

September 10, 2021

Greg Tadlock 7006 SE Maker Street Mercer Island, Washington

RE: Retaining Wall Design 7006 SE Maker Street Mercer Island, Washington

In accordance with your authorization, Cobalt Geosciences, LLC has prepared this letter to present wall design information for a new modular block wall at the referenced site.

Project Description

One of the proposed modular block walls will be located along the east property line extending to the northwest, abutting an existing cast in place concrete wall in the backyard. The other 6 feet east of the first wall mirroring the lower wall. The backfill zone will be located on the property east of the subject property. The walls may vary from less than 2 feet tall and up to about 6 feet tall. The area above the new walls will be planted with vegetation and will not have surcharge loads. The approximate walls locations are shown on Figure 1.

Geologic Hazards

The site and adjacent areas contain localized steep slope and erosion hazard areas. There are also mass-wastage overprints in this part of Mercer Island along with localized mapped springs. The site is situated within an older erosional bowl-shaped feature that faces downward to the west. The site slopes are generally less than 30 percent in magnitude with total relief of about 20 feet. There are steeper cut slopes near the east property line that are up to 6 feet tall at 30 to 60 percent in magnitude.

The area geology includes Olympic-era fine grained deposits underlain by Olympic-era nonglacial deposits. In general, these soils include fine to medium grained sands with gravel. These deposits are all typically dense to very dense below a variable thickness of weathered soils.

The site and adjacent areas are mostly developed with residences, basement walls, yard walls, and other features. There is no evidence of global instability at the site and adjacent areas and the properties are well vegetated with ground covers and variable diameter trees. The site and adjacent areas appear stable at this time and the risk of landslide activity is relatively low. The geologic processes that created the landforms in this area occurred mostly following glacial retreat, approximately 11,000 years ago.

There is evidence of recent soil erosion along the east property line where previous cuts as part of home construction were not faced with walls. This erosion activity appears to be ongoing and the eroded soils are consistent with coarse grained Olympia-era non-glacial deposits. The proposed modular block wall with geogrid reinforcement will improve stability in the area and eliminate this erosion issue.

Retaining Wall Design

To prepare the wall areas for construction, all vegetation, organic surface soils, and other deleterious materials should be stripped and removed from the wall keyway. Organic topsoil will not be suitable for use as structural fill but may be used in non-structural areas and the upper topsoil zone for plantings.

The area behind the proposed walls will require benching to create adequate space for geogrid reinforced fill. Benching should consist of vertical steps with a maximum height of 4 feet and minimum lateral length of 4 feet. The wall keyway and benches should be excavated into medium dense or firmer native soils and verified by the geotechnical engineer. Based on our estimation of wall heights, the benching and keyway excavations can be located to minimize disruption of root systems for any trees that will remain in place.

The following soil parameters were used in our designs:

Soil Type	Friction Angle	Cohesion	<u>Unit Weight</u>
Structural Fill	32 degrees	o psf	135 pcf
Native Soils	34 degrees	o psf	135 pcf

psf = pounds per square foot

pcf = pounds per cubic foot

All fill placed behind the walls, regardless of whether or not it is in the reinforced backfill zone, must be compacted as structural fill. The native soils at the site contain a sufficient percentage of fines that will make them difficult, if not impossible, to compact as structural fill when they are over-optimum in moisture content. Therefore, if earthwork occurs during wet weather months, it may be necessary to import a granular soil for use in geogrid reinforced walls that meets the following gradation requirements:

U. S. Sieve Size	Percent Passing
6 inches	100
No. 4	75 maximum
No. 200	5 maximum*

* Based on the 0.25 inch fraction

Prior to use, Cobalt Geosciences should examine and test all materials to be imported to the site for use as structural fill. Native soils may be suitable for use as structural fill provided they are within 3 percent of the optimum moisture, free of roots larger than 1 inch in size, and cobbles greater than 3 inches in diameter are removed.

The new retaining wall should consist of the Cornerstone 200 series blocks, or an equivalent approved by us. The new Cornerstone wall should be constructed as a Mechanically Stabilized Earth (MSE) wall with segmental block facing. The new retaining wall should be constructed according to the manufacturers' specifications and the recommendations provided in this report.

We have designed the walls with a maximum 4H:1V backslope/backfill condition. We recommend the following recommendations be incorporated into the construction of the walls:

• Wall designs based on use of Cornerstone 200 Series blocks. Design is based on vertical application (no batter); however, a batter of up to 1/2 inch per block can be utilized.

