top of wall to the base of that row. For trial wedge analysis, the ka and kae are back-calculated from the Pa, Pae values.

Column Descriptions:

ka: active earth pressure coefficient
kae: active seismic earth pressure coefficient
Pa: active earth pressure
Pae: dynamic earth pressure
Pir: inertia force
Paq: live surcharge earth pressure
Paq2: live load 2 surcharge earth pressure
Paqd: dead surcharge earth pressure
(PaC): reduction in load due to cohesion
PaT: sum of all earth pressures
FSsl(lvl Pad): factor of safety for sliding at each layer. (FS sliding below the leveling pad)
FSot: factor of safety of overturning about the toe.

DESIGN DATA

TARGET DESIGN VALUES (Factors of Safety - Static / Seismic)

Minimum Factor of Safety for the sliding along the base	FSsl = 1.50 /1.125
Minimum Factor of Safety for overturning about the toe	FSot = 1.50 /1.125
Minimum Factor of Safety for bearing (foundation shear failure)	FSbr = 2.00 /1.500

MINIMUM DESIGN REQUIREMENTS

Minimum embedment depth	Min_emb = 0.50 ft

INPUT DATA

Geometry

Wall Geometry

Design Height, top of leveling pad to top of wall	H = 4.50 ft
Design Height External, top of leveling pad to finished grade at top of wall	he = 4.50 ft
Embedment, measured from top of leveling pad to finished grade	emb = 0.50 ft
Leveling Pad Depth	Thickness = 0.30 ft
Face Batter, measured from vertical	i = 0.00 deg

Slope Geometry

Back Slope Angle, measured from horizontal	β = 0.00 deg
Back Slope Toe Offset, measured from back of the face unit	STL_offset = 0.00 ft
Back Slope Length, measured from toe to crest	SL_Length = 0.00 ft

NOTE: If the back slope toe is offset or the slope breaks within three times the wall height, a Coulomb Trial Wedge method of analysis is used.

Toe Slope Angle, measured from horizontal	β = 0.00 deg
Toe Slope Crest Offset, measured from front of the face unit	STL_offset = 0.00 ft
Toe Slope Length, measured from crest to toe	SL_Length = 0.00 ft

Surcharge Loading

Live Load, assumed transient loading (e.g. traffic)	LL = 0.00 lbf/ft2
Live Load Offset, measured from back face of wall	LL_offset = 0.00 ft
Live Load Width, assumed strip loading	LL_width = 0.00 ft

Soil Parameters

Retained Zone

Angle of Internal Friction	Φ = 32.00 deg
Cohesion	coh = 0.00 lbf/ft2
Moist Unit Weight	γ = 110.00 lbf/ft3

Foundation

Angle of Internal Friction	Φ = 36.00 deg
Cohesion	coh = 0.00 lbf/ft2
Moist Unit Weight	γ = 130.00 lbf/ft3

Leveling Pad

Angle of Internal Friction	Φ = 40.00 deg
Cohesion	coh = 0.00 lbf/ft2
Moist Unit Weight	γ = 135.00 lbf/ft3

RETAINING WALL UNITS

STRUCTURAL PROPERTIES:

N is the normal force [or factored normal load] on the base unit

The default leveling pad to base unit shear is 0.8 tan(Φ) [AASHTO 10.6.3.4] or may be the manufacturer supplied data. Φ is assumed to be 40 degrees for a stone leveling pad.

Unit	Aggr_Vol (cf)	Aggr_Density (pcf)	Aggr_CG (in)	Equiv_Density (pcf)	Equiv_CG (in)
Cap	0.00	105	14.75, 7.37	0	NaN
Full Cap	0.00	105	14.75, 14.75	0	NaN
Full	0.00	105	14.75, 14.75	0	NaN
Double	0.00	105	29.50, 14.75	0	NaN

CALCULATION RESULTS

OVERVIEW

UltraWall calculates stability assuming the wall is a rigid body. Forces and moments are calculated about the base and the front toe of the wall. The base block width is used in the calculations. The concrete units and granular fill over the blocks are used as resisting forces.

