SPECIFICATIONS

REFERENCE:
1. CES NW, Inc., Civil Plans, Job No. 20083, dated March 12, 2025
2. Earth Solutions NW, LLC, Geotechnical Evalation, ES-6481, dated February 12, 2019

GENERAL

A. Work shall consist of furnishing and construction of an Ultrablock Retaining Wall System (or equivalent) in accordance with these specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the plans.

B. Work includes preparing foundation soil as well as furnishing and installing leveling pads, drainage fill, and backfill to the lines and grades shown on the construction drawings.

C. The following design assumptions were used:
- Internal angle of friction for retained soil = 32 degrees
- Unit weight of retained soil = 120 pcf
- Maximum exposed wall height = 5.5 feet
- Batter of wall = 1H : 10V
- Site-modified peak ground acceleration = 0.55 g (per 2021 IBC; Site Class D)
- Surcharge (Where Applicable) = 2H:1V Top Slope (Modeled)

SUBMITTALS

A. Contractor shall submit to the Geotechnical Engineer a Manufacturer's Certification, prior to start of work, that the retaining wall system components meet the requirements of these specifications and the structural design.

QUALITY ASSURANCE

A. Contractor, other than the owner, shall demonstrate prior experience on projects of similar size and magnitude where the specific retaining wall system has been constructed successfully. Contact names and telephone numbers shall be listed for each project.

B. Owner shall provide soil testing and quality assurance on a periodic or full-time basis (as required) during Ultrablock wall installation and related earthwork activities. Owner's quality assurance program does not relieve the contractor of responsibility for wall performance.

DELIVERY, STORAGE, AND HANDLING

A. Contractor shall check all materials upon delivery to ensure that the proper type, grade, color, and certification have been received.

B. Contractor shall protect all materials from damage due to job site conditions and in accordance with manufacturer's recommendations. Damaged materials shall not be incorporated into the work.

PRODUCTS

DEFINITIONS

A. Block: a concrete retaining wall element, wet cast from Portland Cement, water, and aggregates, with dimensions of 2.46'H x 4.92'W x 2.46'D.

B. Drainage Fill: free-draining, angular aggregate (less than 5% fines) which is placed immediately behind the modular concrete units.

BLOCK RETAINING WALL UNITS

A. Block Units shall conform to the following architectural requirement:

Bond Configuration: running with bonds nominally located at midpoint vertically adjacent units, in both straight and curved alignments.

B. Block materials shall conform to the requirements of Standard Specifications for Ultrablock Wall Units.

C. Block Units shall conform to the following structural and geometric requirements, measured in accordance with appropriate references:

minimum compressive strength = 2,200 psi (28-day)

absorption = 6% (max.) for standard weight aggregates

unit size = 2.46'H x 4.92'W x 2.46'D minimum

unit weight = 4,320 lb. each (approximate)

AS-BUILT CONSTRUCTION TOLERANCES

A. Vertical Alignment: ±1.5 inches over any 10-foot distance

B. Wall Batter: ±2 degrees of design batter

C. Horizontal Alignment: ±1.5 inches over any 10-foot distance
Corners, bends, and curves: ±1 foot to theoretical location

D. Maximum horizontal gap between erected units: 1/2 inch

BASE LEVELING PAD

A. Leveling Pad shall consist of a minimum of 6 inches of 5/8"-minus crushed rock.

B. The subgrade shall be dense, firm, and unyielding in areas of Native Soil. If the subgrade is comprised of Structural Fill, minimum compaction of 95% of the laboratory maximum dry density, per ASTM D1557 (Modified Proctor), shall be achieved, and the moisture content shall be at (or slightly above) the optimum level.

C. Leveling Pad shall be prepared to ensure full contact to the base surface of the Ultrablock Units.

ULTRABLOCK UNIT INSTALLATION

A. The first course of Ultrablocks shall be placed on the leveling pad at the appropriate line and grade. Alignment and level shall be checked in all directions to ensure that all units are in full contact with the base and properly seated.

B. Place the front units side-by-side. Gaps shall be minimized between adjacent units. Layout of corners and curves shall be in accordance with manufacturer's recommendations and installation guidelines.

C. Place and compact Drainage Fill behind Ultrablock Units. Follow wall erection and drainage fill closely with block placement. Compact reinforced backfill to 95% of the laboratory maximum dry density, per ASTM D1557 (Modified Proctor), in loose lifts not exceeding 12 inches.

D. Maximum stacked vertical height of Ultrablock Wall Units, prior to unit Drainage Fill and backfill placement and compaction, shall not exceed one course (2.5 feet).

E. Utility conflicts shall be resolved per coordination between the project owner, wall contractor, and Geotechnical Engineer.