- If a cap block is used, it must be entirely above ground and as such will not be considered in the total height of the wall.
- A minimum 0.5 feet of toe embedment is necessary for erosion protection and stability. The area below the wall should be level.
- A 6-inch thick layer of 5/8 inch minus or 1-1/4 inch minus crushed rock should be placed and compacted along the wall subgrade to provide a leveling course.
- Geogrid reinforcement should consist of Mirafi 10xt or an equivalent approved by us.
- A minimum 12-inch wide zone of clean angular rock (5/8-inch) should be placed behind the blocks extending from the toe to the top of the walls.
- Geogrid will require overlapping onto adjacent grids where the wall turns 90 degrees.
- The soil used in the reinforcement zone must consist of structural fill as described above.
- A layer of separation fabric should be placed over the top of the 12-inch wide drainage zone. No other separation fabric should be used.
- The upper 12 inches of fill may contain organic-laced soil for landscaping (if proposed).
- Density testing of structural fill should be performed per manufacturer's recommendations. At least one test per lift is typically recommended.

Total Wall Height	No. of Geogrids	Min. Geogrid Length
2-3.33'	1	4.0'
3.5-5.33'	2	4.0'
5.5-7.33'	3	4.7'
7.5-8.67'	4	5.7'

Geogrid Schedule

Geogrid should be placed above the lowest 2 blocks and every 24 inches vertically (3 blocks) from that point up to finish grade elevations with at least one block above the uppermost grid. Geogrid should be pinned between blocks and overlap onto adjacent geogrids at least 12 inches. Grid should be staked flat as fill is placed. See the attached figure and design files for block and grid lavouts.

A 4 inch diameter perforated PVC pipe should be placed at the base of the wall behind the first row of blocks. The 5/8 inch clean angular rock used as the chimney drain behind the blocks may be used around this pipe.

We recommend that the 4-inch perforated wall drain be directed into a tightline extending into the storm catchbasin or other approved stormwater infrastructure near the street.

Closure

The information presented herein is based upon professional interpretation utilizing standard practices and a degree of conservatism deemed proper for this project. We emphasize that this report is valid for this project as outlined above and for the current site conditions and should not be used for any other site.

September 10, 2021 Page 4 of 4 Retaining Wall Design

Sincerely,

Cobalt Geosciences, LLC



Phil Haberman, PE, LG, LEG Principal

PH/sc

Exp 6-26-2020



Wall heights are anticipated to vary from less than 2 feet at the south end, up to about X feet near the existing residence, decreasing to about 4 to 5 feet near the northwest end.





Proposed Retaining Wall 7006 SE Maker Street Mercer Island, Washington

Site Layout Figure 1 Cobalt Geosciences, LLC P.O. Box 82243 Kenmore, WA 98028 (206) 331-1097 www.cobaltgeo.com cobaltgeo@gmail.com



All fill to be compacted to at least 95 percent of the modified proctor in maximum 6 inch lifts.

Maximum 4H:1V backslope created with fill.

Geogrid should be placed every three blocks (2') with the uppermost grid below at least one block.

Section is not to scale. See attached files and report for number and length of geogrids based on wall height.

Not to Scale



Proposed Retaining Wall 7006 SE Maker Street Mercer Island, Washington Wall Section Figure 2 Cobalt Geosciences, LLC P.O. Box 82243 Kenmore, WA 98028 (206) 331-1097 www.cobaltgeo.com cobaltgeo@gmail.com