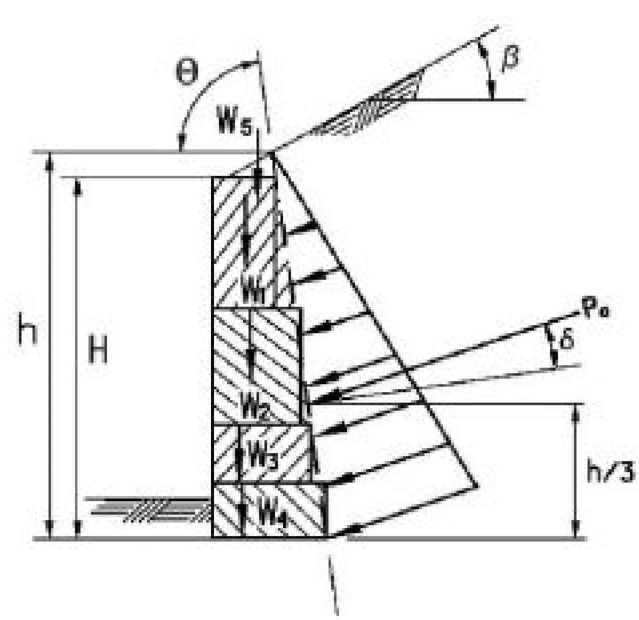
EARTH PRESSURES

The method of analysis uses the Coulomb Earth Pressure equation (below) to calculate active earth pressures. Wall friction is assumed to act at the back of the wall face. The component of earth pressure is assumed to act perpendicular to the boundary surface. The effective δ angle is δ minus the wall batter at the back face. If the slope breaks within the failure zone, a trial wedge method of analysis is used.

EXTERNAL EARTH PRESSURES

Effective δ angle (2/3 retained phi)	δ = 21.3 deg
Coefficient of active earth pressure	ka = 0.237
External failure plane	ρ = 55 deg
Effective Angle from horizontal	θ = 95.70 deg
Coefficient of passive earth pressure: kp = (1 + sin(Φ)) / (1 - sin(Φ))	kp = 0.00

$$Ka := \frac{\cos(\phi_i + i)^2}{\cos(i)^2 \cdot \cos(\delta_i - i)\left(1 + \sqrt{\frac{\sin(\phi_i + \delta_i)\cdot\sin(\phi_i - \beta)}{\cos(\delta_i - i)\cdot\cos(i + \beta)}}\right)^2}$$



where:

- δ = friction angle between fill and wall (degrees)
- β = angle of fill to the horizontal (degrees)
- θ = angle of back face of wall to the horizontal (degrees)
- ω = angle of wall batter (degrees) = θ - 90
- Φ' = effective angle of internal friction (degrees)

Note: Calculations and quantities are for PRELIMINARY ANALYTICAL USE ONLY and MUST NOT be used for final n or construction without the independent review, verification, and approval by a qualified professional engineer.

FORCE DETAILS

The details below shown how the forces are calculated for each force component. The values shown are not factored. All loads are based on a unit width (lbf/ft or kN/m).

Layer	Block Wt lbf	Soil Infill Wt lbf	Soil Wedge Wt lbf
1	846.08	0	0
2	846.08	0	

Block Weight = 1692.15 lbf/ft X-Arm = 1.47 ft
Soil Infill Weight = 0.00 lbf/ft X-Arm = 0.00 ft
Soils Wedge Weight = volume x Drain rock density
0.00 * 120.00 = 0.00 lbf/ft X-Arm = 0.00 ft

Active Earth Pressure Pa = 263.45 lbf/ft
Pa_h (W9) = Pa cos(δ - ω) = 263.45 x cos(21.33 - (5.70)) = 254 lbf/ft
Y-Arm = 1.58 ft
Pa_v (W9) = Pa sin(δ - ω) = 263.45 x sin(21.33 - (5.70)) = 0 lbf/ft
X-Arm = 2.62 ft

FORCES AND MOMENTS

The program resolves all the geometry into simple geometric shapes to make checking easier. All x and y coordinates are referenced to a zero point at the toe of the bottom unit.

LOADS FOR OVERTURNING ABOUT THE TOE

Name	Force(V) lbf	Force(H) lbf	X-len ft	Y-len ft	Mo ft-lbf	Mr ft-lbf
Face Blocks (W1)	1692.15		1.466			2480.01
Pa_h (W9)		253.71		1.581	401.21	
Pa_v (W9)	0.00		2.616			0.00
Sum V / H	1,692	254		Sum Mom	401	2,480

W0: stone within units
W1: facing units
W2: soil wedge behind the face
X-Len: is measured from the front of the base block (+) Driving, (-) Resisting.
Pa_h (W9): horizontal earth pressure
Pa_v (W9): vertical earth pressure
Pq_h: horizontal surcharge pressure
Pq_v: vertical surcharge pressure

BEARING LOADS: NCMA

All x and y coordinates are referenced to a zero point at the middle of the base block for eccentricity calculations.