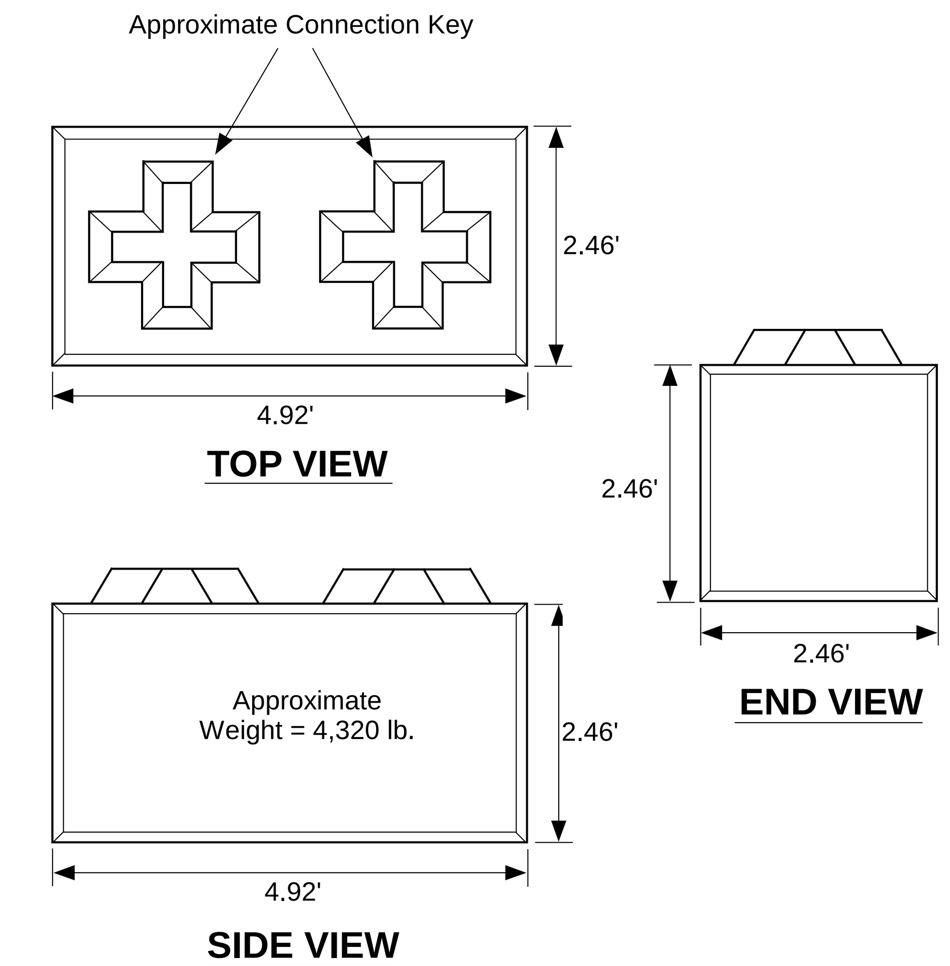
F. One row of Cap Ultrablocks may be added atop each wall, as needed, without further design analysis.

GEOTECHNICAL OBSERVATIONS & TESTING

A. The Geotechnical Engineer shall be retained to provide observation and testing services during Ultrablock retaining wall construction. The Geotechnical Engineer shall be contacted, at least 48 hours prior to the start of wall construction and related grading activities, to observe Ultrablock wall installation on a part-time or full-time basis (as appropriate).

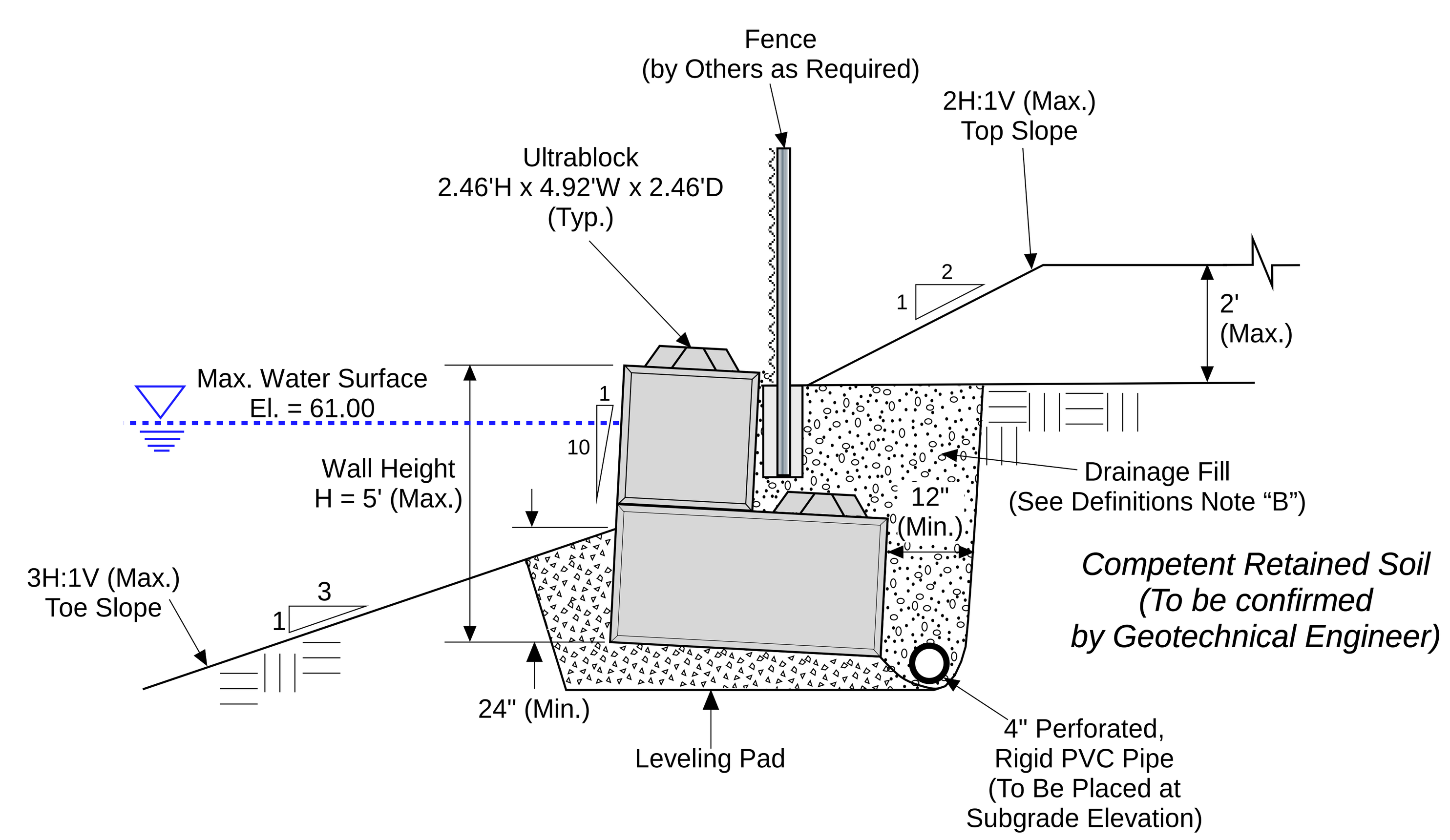
B. Observations by the Geotechnical Engineer (or their representative) do not relieve the contractor of their responsibility to comply with the contract documents, including the notes, details, and specifications provided on these sheets.