ia eight (re Il slope Il angle dment Iata al Soil,	etainec	d heig	ht), ft	5.												-
eight (re Il slope Il angle dment I <mark>ata</mark> al Soil,	etainec	d heig	ht), ft	5.												
Il slope Il angle dment Iata al Soil,		0	,,		33									_		
ll angle dment l ata al Soil,				4:	1										1	
dment lata al Soil,				14.	0											
l ata al Soil,				0.	5											
al Soil,																
	Phi_e			34												
al soil d	ensity	(In si	tu), pcf	135										/		
al Soil, F	°hi_i ́		<i>,</i>	32												
al soil de	ensity,	pcf		135									, sill			
oil Frict	ion An	gle		21												
oriz)		-		0	.31											
Horiz)				0	.40								Thumbr	nail		
lity						Γ	Segmen	tal bloc	k data							-∎
irning ra	tio			2	.80	L V	/endor se	election			'Kevstor	ne Retainir	ng Wall Syst	ems'		
ratio				2	.10	V	/endor w	eb addre	ess		'www.ke	evstonewal	ls.com'			
irning m	oment	t, ft-lb	s	2,145		E	Block sel	ection tv	pe		'Standa	rd'				
ing mor	nent, f	t-lbs		6,004		E	Block hei	ght, in			8.0	0				
ateral/sl	iding f	orce,	lbs	921		E	Block dep	oth, in			18.0	18.00				
Resist	ance, f	ft		1,932	.59	C	Offset pe	r block, i	n		0.0	0.00				
ertical f	orce, l	bs		2,865		E	Batter an	gle			0.0	0.00				
ength, f	i i			4	.00	V	Vall weig	ht, psf			180.0	80.00				
tricity or	n base	, ft		0	.65	F	- linge hei	ght, ft			0.0	0.00				
ve base	length	n, ft		2	.69	_										_
earing p	essur	e, psf		1,063	.67		Geogrid	materia	al							
ble soil	bearin	ig, ps	f	3,000	.00	١	vendor S	election			'Mirafi G	Geogrid'				
earing R	atio			2	.82	١	Vendor w	/eb addr	ess		'www.m	irafi.com'				
nic is in	cluder	the	OTM and	l slidina	ratios ma		Geogrid 1	type			'Miragrio	10XT'				
per sec	tion 18	807.2	.3 of IBC	2009 or	IBC 2012	2. L	TDS				4969.1	4				
na						F	actor of	safety			1.5	D				
iig						L	TADS				3312.7	6				
load, ps	f			0		F	Peak cor	nection	equatior	n	1226 +	0.53N				
ad, psf				0		F	Peak cor	nection	maximu	Im	2896					
ic Desig	jn Kh			0	.10	5	Serviceal	bility con	inection	equation	1000 +	0.21N				
Analy	sis T	able):				Servicea	bility con	inection	maximur	m 1766	_				
Layer	Heig Ft	ht abo In	ove base Dec	Te Static	nsion Seismic	Conn Peak	ection Serv	Embed Le	Vert N	S. F.	Required Extent, F	t*				
	5'	4"	5.33													
2	3'	4"	3.33	166	107	944.5	1075.6	0.02	360	3.47	4.00					
1	1'	4"	1.33	276	89	1071.7	1151.2	1.51	720	2.94	4.00					
	0'	0"	0.00						960			7				
nt of ge	ogrid r	eferei	nced from	the fro	nt face of	wall, FT	-									
	al soil de coil Fricti oriz) Horiz) lity urning ra gratio urning m ateral/sl gresista vertical fr ength, ft tricity or ve base earing pr ble soil earing R mic is in per sec ing load, psf ic Desig Analy Layer	al soil density, soil Friction An oriz) Horiz) lity urning ratio gratio urning moment, f ateral/sliding f g Resistance, f rertical force, I ength, ft tricity on base ve base length earing pressur ble soil bearin earing Ratio mic is included per section 18 ing load, psf ic Design Kh Analysis T Layer Heig Ft 5' 2 3' 1 1' 0' nt of geogrid r	al soil density, pcf soil Friction Angle oriz) Horiz) Horiz) lity Iming ratio g ratio Irrning moment, ft-lbs ateral/sliding force, g Resistance, ft vertical force, lbs ength, ft tricity on base, ft ve base length, ft searing pressure, psf ible soil bearing, ps earing Ratio mic is included, the per section 1807.2 ing load, psf bad, psf ic Design Kh Analysis Table Layer Height abo Ft In 5' 4" 2 3' 4" 1 1' 4" 0' 0" mt of geogrid referent	al soil density, pcf soil Friction Angle oriz) Horiz) Horiz) lity urning ratio gratio urning moment, ft-lbs ing moment, ft-lbs ateral/sliding force, lbs ateral/sliding force, lbs ateral/sliding force, lbs ateral/sliding force, lbs ength, ft tricity on base, ft ve base length, ft earing pressure, psf ible soil bearing, psf earing Ratio mic is included, the OTM and per section 1807.2.3 of IBC ing load, psf ic Design Kh Analysis Table: Layer Height above base Ft In Dec 5' 4" 5.33 2 3' 4" 3.33 1 1' 4" 1.33 0' 0" 0.00 nt of geogrid referenced from	al soil density, pcf 135 soil Friction Angle 21 oriz) 0 Horiz) 0 Iity Iming ratio 2 g Resistance, ft 1,932 y retrical force, lbs 921 