Name	Force(V) lbf	Force(H) lbf	X-len ft	Y-len ft	Mo ft-lbf	Mr ft-lbf
Face Blocks (W1)	1692.15		-0.243			-788.51
Pa_h (W9)		253.71		1.581	401.21	
Pa_v (W9)	0.00		-1.308			0.00
Sum V / H	1692	254		Sum Mom	401	-789

BASE SLIDING

Sliding at the base is checked at the block to leveling pad interface between the base block and the leveling pad. Sliding is also checked between the leveling pad and the foundation soils.

Forces Resisting sliding = W1
1692.15 N = 1692.15 lbf/ft

Sliding between Concrete Units and Leveling Pad/Drain Mat (Rf1)
Resisting force at pad = (N x φ x tan(slope) + intercept)
(1692 x 0.8 + tan(40.00) + 0.0) RF(lvlPd) = 1420 lbf

Driving force is the horizontal component of Pah
253.71 Df = 253.71

FSsl = Rf / Df FSsl = 5.60 lbf

FSslfndn = Rf1 / Df FSslfndn = 100.00

ROW TO ROW SLIDING

Sliding between rows is checked at the interface between two adjacent rows.

Details of the calculation are shown on the previous page. The leveling pad interaction is now replaced with the unit/unit interaction.

Resisting Force = Normal Force x 0.8 + intercept)

Units: All units are in lbf/ft or ft-lbf/ft of wall.

RESULTS TABLE

Elev[ft]	Normal[lbf/ft]	RF Concrete	Shear Intcpt	Resisting Force	Driving Force[lbf/ft]	FS Sliding/Shear
2.42	846.08	676.86	3619.55	4296.41	54.10	79.42

OVERTURNING ABOUT THE TOE

Overturning at the base is checked by assuming rotation about the front toe by the block mass and the soil retained on the blocks. Allowable overturning can be defined by factor of safety of overturning. For concrete leveling pads overturning is checked at the base of the pad.

Moments Resisting Overturning = M1
2480.01 — Mr = 2480.01 ft-lbs

Moments causing Overturning = MPah
401.21 — Mo = 401.21 ft-lbs

FSot = Mr / Mo
FSot = 2480.01 / 401.21 — FSot = 6.18

OVERTURNING ABOUT THE ROW BELOW

Overturning at the row below is checked by assuming rotation about the front toe by the block mass and the soil retained on the blocks. Allowable overturning can be defined by Factor of safety of Overturning. For concrete leveling pads overturning is checked at the base of the pad.

Factor of Safety Overturning = Moment Resisting / Moment Driving

RESULTS TABLE

Elev[ft]	Mr[ft-lbf]	Mo[lbf/ft]	FS Overturning
2.42	1138.12	41.88	27.18

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant measured from the centroid of base. In wall design the eccentricity is used to calculate an effective footing width and bearing pressure.

Calculation of Eccentricity

SumV = + W1

+ 1692.15 SumV = 1692.15 lbf

Moment Resisting Mr = 788.51 ft-lbf

Moment Driving Md = 401.21 ft-lbf

e = (SumMr + SumMd)/(SumV)

e = (788.51 - 401.21) /1692.15 e = 0.229 ft

Note: Calculations and quantities are for PRELIMINARY ANALYTICAL USE ONLY and MUST NOT be used for final n or construction without the independent review, verification, and approval by a qualified professional engineer.

BEARING

Bearing Capacity Factors [Foundation]
Nc = 50.59 Myerhoff Eqn
Nq = 37.75 Myerhoff Eqn
Ng = 56.31 Vesic Eqn

Shape Factors [Foundation]
Sc = 1.07
Sq = 1.07
Sg = 0.96

Depth Correction Factor
df = 1.08

Modified Bearing Capacity Factors [Foundation]
Ncm = Nc x Sc = 54.36
Nqm = Nq x Sq x df = 43.64
Ngm = Ng x Sg = 54.06

Water Correction Factor
Cwq = 1.00
Cwg = 1.00

Base width at foundation, B'f
B'f = B - 2e + lvlPad Thickness (Bearing area at foundation)
2.46 - 2 x 0.23 + 0.30 B'f = 2.30 ft

q = embedment * γ
= 0.50 x 130.00 q = 65.00 lbf/ft2

Calculation of Bearing Pressures on Foundation
qr = (c * Ncm) + (q * Nqm * Cwq) + 0.5 * γ * B'f * Ngm * Cwg)
[(0.00 x 54.36) + (65.00 x 43.64 x 1.00) + (0.5 x 130.00 x 2.30 x 54.06 x 1.00)]
qult = 12622.41 lbf/ft2

Nbrg = Bearing at Foundation Level NBrg = 1798 lbf/ft2

Calculate Ultimate Bearing, qult qult = 12622.41 lbf/ft2
Bearing Pressures (σ) Nbrg/Bf' = 781.45 lbf/ft2
Calculated Factor of safety for bearing qult/σ = 16.15