C. The scope of observations and testing shall include, but is not necessarily limited to, the following: erosion control; excavation activities; subsurface drainage installation; soil bearing and subgrade/keyway competency; Ultrablock placement and orientation; wall batter; and structural fill placement and compaction testing (where applicable).



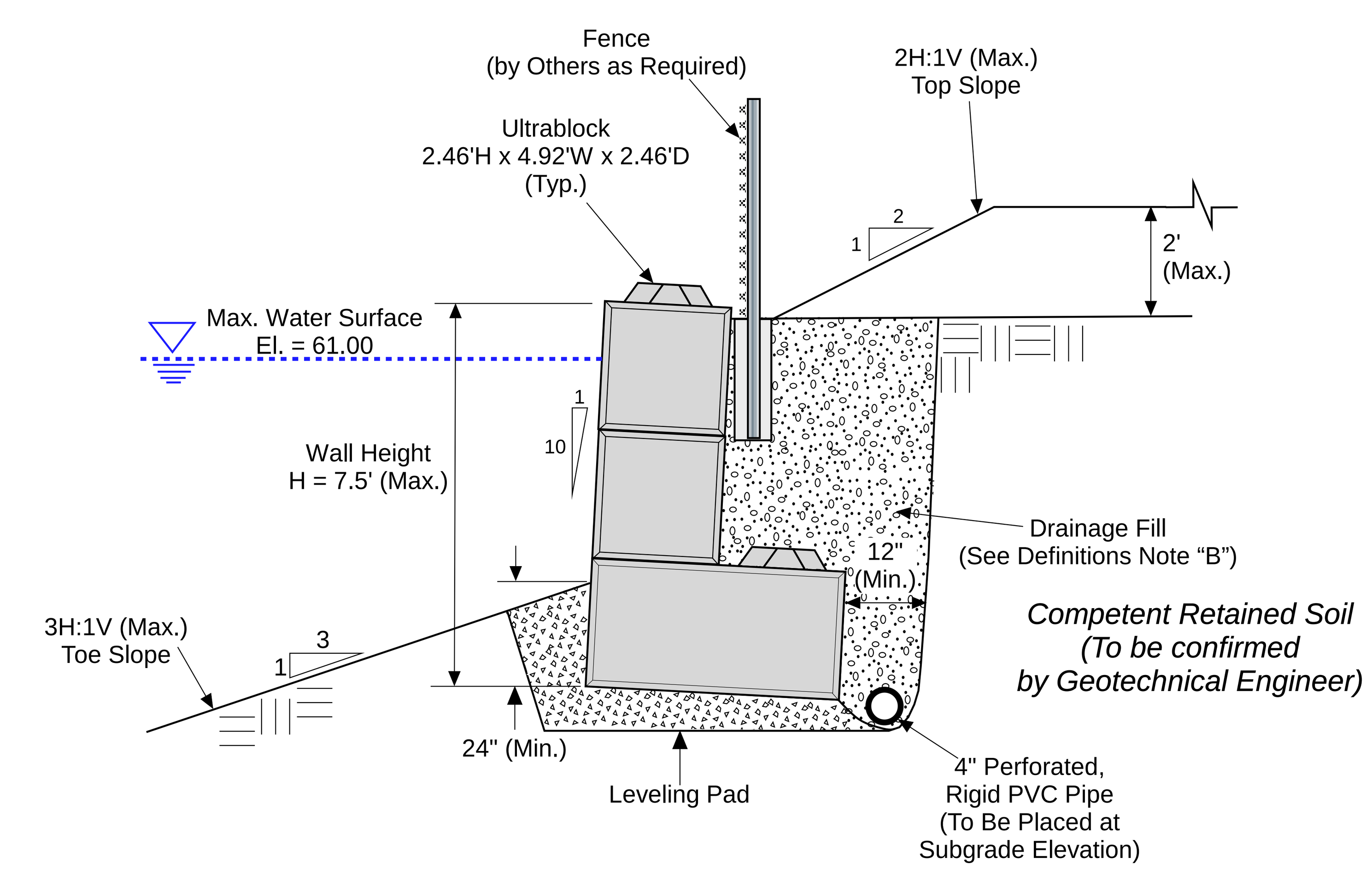
ULTRABLOCK UNIT DETAIL

NOT - TO - SCALE



TYPICAL 5.0' WALL SECTION

NOT - TO - SCALE



TYPICAL 7.5' WALL SECTION

NOT - TO - SCALE

Client	Through Terra, LLC		
Proj. No.	6481.02	Date	04/04/2025
Designed	KDH	Drawn	MRS
Checked	KDH	Approved	KDH