g Resistance, ft 1,932 y retrical force, lbs 921 g Resistance, ft 1,932 y retrical force, lbs 2,865 ength, ft 4 tricity on base, ft 0 ve base length, ft 2 saring pressure, psf 1,063 ible soil bearing, psf 3,000 earing Ratio 2 mic is included, the OTM and sliding per section 1807.2.3 of IBC 2009 or ing load, psf 0 bad, psf 0 bad, psf 0 ic Design Kh 0 Analysis Table: Layer Height above base Te Ft In Dec Static 5' 4" 5.33 2 3' 4" 3.33 166 1 1' 4" 1.33 276 0' 0" 0.00 mt of geogrid referenced from the fro	al soil density, pcf 135 toil Friction Angle 21 oriz) 0.31 Horiz) 0.40 Ity Iming ratio 2.80 gratio 2.10 Iming moment, ft-lbs 2,145 ing moment, ft-lbs 6,004 ateral/sliding force, lbs 921 g Resistance, ft 1,932.59 vertical force, lbs 2,865 ength, ft 4.00 tricity on base, ft 0.65 ve base length, ft 2.69 baring pressure, psf 1,063.67 ible soil bearing, psf 3,000.00 earing Ratio 2.82 mic is included, the OTM and sliding ratios map per section 1807.2.3 of IBC 2009 or IBC 2012 Ing load, psf 0 ic Design Kh 0.10 Analysis Table: Layer Height above base Tension 5' 4" 5.33 2 3' 4" 3.33 166 107 1 1' 4" 1 1' 4" 0' 0.00 ator geogrid referenced from the front face of	al soil density, pcf 135 soil Friction Angle 21 oriz) 0.31 Horiz) 0.40 iity 0.40 iity 0.40 iity 0.40 iity 0.40 iity 0.40 iity 0.40 iity 0.40 iity 0.40 ing moment, ft-lbs 2,145 ateral/sliding force, lbs 921 g Resistance, ft 1,932.59 orertical force, lbs 2,865 ength, ft 4.00 vertical force, lbs 2,865 ength, ft 0.65 Hoe base length, ft 2.69 earing pressure, psf 1,063.67 ible soil bearing, psf 3,000.00 earing Ratio 2.82 mic is included, the OTM and sliding ratios may per section 1807.2.3 of IBC 2009 or IBC 2012. ing 0 load, psf 0 ic Design Kh 0.10 Analysis Table: add psf 1 above base Tension Conr Ft In Dec Static Seismic Peak 5' 4'' 5.33 4 2 3' 4'' 3.33 166 107 944.5 1 1' 4'' 1.33 276 89 1071.7 o' 0'' 0.00 4 int of geogrid referenced from the front face of wall, FT	al soil density, pcf 135 soil Friction Angle 21 oriz) 0.31 Horiz) 0.40 Ity 0.40 Ity Vendor so pratio 2.10 pratio 2.10 runing moment, ft-lbs 2,145 ing moment, ft-lbs 6,004 ateral/sliding force, lbs 921 g Resistance, ft 1,932.59 g Resistance, ft 0.65 ength, ft 4.00 ve base length, ft 2.69 saring pressure, psf 1,063.67 ble soil bearing, psf 3,000.00 vendor w mic is included, the OTM and sliding ratios may per section 1807.2.3 of IBC 2009 or IBC 2012. Ing load, psf 0 peak cor ic Design Kh 0.10 Serviceal TADS Analysis Table: Tension Connection Ft In Dec Static Seismic Peak Serv 5' 4" 5.33 2 3' 4" 3.33 166 107 944.5 1075.6 1 1' 4" 1.33 276 89 1071.7 1151.2 of 0' 0' 0.00 a a a a a a a a a a a a a a a a a	al soil density, pcf 135 foil Friction Angle 21 oriz) 0.31 Horiz) 0.40 Ity 0.40 ing 2.10 gratio 2.145 ing moment, ft-lbs 6,004 ateral/sliding force, lbs 921 gresstance, ft 1,932.59 ength, ft 4.00 tricity on base, ft 0.65 we base length, ft 2.69 earing pressure, psf 1,063.67 ble soil bearing, psf 3,000.00 earing Ratio 2.82 mic is included, the OTM and sliding ratios may per section 1807.2.3 of IBC 2009 or IBC 2012. Ceogrid materia ing 0 blac, psf 0 ord, psf 0 ord, psf 0 ic Design Kh 0.10 Serviceability cor Analysis Table: Serviceability cor Image: The fit in Dec Static Seismic Peak Serv Lee Serviceability cor 2 3' 4'' 5.33 1075.6 0.02 1 1' 4' 1.33 26 107.7 </td <td>al soil density, pcf 135 toil Friction Angle 21 oriz) 0.31 Horiz) 0.40 Ity Ity Ity Ity Ity Ity Ity Ity</td> <td>al soil density, pcf 135 foil Friction Angle 21 oriz) 0.31 Horiz) 0.40 itty</td> <td>al soli density, pcf 135 tooli Friction Angle 21 oriz) 0.31 Horiz) 0.40 ity irrning ratio 2.80 pratio 2.10 rratio 2.10 rratio 2.10 read/Silding force, lbs 2.145 Block selection type 'Standal Block height, in 8.00 Hateral/Silding force, lbs 2.865 early pressure, pt 1.063.67 tricity on base, ft 0.65 earling Ratio 2.82 ble soil bearing, psf 3.000.00 earling Ratio 2.82 Vendor web address 'www.me Geogrid type 180ck, in 0.00 Hinge height, ft 0.00 Vendor web address 'www.me Geogrid type 1800.00 Hinge height, ft 0.00 Vendor web address 'www.me Geogrid type 1800.00 Serviceability connection equation 1226 + 