SEISMIC CALCULATIONS

The loads considered under seismic loading are primarily inertial loadings. The wave passes the structure putting the mass into motion and then the mass will try to continue in the direction of the initial wave. In the calculations you see the one dynamic earth pressure from the wedge of the soil behind the reinforced mass, and then all the other forces come from inertia calculations of the face put into motion and then trying to be held in place.

kmax = PGA x Fpga = 0.627 x 1.1	kmax = 0.690g
Displacment (d)	d = 6.0 in
khint = khext = 0.74 A (A/d)^0.25	kh(ext) = 0.297
Vertical Acceleration	kv = 0.000

EXTERNAL Kae_ext

Kae_ext	Kae_ext = 0.479
D_Kae_ext = Kae_ext - Ka = (0.479 - 0.237)	D_Kae_ext = 0.242
Pae_ext = 0.5 x gamma*(H)² x D_Kae_ext	Pae = 270 lbf/ft
Pae_h/2 = Pae x cos(delta)/2	Pae_h/2 = 126 lbf/ft
Pae_v/2 = Pae*sin(delta)/2	Pae_v/2 = 49 lbf/ft

INERTIA FORCES OF THE STRUCTURE

Face (Pir) = (W0 + W1) x kh(ext) = (0 + 1,692) x 0.297	Pir = 503 lbf/ft

MONONOBE-OKABE EQ (REF AASHTO A11.3.1.1)

$$K_{AE} = \frac{\cos^2(\phi - \theta_{MO} - \beta)}{\cos\theta_{MO}\cos^2\beta\cos(\delta + \beta + \theta_{MO})} \times \left[1 + \sqrt{\frac{\sin(\phi + \delta)\sin(\phi - \theta_{MO} - i)}{\cos(\delta + \beta + \theta_{MO})\cos(i - \beta)}}\right]^{-2} \quad \text{(A11.3.1-1)}$$

where:

K_{AE} = seismic active earth pressure coefficient (dim)
γ = unit weight of soil (kcf)
H = height of wall (ft)
h = vertical distance between ground surface and wall base at the back of wall heel (ft)
ϕ_f = friction angle of soil (degrees)
θ_{MO} = arc tan $[k_h/(1 - k_v)]$ (degrees)
δ = wall backfill interface friction angle (degrees)
k_h = horizontal seismic acceleration coefficient (dim.)
k_v = vertical seismic acceleration coefficient (dim.)
i = backfill slope angle (degrees)
β = slope of wall to the vertical, negative as shown (degrees)

SEISMIC SLIDING

The target factor of safety for seismic is 75% of the static value. Live loads are ignored in these analysis based on the basic premise that the probability of the maximum acceleration occuring at the exact same instant as the maximum live load is small.

Details are only shown for sliding at the base of blocks, a check is made at the foundation level with the answer only shown.

The vertical resisting forces is W1 + W2 + Pav + Paev	
1692 + 0 + 0 + 73	SumVs = 1764.83
Resisting force = SumVs * tan(phi) + intercept x L	FRe = 1480.87 lbf/ft
Driving force = Pa_h + Pae_h + Pir	
= 253.71 +259.71 +502.57	FDr = 513.41 lbf/ft
FOS = FRe/FDr [leveling pad / foundation]	FoS = 2.88 / 2.65

SEISMIC OVERTURNING

Overturning is rotation about the front toe of the wall. Eccentricity is also a check on overturning

Resisting Moment = M1 + M2 + MPav + MPaev	
2480 + 0 + 0 + 195	SumMrS = 2674.99 ft lbf/ft
Driving Moment = MPah + MPaeh + MPif	
401 + 616 + 1131	SumMoS = 2148.04 ft lbf/ft
Factor of Safety = SumMrS/SumMoS	FoS = 1.25

SEISMIC BEARING

Bearing is the ability of the foundation to support the mass of the structure.

Qult = c*Nc + q*Nq + 0.5*gamma*(B')*Ng

where:

Nc = 50.59 Myerhoff Eqn
Nq = 37.75 Myerhoff Eqn
Ng = 56.31 Vesic Eqn
c = 0.00 lbf/ft2
q = 104.00 lbf/ft2

Calculate Ultimate Bearing, Qult (seismic)	Qult = 8460.74 lbf/ft2
eccentricity (e)	e = 0.821
Equivalent Footing Width, B' = L - 2e + lvl pad	B' = 1.12 ft
Bearing Pressure = sumVs/B'	sigma = 1675.76 lbf/ft2
Factor of Safety for Bearing = Qult/Bearing	FoS = 5.05