No.	Date	Revision

EARTH SOLUTIONS NW

Geotechnical Engineering
Environmental Services
Earthwork Observation & Testing
CESCL & Stormwater Services

REDMOND 425-449-4704
PASCO 509-905-0275
SILVERDALE 360-722-5081
esnw.com

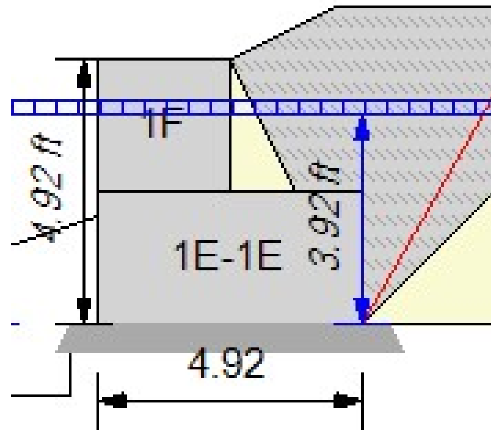
Gravity Ultrablock Retaining Wall Design
BPLC PROPERTIES
Puyallup, Washington

KEVEN D. HOFFMANN
STATE OF WASHINGTON
53734
REGISTERED
PROFESSIONAL ENGINEER
04/04/2025

Sheet No.
W1

UltraWall

Project: BPLC Properties - Inter Ave
Location: Puyallup, WA
Designer: KDH
Date: 4/3/2025
Section: 5.0 Wall
Design Method: AASHTO_LRFD_2020
Design Unit: UltraBlock: 1E-1E



Seismic Acc: 0.550g

SOIL PARAMETERS	Φ	coh	γ	γsat
Select Soil:	36 deg	0 lbf/ft2	135 lbf/ft3	137 lbf/ft3
Retained Soil:	30 deg	50 lbf/ft2	120 lbf/ft3	137 lbf/ft3
Foundation Soil:	30 deg	50 lbf/ft2	120 lbf/ft3	137 lbf/ft3
Leveling Pad:	40 deg	0 lbf/ft2	140 lbf/ft3	137 lbf/ft3
Crushed Stone Lvlng Pad				

GEOMETRY

Design Height:	4.92 ft	Live Load:	0.00 lbf/ft2
Wall Batter/Tilt:	0.00/ 0.00 deg	Live Load Offset:	0.00 ft
Embedment:	2.00 ft*	Live Load Width:	0.00 ft
Leveling Pad Depth:	0.50 ft		
Slope Angle:	26.6 deg	Dead Load:	0.0 lbf/ft2
Slope Length:	2.0 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		Toe Slope Angle:	18.40
		Toe Slope Length:	10.00
		Toe Slope Bench:	0.00

04/04/2025

Select Fill Offset: 0.00 ft
Select Fill Angle: 45.00 deg.

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

Water

Front Height: 3.92 ft
Internal Ht: 3.92 ft
Drainage Depth: 1.00 ft

RESULTS (Static / Seismic)

CDR Sliding: 2.27 (lvlpd) / 2.53 CDR Brng: 2.75 / 6.25

Eccentricity (e/L): 0.27 (e/L <= 0.33) / [0.28 (e/L <= 0.40)] Bearing: 1136 / 838 / 911 (Service)

Ecc Internal(e/L): 0.05 (e/L <= 0.45)

Name	*Elev.*	*ka*	*kae*	*Pae*	*Paw1*	*Paw2*	*Paw3*	*Pif*	*Pwd*	*(Pwr)*	*PaT*	*PaTs*	*CDRsl*	*seisCDRsl*	*e/L*	*Seis e/L (Pae/Pir)*
1F	*2.46*	*0.344*	*0.000*	*126*	*0*	*0*	*78*	*171*	*67*	*-67*	*78*	*382*	*32.01*	*25.01 / 23.35*	*0.05*	*0.00*
1E-1E	*0.00*	*0.342*	*0.529*	*450*	*23*	*181*	*197*	*429*	*479*	*-479*	*401*	*1789*	*2.27*	*2.53 / 2.65*	*0.25*	*0.00*

Column Descriptions:

ka: active earth pressure coefficient; kae: active seismic earth pressure coefficient
Paw1: active earth pressure of soils above the water line
Paw2: active earth pressures (1) of submerged soils below the water line
Paw3: active earth pressures (2) of submerged soils below the water line
Pwd: driving pressures of water from behind the face
Pwr: resisting pressures of water in front of wall
Pif: Inertia of the facing units, Pir: Inertia of the gravel fill behind the units.
Paq: live surcharge earth pressure
Paqd: dead surcharge earth pressure
(PaC): reduction in load due to cohesion
PaT: sum of all earth pressures
CDRsl (lvlPad): 'Capacity/Demand Ratio' for sliding at each layer. (CDR sliding below the leveling pad)
e/L: eccentricity/base width ratio
e/L (Srvs): service state condition eccentricity/base width ratio
%D/H: ratio of based depth to height (warning for narrow walls, < 35%)