1 Block selection maximum 2896 is Design Kh 0.10 Serviceability connection equation 1000 + 1 Serviceability connection equation 1000 + 1 Serviceabili</td> <td>al soli density, pcf 135 toil Friction Angle 21 toil Friction Angle 21 thoir 2 0.31 Horiz) 0.40 Biox selection type 'Standard' Block begith, in 8.00 Block begith, in 18.00 Under the base ft 0.65 ve base length, ft 2.69 paring Ratio 2.82 ve dors selection type 'Standard' Block depth, in 18.00 Under the base ft 0.65 we base length, ft 2.69 ble soli bearing, psf 3.000.00 we ficial floce, be 2.82 ve dors selection type 180.00 Hinge height, ft 0.00 Wall weight, psf 180.00 Hinge height, ft 0.00 Wall weight, psf 180.00 Hinge height, ft 0.00 Wall weight, psf 180.00 Wall weight, psf 180.00 Hinge height, ft 0.00 Wall weight, psf 180.00 Wall weight, psf 180.00 Hinge height, ft 0.00 Wall weight, psf 1.00 Hinge height, ft 0.00 Hinge heigh</td> <td>al soil density, pcf 135 joil Friction Angle 21 oriz) 0.31 Horiz) 0.40 Ity Ity irraing moment, ft-lbs 2.10 ing moment, ft-lbs 6.004 ateral/sliding force, lbs 921 Pesistance, ft 1.932.59 Offset per block, in 0.00 ertical force, lbs 2.865 Batter angle 0.00 ertical force, lbs 3.000.00 earing pressure, psf 1.063.67 bie soil bearing, psf 3.000.00 earing Ratio 2.82 rig 1.50 food, psf 0 ic besidned, the OTM and sliding ratios may per section 1807.2.3 of IBC 2009 or IBC 2012 rig 0 ic besign Rh 0.10 Serviceability connection maximum 1226 + 0.53N</td> <td>al soil density, pcf 135 joil Friction Angle 21 join Friction Angle 210 join Friction Frictin Frictin Friction Friction Frictin Fricti</td> <td>la soil density, pcf 135 coil Friction Angle 21 friction Angle 20 friction Angle 20</td>	al soil density, pcf 135 toil Friction Angle 21 oriz) 0.31 Horiz) 0.40 Ity Ity Ity Ity Ity Ity Ity Ity	al soil density, pcf 135 foil Friction Angle 21 oriz) 0.31 Horiz) 0.40 itty	al soli density, pcf 135 tooli Friction Angle 21 oriz) 0.31 Horiz) 0.40 ity irrning ratio 2.80 pratio 2.10 rratio 2.10 rratio 2.10 read/Silding force, lbs 2.145 Block selection type 'Standal Block height, in 8.00 Hateral/Silding force, lbs 2.865 early pressure, pt 1.063.67 tricity on base, ft 0.65 earling Ratio 2.82 ble soil bearing, psf 3.000.00 earling Ratio 2.82 Vendor web address 'www.me Geogrid type 180ck, in 0.00 Hinge height, ft 0.00 Vendor web address 'www.me Geogrid type 1800.00 Hinge height, ft 0.00 Vendor web address 'www.me Geogrid type 1800.00 Serviceability connection equation 1226 + 1 Block selection maximum 2896 is Design Kh 0.10 Serviceability connection equation 1000 + 1 Serviceability connection equation 1000 + 1 Serviceabili	al soli density, pcf 135 toil Friction Angle 21 toil Friction Angle 21 thoir 2 0.31 Horiz) 0.40 Biox selection type 'Standard' Block begith, in 8.00 Block begith, in 18.00 Under the base ft 0.65 ve base length, ft 2.69 paring Ratio 2.82 ve dors selection type 'Standard' Block depth, in 18.00 Under the base ft 0.65 we base length, ft 2.69 ble soli bearing, psf 3.000.00 we ficial floce, be 2.82 ve dors selection type 180.00 Hinge height, ft 0.00 Wall weight, psf 180.00 Hinge height, ft 0.00 Wall weight, psf 180.00 Hinge height, ft 0.00 Wall weight, psf 180.00 Wall weight, psf 180.00 Hinge height, ft 0.00 Wall weight, psf 180.00 Wall weight, psf 180.00 Hinge height, ft 0.00 Wall weight, psf 1.00 Hinge height, ft 0.00 Hinge heigh	al soil density, pcf 135 joil Friction Angle 21 oriz) 0.31 Horiz) 0.40 Ity Ity irraing moment, ft-lbs 2.10 ing moment, ft-lbs 6.004 ateral/sliding force, lbs 921 Pesistance, ft 1.932.59 Offset per block, in 0.00 ertical force, lbs 2.865 Batter angle 0.00 ertical force, lbs 3.000.00 earing pressure, psf 1.063.67 bie soil bearing, psf 3.000.00 earing Ratio 2.82 rig 1.50 food, psf 0 ic besidned, the OTM and sliding ratios may per section 1807.2.3 of IBC 2009 or IBC 2012 rig 0 ic besign Rh 0.10 Serviceability connection maximum 1226 + 0.53N	al soil density, pcf 135 joil Friction Angle 21 join Friction Angle 210 join Friction Frictin Frictin Friction Friction Frictin Fricti	la soil density, pcf 135 coil Friction Angle 21 friction Angle 20 friction Angle 20

This Wall in File: c:\users\phil\documents\retainpro 10 project files\examples.rpx

RetainPro (c) 1987-2018, Build 11.18.06.30

License : KW-06062373 License To : Cobalt Geosciences

Segmental Retaining Wall with Geogrids

Code: NCMA

Summary: Resisting / Overturning

Resisting Moments

Item	Force, lbs	Distance, ft	Moment, ft-lbs
Wall	960	0.75	720
Reinf. earth	1,800	2.75	4,950
Sloped	105	3.18	334
Dead load	0	2.75	0
Live load	0	2.75	0
Total	2,865		6,004

Overturning Moments

Item	Force, lbs	Distance, ft	Moment, ft-lbs
Earth	621	1.99	1,233
Surcharge, DL	0	2.98	0
Surcharge, LL	0	2.98	0
Seismic, Wall	96	2.67	256
Seismic, Reinf.	84	2.67	224
Seismic, Sloped soil	2	5.43	12
Seismic, Exterior	117	3.57	419
Total	921		2,145
Overturning Ratio	2.80		

ASSUMPTIONS AND CRITERIA USED

1. References used include Design Manual for Segmental Retaining Walls, 2nd Edition, and Segmental Retaining Walls – Seismic Design Manual, 1st Edition, both by NCMA.

- 2. Blocks are all same size and uniform offsets (batter) for full wall height.
- 3. Coulomb earth pressure theory used for earth pressures and failure plane angle.
- 4. Refer to geotechnical report for backfill material, compaction, and other design data and recommendations.
- Cap blocks if used are above the retained height and are neglected in this design. 5.
- 6. Geogrid LTDS and connection values for block vendors obtained from ICC Evaluation Service (ES Legacy Reports) or as provided by vendors. Since these may change or be updated, verification of values is recommended.
- 7. Block sizes obtained from vendors' literature and may vary with locality.
- 8. Geogrid layers are equally spaced vertically, all same length, and laid horizontally.
- Average weight of block and cell infill assumed to be 120 pcf. 9.
- 10. See vendor web sites (on input screen) for more information and specifications.
- Design height is limited to 16 feet or 24 blocks, whichever is less. Contact vendor for higher designs or special conditions. 11.
- 12. Seismic design is per Seismic Design Manual cited above. Also see Methodology/Seismic Design in User's Manual.
- 13. Vendor specifications or project specifications, whichever is most restrictive, to be followed for construction procedures.

14. Add notes and details for proper drainage.

- 15. See User's Manual Design Example #10 for methodology and sample verification calculations.
- 16. Final design responsibility is with the project Engineer-of-Record.

icense	:KW-0 To:	987-2 6062 Cob	373 alt (Geos	cier	nces		Segn	nental	Retai	ning \	Nall w	vith Ge	ogrids		Code: NCM
Criter	ia															
Wall h	eight (retai	ned	heig	ht), 1	ft	7.	33								_
Backfil	ll slope)		0	,.		4:	1								
Backfil	Il angle)					14.	0								
Embeo	dment						0.	5								
Soil d	lata															
Extern	al Soil	. Phi	е				34									
Extern	al soil	dens	 sitv	(In si	tu). I	ocf	135									
Interna	al Soil.	Phi	i	`	,,,		32									
Interna	al soil (dens	itv. i	ocf			135								/	·/
Wall S	oil Frid	ction	And	nle			21									
K a(H	oriz)			9.0				31								
K_AE(Horiz)						0	.40							Thu	Imbnail
Stabi	litv								ſ	Saamar		k data				
Overtu	irning	ratio					2	07	l	Segmen		K Udid			5	
Sliding	n ratio	ano					1	82	````	/endor s	election			Keystor	ne Retaining Wal	Il Systems'
Overtu	rning	mor	ont	ft_lh	c		5 5 3 3	.02	`	/endor w	eb addre	ess		'www.ke	eystonewalls.com)'
Resist	ing mo	mor	torit,	, It-iu -lhe	3		11 / 30		E	Block sel	ection ty	ре		Standar	rd'	
Total	nig nic storol/		11, 11 [.]	-105	lha		1 720		E	Block hei	ght, in			8.00	0	
Total la	ateral/s	siidir	ig ic	orce,	IDS		1,730		E	Block dep	oth, in			18.00	0	
Silaing	Resis	tanc	е, п	[3,143	.44	(Offset pe	r block, i	n		0.00	0	
I otal V	/ertical	torc	e, it	DS			4,660	70	E	Batter an	gle			0.00	0	
Base I	engtn,	π.					4	.70	١	Vall weig	ght, psf			180.00	0	
Eccen		on da	ase,	π			1	.08	ŀ	linge hei	ight, ft			0.00	0	
Effecti	ve bas	e iei	ngth	ι, π			2	.53	ſ	Coogrid	Imotoria					
Soll be	earing	pres	sure	e, pst			1,838	.88	l	Geogrid	materia	ai				
Allowa	ible so	I be	arınç	g, ps	t		3,000	.00	,	Vendor S	Selection			'Mirafi G	Geogrid'	
Soil Be	earing	Rati	0				1	.63		Vendor w	veb addr	ess		'www.mi	irafi.com'	
If seisr	mic is i	nclu	ded	, the	OTN	/ and	l sliding	ratios ma	iy (Geogrid	type			'Miragric	d 10XT'	
be 1.1	per se	ectio	n 18	07.2	.3 of	IBC	2009 or	IBC 2012	2.	LTDS				4969.14	4	
Loadi	ing									-actor of	safety			1.50	0	
Deed		of					0			LTADS				3312.76	6	
Deau	ioau, p	r T					0			Peak cor	nnection	equation	า	1226 + (0.53N	
Live id	ia Daa	l ian I	/h				0	10	l	Peak cor	nnection	maximu	m	2896		
Seisiii	IC Des	ign r	<u> </u>				0	.10		Servicea	bility con	inection	equation	1000 + (0.21N	
Wall	Anal	ysi	s Ta	able):		-		-	Servicea	bility con	inection	maximun	n 1766		
Block	Laye	r H	eigh Ft	nt abo In ∣	ove t I D	base Dec	Te Static	nsion Seismic	Conr Peak	ection Serv	Embed Le	Vert N	S. F.	Required Extent. Fi	t*	
11			7'	4"		7.33								, , , ,		
8	3	-	5'	4"		5.33	166	133	944.5	1075.6	0.77	360	3.16	4.70		
5	2	+	3'	4"		3.33	332	133	1071.7	1151.2	0.72	720	2.31	4.70	1	
2	1	+	1'	4"		1.33	414	111	1198.9	1226.8	2.21	1,080	2.28	4.70	1	
Base		1	0'	0"		0.00						1,320			1	
Base * Exter	nt of g	eogr	0' id re	0" eferei	ncec	0.00 I from	the fro	nt face of	wall, F1	-	2.21	1,320	2.20	4.70		