DESIGN DATA
Load Factors for Design

AASHTO Table 3.4.1-1 & 3.4.1-2

Load Case	Str_Max	Str_Min	Extreme Max	Extreme Min	Service
Str I Dead Load (DC)	1.25	0.90	1.00	1.00	1.00
Soil Load Driving (EH)	1.50	0.90	1.00	1.00	1.00
Str I Vert Earth Load (EV)	1.35	1.00	1.00	1.00	1.00
Dead Load Surcharge (ES)	1.50	0.75	1.00	1.00	1.00
Live Load (LL, PL, LS)	1.75	0.00	1.00	0.00	1.00

Application of Load Factors

Group	DC	EV	LS	EH	Probable Use
Strength I-a	0.90	1.00	1.75	1.50	BC/EC/SL
Strength I-b	1.25	1.35	1.75	1.50	BC (max. value)
Service I	1.00	1.00	1.00	1.00	Settlement

Notes: BC - Bearing Capacity; EC - Eccentricity; SL - Sliding

By Inspection:

• Strength I-a (minimum vertical loads and maximum horizontal loads) will govern for the case of sliding and eccentricity (overturning); and

• For the case of bearing capacity, maximum vertical loads will govern, and the factored loads must be compared for Strength I-b.

DESIGN DATA
Load Factors for Design

MINIMUM DESIGN REQUIREMENTS

Minimum embedment depth	Min_emb = 2.00 ft

INPUT DATA
Geometry

Wall Geometry	
Design Height, top of leveling pad to finished grade at top of wall	H = 4.92 ft
Embedment, measured from top of leveling pad to finished grade	emb = 2.00 ft
Leveling Pad Depth	Thickness = 0.50 ft
Face Batter, measured from vertical	i = 0.00 deg
Slope Geometry	
Back Slope Angle, measured from horizontal	β = 26.60 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 = 2.00 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 = 18.40 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 = 10.00 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 = 36.00 deg
Cohesion	coh = 0.00 lbf/ft2
Moist Unit Weight	γ = 135.00 lbf/ft3

Backfill Zone

Angle of Internal Friction	Φ = 30.00 deg
Cohesion	coh = 50.00 lbf/ft2
Moist Unit Weight	γ = 120.00 lbf/ft3

Foundation

Angle of Internal Friction	Φ = 30.00 deg
Cohesion	coh = 50.00 lbf/ft2
Moist Unit Weight	γ = 120.00 lbf/ft3

Leveling Pad

Angle of Internal Friction	Φ = 40.00 deg
Cohesion	coh = 0.00 lbf/ft2
Moist Unit Weight	γ = 140.00 lbf/ft3

RETAINING WALL UNITS

STRUCTURAL PROPERTIES:

N is the normal force [or factored normal load] on unit to unit interface
The unit to unit shear is N x Tan(0.0) + 3619.6

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(40), or 34 deg. [AASHTO LRFD 10.6.3.4-2] or may be the manufacturer supplied data.
[Note: concrete to concrete has a coefficient of Φ0.6 N.

Table of Values:

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 or live load break within the failure zone, a trial wedge method of analysis is used.

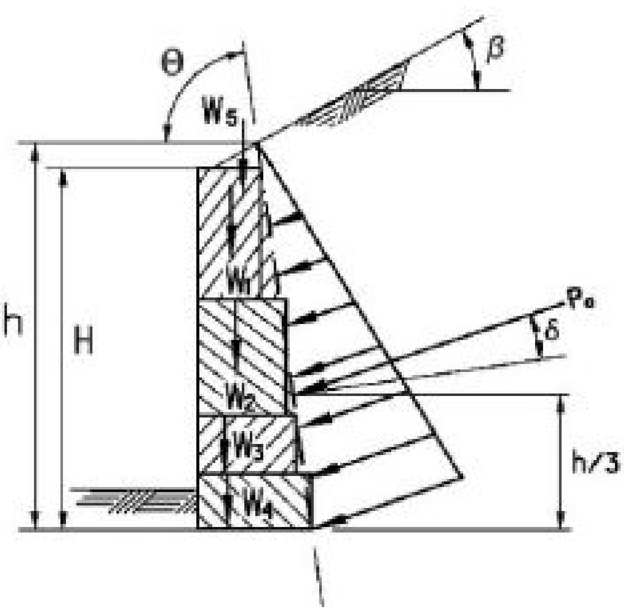
EXTERNAL EARTH PRESSURES

Effective δ angle (1/2 retained phi)	δ = 18.0 deg
Coefficient of active earth pressure	ka = 0.342
External failure plane	ρ = 60 deg
Back Face Angle from horizontal	θ = 90.00 deg
Coefficient of passive earth pressure	kp = 0.00

$$k_a = \frac{\sin^2(\theta + \phi'_f)}{\Gamma\,[\sin^2\theta \sin(\theta - \delta)]}$$

in which:

$$\Gamma = \left[1 + \sqrt{\frac{\sin(\phi'_f + \delta)\sin(\phi'_f - \beta)}{\sin(\theta - \delta)\sin(\theta + \beta)}} \right.$$



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 (ppf / kNpm).