Dsgnr:

This Wall in File: c:\users\phil\documents\retainpro 10 project files\examples.rpx

RetainPro (c) 1987-2018, Build 11.18.06.30 License : KW-06062373 License To : Cobalt Geosciences

Segmental Retaining Wall with Geogrids

Code: NCMA

Summary: Resisting / Overturning

S
l

Item	Force, lbs	Distance, ft	Moment, ft-lbs
Wall	1,320	0.75	990
Reinf. earth	3,168	3.10	9,821
Sloped	172	3.64	628
Dead load	0	3.10	0
Live load	0	3.10	0
Total	4,660		11,439

Overturning Moments

Item	Force, lbs	Distance, ft	Moment, ft-lbs
Earth	1,157	2.71	3,137
Surcharge, DL	0	4.07	0
Surcharge, LL	0	4.07	0
Seismic, Wall	132	3.67	484
Seismic, Reinf.	215	3.67	787
Seismic, Sloped soil	8	7.51	59
Seismic, Exterior	219	4.88	1,066
Total	1,730		5,533
Overturning Ratio	2.07		

ASSUMPTIONS AND CRITERIA USED

 References used include Design Manual for Segmental Retaining Walls, 2nd Edition, and Segmental Retaining Walls – Seismic Design Manual, 1st Edition, both by NCMA.

- 2. Blocks are all same size and uniform offsets (batter) for full wall height.
- 3. Coulomb earth pressure theory used for earth pressures and failure plane angle.
- 4. Refer to geotechnical report for backfill material, compaction, and other design data and recommendations.
- 5. Cap blocks if used are above the retained height and are neglected in this design.
- Geogrid LTDS and connection values for block vendors obtained from ICC Evaluation Service (ES Legacy Reports) or as provided by vendors. Since these may change or be updated, verification of values is recommended.
- 7. Block sizes obtained from vendors' literature and may vary with locality.
- 8. Geogrid layers are equally spaced vertically, all same length, and laid horizontally.
- 9. Average weight of block and cell infill assumed to be 120 pcf.
- 10. See vendor web sites (on input screen) for more information and specifications.
- 11. Design height is limited to 16 feet or 24 blocks, whichever is less. Contact vendor for higher designs or special conditions.
- 12. Seismic design is per Seismic Design Manual cited above. Also see Methodology/Seismic Design in User's Manual.
- 13. Vendor specifications or project specifications, whichever is most restrictive, to be followed for construction procedures.
- 14. Add notes and details for proper drainage.
- 15. See User's Manual Design Example #10 for methodology and sample verification calculations.
- 16. Final design responsibility is with the project Engineer-of-Record.

This Wall in File: c:\users\phil\documents\retainpro 10 project files\examples.rpx

cense : KW-06062373 cense To : Cobalt Geosciences	Segr	nental	Retai	ning \	Nall w	ith Ge	eogrids	Code: 1	NCM/
Criteria									
Vall height (retained height), ft	8.67								
Backfill slope	4:1								
Backfill angle	14.0								
Embedment	0.5								
Soil data									
	24								
External soil donsity (In situ) nef	34 135								
nternal Soil Phi i	32								
nternal soil density not	135								_
	21								
	0.31								
	0.31							Thumbnail	
	0.40	_						Indianal	
Stability			Segmer	ntal bloc	k data				
Overturning ratio	2.14	V	/endor s	election			'Keystor	ne Retaining Wall Systems'	
Sliding ratio	1.85	N	/endor w	eb addre	ess		'www.ke	eystonewalls.com'	
Dverturning moment, ft-lbs	9,400	E	Block sel	ection ty	ре		'Standa	rd'	
Resisting moment, ft-lbs	20,141	E	Block hei	ght, in			8.0	0	
l otal lateral/sliding force, lbs	2,465	E	Block depth, in			18.00			
Sliding Resistance, ft	4,567.01	C	Offset pe	r block, i	n		0.0	0	
lotal vertical force, lbs	6,771	E	Batter an	gle			0.0	0	
Base length, ft	5.70	V	Vall weig	ght, psf			180.0	0	
	1.20	F	linge hei	ight, ft			0.0	0	
	3.17	Г	Geogrid	Imatoria	al				
Newoble soil bearing paf	2,133.99	L	Coognia	materia					
Allowable soli bearing, psi	3,000.00	```````````````````````````````````````	Vendor S	Selection			'Mirafi G	Seogrid'	
Soli Bearing Ratio	1.41		vendor w	veb addr	ess		'www.m	irati.com	
f seismic is included, the OTM an	d sliding ratios m	ay (type			iviragrie		
be 1.1 per section 1807.2.3 of IBC	2009 or IBC 201	2. L	_1DS =============				4969.14	4	
Loading		1		safety			2240.7		
Dead load, psf	0	L [naction	oquation		1226	0 0 53N	
_ive load, psf	0	r c	Peak cor	nection	movimu	n m	2806	0.551	
Seismic Design Kh	0.10	r c	Serviceal	hility con	nection	aquation	2090 1000 ±	0.21N	
Wall Analysis Table:			Servicea	bility con	nection	maximur	n 1766	0.211	
Rick Laver Height shove base	Tension	Conn		Embed	\/ort	SE	Required		
Ft In Dec	Static Seismic	Peak	Serv	Le	N	0.1.	Extent, F	t*	
13 8' 8" 8.67									
11 4 7' 4" 7.33	92 125	902.1	1050.4	1.26	240	4.15	5.70	1	
8 3 5' 4" 5.33	276 151	1029.3	1126.0	0.23	600	2.41	5.70		
5 2 3' 4" 3.33	442 151	1156.5	1201.6	1.72	960	1.95	5.70		
2 1 1' 4" 1.33	507 125	1283.7	1277.2	3.21	1,320	2.02	5.70		
Base 0' 0" 0.00					1,560				

This Wall in File: c:\users\phil\documents\retainpro 10 project files\examples.rpx

RetainPro (c) 1987-2018, Build 11.18.06.30 Segmental Retaining Wall with Geogrids

License : KW-06062373 License To : Cobalt Geosciences

Code: NCMA

Summary: Resisting / Overturning

Resisting Moments

Item	Force, lbs	Distance, ft	Moment, ft-lbs
Wall	1,560	0.75	1,170
Reinf. earth	4,914	3.60	17,690
Sloped	297	4.31	1,281
Dead load	0	3.60	0
Live load	0	3.60	0
Total	6,771		20,141

Overturning Moments

Item	Force, lbs	Distance, ft	Moment, ft-lbs
Earth	1,652	3.24	5,349
Surcharge, DL	0	4.86	0
Surcharge, LL	0	4.86	0
Seismic, Wall	156	4.33	676
Seismic, Reinf.	332	4.33	1,437
Seismic, Sloped soil	14	8.90	120
Seismic, Exterior	312	5.83	1,818
Total	2,465		9,400
Overturning Ratio	2.14		

ASSUMPTIONS AND CRITERIA USED

1. References used include Design Manual for Segmental Retaining Walls, 2nd Edition, and Segmental Retaining Walls – Seismic Design Manual, 1st Edition, both by NCMA.

- 2. Blocks are all same size and uniform offsets (batter) for full wall height.
- 3. Coulomb earth pressure theory used for earth pressures and failure plane angle.
- 4. Refer to geotechnical report for backfill material, compaction, and other design data and recommendations.
- Cap blocks if used are above the retained height and are neglected in this design. 5.
- 6. Geogrid LTDS and connection values for block vendors obtained from ICC Evaluation Service (ES Legacy Reports) or as provided by vendors. Since these may change or be updated, verification of values is recommended.
- 7. Block sizes obtained from vendors' literature and may vary with locality.
- 8. Geogrid layers are equally spaced vertically, all same length, and laid horizontally.
- Average weight of block and cell infill assumed to be 120 pcf. 9.
- 10. See vendor web sites (on input screen) for more information and specifications.
- Design height is limited to 16 feet or 24 blocks, whichever is less. Contact vendor for higher designs or special conditions. 11.
- 12. Seismic design is per Seismic Design Manual cited above. Also see Methodology/Seismic Design in User's Manual.
- Vendor specifications or project specifications, whichever is most restrictive, to be followed for construction procedures. 13.

14. Add notes and details for proper drainage.

- 15. See User's Manual Design Example #10 for methodology and sample verification calculations.
- 16. Final design responsibility is with the project Engineer-of-Record.