Layer	Block Wt	Soil Infill Wt	Soil Wedge Wt
1 w	621.86	0.00	563.08
2 w	937.94	0.00	

Block Weight = 1559.79 lbf/ft X-Arm = 4.22 ft

Soil Infill Weight = 0.00 lbf/ft X-Arm = 0.00 ft

Soils Wedge Weight = 563.08 lbf/ft X-Arm = 3.69 ft

Active Earth Pressure Pa = 449.80 lbf/ft

Pa_h (Force H) = Pa cos(δ - ω) = 449.80 x cos(18.00 - (0.00)) = 381 lbf/ft

Y-Arm = 1.64 ft

Pa_v (Force V) = Pa sin(δ - ω) = 449.80 x sin(18.00 - (0.00)) = 124 lbf/ft

X-Arm = 4.92 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 middle of the base block for eccentricity calculations.

LOADS FOR ECCENTRICITY ABOUT THE CENTER OF THE BASE

Name	Factor γ	Force (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	1.00	1559.79		-1.765			-2753.11
Soil Wedge(W2)	1.00	563.08		-1.229			-692.12
Pa_h	1.00		381.26		1.771	675.35	
Pa_v	1.00	123.88		-2.458			-304.53
Sum V / H	1.00	2247	381		Sum Mom	675	-3750

W0: stone within units

W1: facing units

W2: soil wedge behind the face

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

Pa_h: horizontal earth pressure

Pa_v: vertical earth pressure

Pq_h: horizontal surcharge pressure

Pq_v: vertical surcharge pressure

FORCES AND MOMENTS FACTORED FOR Str I-a

UltraWall increases all driving forces and reduces the resisting forces by the factors shown for Str I.

FACTORED LOADS: Str Ia

Name	FactorMax γ	FactorMin γ	ForceSldg (V)	ForceEcc (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	1.25	0.90	1403.81	1403.81		-1.765			-2477.80
Soil Wedge(W2)	1.35	1.00	563.08	563.08		-1.229			-692.12
Paw_h	1.50				571.88		1.771	1013.02	
Paw_v		0.90	185.82	185.82		-2.458			-274.08
Sum V / H			2153	2153	572		Sum Mom	1013	-3627

FORCES AND MOMENTS FACTORED FOR Str I-b

UltraWall increase resisting forces and increases driving forces by the factors shown for Str I-b.

FACTORED LOADS: Str Ib

Name	Factor γ	Force (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	1.25	1949.74		-1.765			-3441.39
Soil Wedge(W2)	1.35	760.16		-1.229			-934.36
Pa_h	1.50		571.88		1.771	1013.02	
Pa_v	1.50	185.82		-2.458			-456.80
Sum V / H		2896	572		Sum Mom	1013	-4833

BASE SLIDING

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

Forces Resisting sliding

N = W1(DCr)+ W2(EVr) + Pav(EHd)

(1,560 x 0.90) + (563 x 1.00) + (124 x 1.50)

N = 2,153 lbf/ft

Sliding between Concrete Units and Leveling Pad/Drain Mat (Rf1)

Resisting force at pad = (θ N tan(slope)) x RFsl

RF1 = (0.8 x 2,153 x tan(40.00) + 0.0) x 0.90 — Rf1 = 1,301

Driving force is the horizontal component of

Pah(EHd)

DF = (381 x 1.50) — Df = 572

CDR = (Rf1 / Df) — CDR = 2.27

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.

RESULTS TABLE FACTORED

Elev[ft]	N[lbf/ft]	Shear Intcpt	Resisting Force	Driving Force[lbf/ft]	CDR Sliding/Shear
2.46	559.67	3,257.59	3,559.82	111.22	32.01

ECCENTRICITY

Eccentricity at the base is checked by assuming rotation by the block mass and the soil retained on the blocks. Allowable overturning can be defined by eccentricity (e/L).

Moments Resisting =
M1(DCr) + M2(EVr) + MPav(EHd)
((-2,753 x 0.90) + (-692 x 1.00) + (-305 x 1.50)

Mr = 3,627 ft-lbs

Moments Driving = MPah(EHd) + M0(EVd)
(675 x 1.50) + (0 x 1.35) + (0 x 1.50)

Mo = 1,013 ft-lbs

e = (Mr - Mo)/ N
e = (3,627 - 1,013) /2,153 e = 1.21
e/L = 1.21 / 4.92 e/L = 0.25

ROW TO ROW ECCENTRICITY

Eccentricity is checked by assuming rotation by the block mass and the soil retained on the blocks about the row below. Factored eccentricity can be defined by eccentricity/Length (e/L).

RESULTS TABLE FACTORED

Elev[ft]	Mr[ft lbf/ft]	Mo[ft lbf/ft]	Sum Vertical[lbf]	Ecc[ft]	BlockLength	Ecc/L
2.46	0.00	102.77	777.32	0.13	2.46	0.05

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant force away from the centroid of the mass. This measure is an indication of the overturning of the mass. UltraWall uses an allowable eccentricity of 9/20 L for concrete to concrete bearing surfaces and a concrete leveling pad (thickness > 1.0 ft), or L/3 for bearing on soil per the AASHTO LRFD guidelines. Eccentricity is still used as a guide to design in some design methods.

UltraWall calculates three eccentricities:

1) Maximum eccentricity (overturning) where it uses the maximum driving forces combined with the minimum resisting forces (see overturning) [Str I-a]. 2) Maximum bearing where it uses the maximum driving forces combined with the maximum resisting forces [Str I-b]. 3) Service: Maximum bearing where it uses the actual driving forces combined with the actual resisting forces in Service loading.

Calculation of Eccentricity for maximum bearing
Moments resisting = M1(DCd) M2(EVd) + MPa(EHd)
(-2,753 x 1.25) + (-692 x 1.35) + (-305 x 1.50)

Mr = 4,833 ft-lbs

Moments driving = + MPah(EHd)
+ (675 x 1.50)

Mo = 1,013 ft-lbs

Nb = W1(DCd) + W2(EVd) + WPa(EHd)
(1,560 x 1.25) + (563 x 1.35) + (124 x 1.50)

Nb = 2,896 lbf/ft

N bearing = W1(DCd) + W2(EVd) + WPlvlpad(EVd) + WPa(EHd)
(1,560 x 1.25) + (563 x 1.35) + (193 x 1.35) + (124 x 1.50)

Nbrg = 3,157 lbf/ft

Calculate Eccentricity (absolute values used for parameters)
e = (Mr - Mo)/ Nb
e = (4,833 - 1,013) /2,896

e = 1.319

BEARING

Bearing Capacity Factors [Foundation]

Nc = 30.140 Myerhoff Eqn
Nq = 18.401 Myerhoff Eqn
Ng = 22.402 Vesic Eqn

Shape Factors [Foundation]

Sc = 1.061
Sq = 1.058
Sg = 0.960

Depth Correction Factor

df = 1.136

Modified Bearing Capacity Factors [Foundation]

Ncm = Nc x Sc = 31.980
Nqm = Nq x Sq = 22.107
Ngm = Ng x Sg = 21.506

Water Correction Factor

Cwq = 0.500
Cwg = 0.500

B'f = B - 2e + lvlPad Thickness (Bearing area at foundation)
B'f = 4.92 - 2 x 1.32 + 0.50 B'f = 2.78 ft

q = embedment * γ
= 2.00 x 120.00 q = 300.00 lbf/ft2

Calculation of Bearing Pressures Foundation

qr = (c * Ncm + q * Nqm * Cwq + 0.5 * γ * B' * Ngm * Cwg) * RFbr
[(50.000 x 31.980) + (240 x 22.107 x 0.500) + (0.5 x 120 x 2.779 x 21.506 x 0.500)] x 0.45

Calculate Factored Bearing, qr qr = 3,128.02 lbf/ft2
Bearing Pressures (σ) Nbrg/B'f = 1,136.13 lbf/ft2
Calculated CDR for bearing qr/σ = 2.75

Design	Sum Vert	Mo	Mr	e	Qal	Sigma	CDR
Strength I-b	3157	1013	-4833	1.319	3128	1136	2.75
Service	2440	675	-3750	1.368	3095	911	3.40

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.

Design Ground Acceleration	As = Fpae * PGA = 0.550
Assumed deformation =	Def = 4.00 in
(with deformation, the kh is reduced by 50%)	
Horizontal Acceleration	kh = 0.275
Vertical Acceleration	kv = 0.000

INERTIA FORCES OF THE STRUCTURE

Pif = (W1 * kh)	
(1559.79 * 0.275)	Pif = 428.94

SEISMIC THRUST

Coefficient of active seismic earth pressure Kae	Kae = 0.529
D_Kae = Kae - Ka = (0.529 -0.342)	D_Kae = 0.000
Pae = 0.5*gamma*(H)^2 * DKae	Pae = 0.00 lbf/ft
Pae_h = Pae*cos(delta)	Pae_h = 0.00 lbf/ft
Pae_v = Pae*sin(delta)	Pae_v = 0.00 lbf/ft

In AASHTO LRFD, two cases are looked at: 1) 100% Pae and 50% of Pir, and 2) 50% Pae and 100% Pir.

TABLE OF RESULTS FOR SEISMIC REACTIONS

SEISMIC SLIDING

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 are
Units(1.0) + SoilWedge(1.0) + Pa_v(1.0)

(1560 * 1.0) + (563 * 1.0) + (124 * 1.0)
Note Pae_v changes between case 1 and case 2, to Pae_v/2)

Case 1, 100% Pae & 50% Pir
SumVs_Pae = 2247

Case 2, 50% Pae & 100% Pir
SumVs_Pir = 2185

Resisting force 1 = (SumVs_Pae * tan(slope) + intercept * L) * RFsl — FReS1 = 1508 lbf/ft
Resisting force 2 = (SumVs_Pir * tan(slope) + intercept * L) * RFsl — FReS2 = 1467 lbf/ft

The inertial force Pif = Face*kh(1.0) + Soil Wedge*kh*(1.0)
Driving force = + Pa_h(1.0) + Pif_h/2(1.0)
[case 2 is 50% Pae, 100% Pir]

(381 * 1.0) + (429/2 * 1.0)

FDrS1 = 596 lbf/ft
FDrS2 = 553 lbf/ft

CDR = (FReS1/FDrS1) / (FReS2/FDrS2) — CDR = 2.53 / 2.65

SEISMIC ECCENTRICITY

Eccentricity is rotation about the center of the wall and is a check on overturning.

Resisting Moment =
(case 2 is 50% Pae)

MomReS [Pae] = -3750 ft lbf/ft
MomReS [Pir] = -3445 ft lbf/ft

Driving Moment =
Pa_h(1.0) + Pif_h/2(1.0)
(675 * 1.0) + (1266/2 * 1.0)

MomDrS [Pae] = 675 ft lbf/ft
MomDrS [Pir] = 0 ft lbf/ft

e = (Mr - Mo)/ N

e [Pae] = (3750 - 675) /2247 e = 1.37

e/L = 0.28

e [Pir] = (3445 - 0) /2185 e = 1.58

e/L = 0.32

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 = 30.14 Myerhoff Eqn

Nq = 18.40 Myerhoff Eqn

Ng = 22.40 Vesic Eqn

c = 50 lbf/ft2

q = (emb + lvl pad) * gamma(EVsr) = 300.00 lbf/ft2

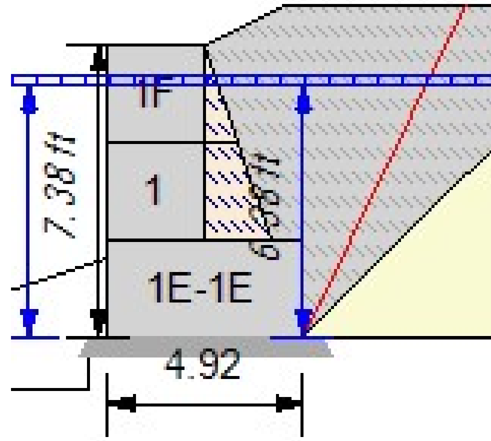
Pae Values (100% Pae, 50% Pir)

Calculate Factored Bearing, Qult (seismic)	Qult = 5,980 lbf/ft2
Equivalent Footing Width, B' = L - 2e + Lvl pad	B' = 2.68 ft
Bearing Pressure = sumVs/B' + B + LP depth/2 * LP depth * gamma	q = 838.37 lbf/ft2
CDR for Bearing = (Qults * RFbr)/Bearing	CDR = 7.13

Pir Values (50% Pae, 100% Pir)

Calculate Factored Bearing, Qult (seismic)	Qult = 7,569 lbf/ft2
Equivalent Footing Width, B' = L - 2e + Lvl pad	B' = 2.35 ft
Bearing Pressure = sumVs/B' + B + LP depth/2 * LP depth * gamma	q = 956.14 lbf/ft2
CDR for Bearing = (Qults * RFbr)/Bearing	CDR = 6.25

UltraWall



Project: BPLC Properties - Inter Ave
Location: Puyallup, WA
Designer: KDH
Date: 4/3/2025
Section: 7.5 Wall
Design Method: AASHTO_LRFD_2020
Design Unit: UltraBlock: 1

Seismic Acc: 0.550g

SOIL PARAMETERS	Φ	coh	γ	γsat
Select Soil:	36 deg	0 lbf/ft2	135 lbf/ft3	137 lbf/ft3
Retained Soil:	30 deg	50 lbf/ft2	120 lbf/ft3	137 lbf/ft3
Foundation Soil:	30 deg	50 lbf/ft2	120 lbf/ft3	137 lbf/ft3
Leveling Pad:	40 deg	0 lbf/ft2	140 lbf/ft3	137 lbf/ft3
Crushed Stone Lvlng Pad				

GEOMETRY

Design Height:	7.38 ft	Live Load:	0.00 lbf/ft2
Wall Batter/Tilt:	0.00/ 0.00 deg	Live Load Offset:	0.00 ft
Embedment:	2.00 ft*	Live Load Width:	0.00 ft
Leveling Pad Depth:	0.50 ft		
Slope Angle:	26.6 deg	Dead Load:	0.0 lbf/ft2
Slope Length:	2.0 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		Toe Slope Angle:	18.40
		Toe Slope Length:	10.00
		Toe Slope Bench:	0.00
Select Fill Offset:	0.00 ft		
Select Fill Angle:	45.00 deg.		

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

Water

Front Height:	6.38 ft
Internal Ht:	6.38 ft
Drainage Depth:	1.00 ft

RESULTS (Static / Seismic)

CDR Sliding: 1.00 (lvlpd) / 1.38 CDR Brng: 6.14 / 11.05

Eccentricity (e/L): 0.12 (e/L <= 0.33) / [0.01 (e/L <= 0.40)] Bearing: 634 / 438 / 474 (Service)

Ecc Internal(e/L): 0.18 (e/L <= 0.45)

Name	Elev.	ka	kae	Pae	Paw1	Paw2	Paw3	Pif	Pwd	(Pwr)	PaT	PaTs	CDRsl	seisCDRsl	e/L	Seis e/L (Pae/Pir)
1F	4.92	0.344	0.000	126	0	0	78	171	67	-67	78	383	31.97	25.00 / 23.36	0.05	0.00
1	2.46	0.309	0.000	396	0	0	280	300	480	-480	280	1540	9.48	10.27 / 14.25	0.18	0.00
1E-1E	0.00	0.500	0.759	1343	34	431	762	558	1270	-1270	1226	4324	1.00	1.38 / 2.83	0.12	0.00

Column Descriptions:

ka: active earth pressure coefficient; kae: active seismic earth pressure coefficient

Paw1: active earth pressure of soils above the water line

Paw2: active earth pressures (1) of submerged soils below the water line

Paw3: active earth pressures (2) of submerged soils below the water line

Pwd: driving pressures of water from behind the face

Pwr: resisting pressures of water in front of wall

Pif: Inertia of the facing units, Pir: Inertia of the gravel fill behind the units.

Paq: live surcharge earth pressure

Paqd: dead surcharge earth pressure

(PaC): reduction in load due to cohesion

PaT: sum of all earth pressures

CDRsl (lvlPad): 'Capacity/Demand Ratio' for sliding at each layer. (CDR sliding below the leveling pad)

e/L: eccentricity/base width ratio

e/L (Srvs): service state condition eccentricity/base width ratio

%D/H: ratio of based depth to height (warning for narrow walls, < 35%)