Cobalt Geosciences, LLC
P.O. Box 82243
Kenmore, Washington 98028

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 non-glacial 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	Unit Weight
Structural Fill	32 degrees	0 psf	135 pcf
Native Soils	34 degrees	0 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.

Geogrid Schedule

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 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 layouts.

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.

Sincerely,

Cobalt Geosciences, LLC

Exp 6-26-2020

Phil Haberman, PE, LG, LEG
Principal

PH/sc

Wall heights are anticipated to vary from less than 2 feet at the south end, up to about 8 feet near the existing residence, decreasing to about 4 to 5 feet near the northwest end.

N

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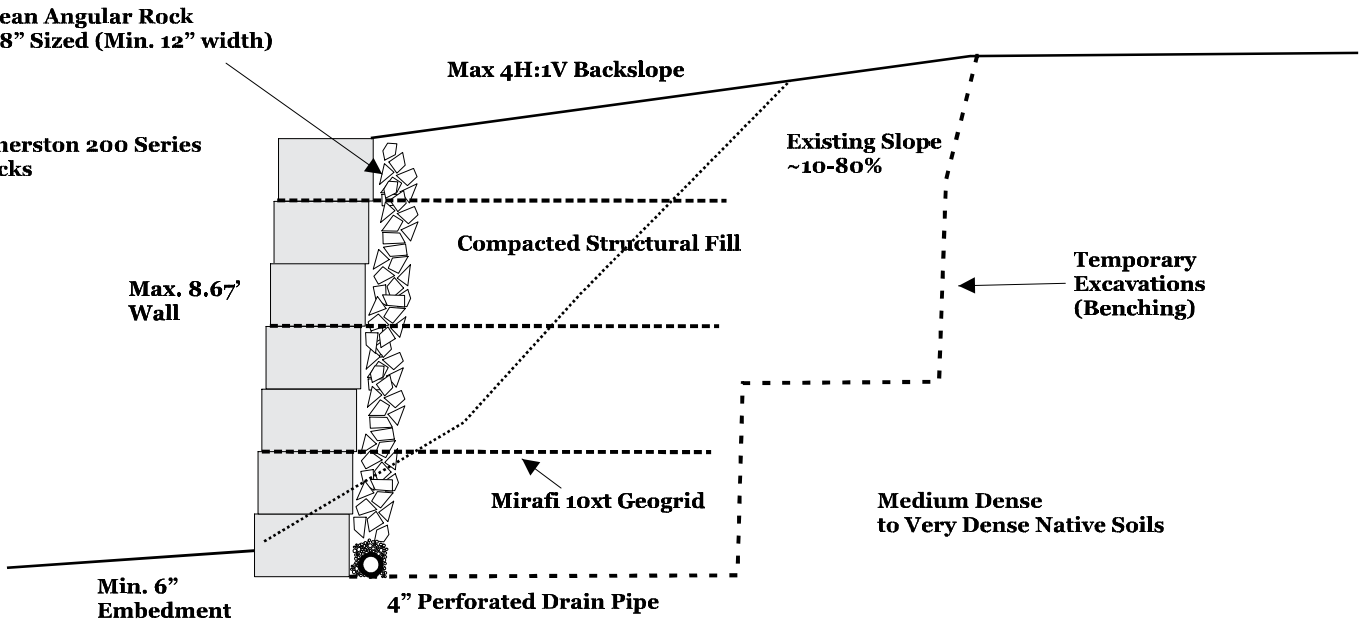
Proposed Retaining Wall
7006 SE Maker Street
Mercer Island, Washington

Site Layout
Figure 1

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

Modular Block Walls



NOTE: Geogrid is not shown to scale or at required locations vertically. See report and design files for spacing and length.

Notes:

Wall designed using Cornerstone 200 blocks with no batter (vertical wall) and geogrid lengths per report.

Drainage system should route to City catchbasin via tightline.

Benching should be performed prior to wall and fill placement. Benches should have maximum 4' vertical cut with minimum 4' bench length.

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

COBALT GEOSCIENCES

Proposed Retaining Wall
7006 SE Maker Street
Mercer Island, Washington

Wall Section Figure 2

Cobalt Geosciences, LLC
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Kenmore, WA 98028
(206) 331-1097
www.cobaltgeo.com
cobaltgeo@gmail.com

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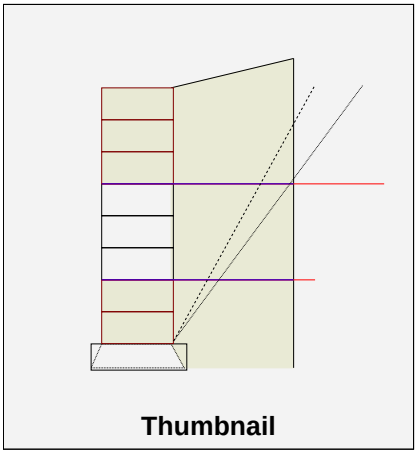
Segmental Retaining Wall with Geogrids

Code: NCMA

Criteria

Wall height (retained height), ft	5.33
Backfill slope	4:1
Backfill angle	14.0
Embedment	0.5



Thumbnail

Soil data

External Soil, Phi_e	34
External soil density (In situ), pcf	135
Internal Soil, Phi_i	32
Internal soil density, pcf	135
Wall Soil Friction Angle	21
K_a(Horiz)	0.31
K_AE(Horiz)	0.40

Stability

Overturning ratio	2.80
Sliding ratio	2.10
Overturning moment, ft-lbs	2,145
Resisting moment, ft-lbs	6,004
Total lateral/sliding force, lbs	921
Sliding Resistance, ft	1,932.59
Total vertical force, lbs	2,865
Base length, ft	4.00
Eccentricity on base, ft	0.65
Effective base length, ft	2.69
Soil bearing pressure, psf	1,063.67
Allowable soil bearing, psf	3,000.00
Soil Bearing Ratio	2.82

If seismic is included, the OTM and sliding ratios may be 1.1 per section 1807.2.3 of IBC 2009 or IBC 2012.

Loading

Dead load, psf	0
Live load, psf	0
Seismic Design Kh	0.10

Segmental block data

Vendor selection	'Keystone Retaining Wall Systems'
Vendor web address	'www.keystonewalls.com'
Block selection type	'Standard'
Block height, in	8.00
Block depth, in	18.00
Offset per block, in	0.00
Batter angle	0.00
Wall weight, psf	180.00
Hinge height, ft	0.00

Geogrid material

Vendor Selection	'Mirafi Geogrid'
Vendor web address	'www.mirafi.com'
Geogrid type	'Miragrid 10XT'
LTDS	4969.14
Factor of safety	1.50
LTADS	3312.76
Peak connection equation	1226 + 0.53N
Peak connection maximum	2896
Serviceability connection equation	1000 + 0.21N
Serviceability connection maximum	1766

Wall Analysis Table:

Block	Layer	Height above base Ft In	Dec	Tension Static	Seismic	Connection Peak	Serv	Embed Le	Vert N	S. F.	Required Extent, Ft*
8		5' 4"	5.33								
5	2	3' 4"	3.33	166	107	944.5	1075.6	0.02	360	3.47	4.00
2	1	1' 4"	1.33	276	89	1071.7	1151.2	1.51	720	2.94	4.00
Base		0' 0"	0.00						960		

* Extent of geogrid referenced from the front face of wall, FT

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.
5. Cap blocks if used are above the retained height and are neglected in this design.
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.
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.

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Segmental Retaining Wall with Geogrids

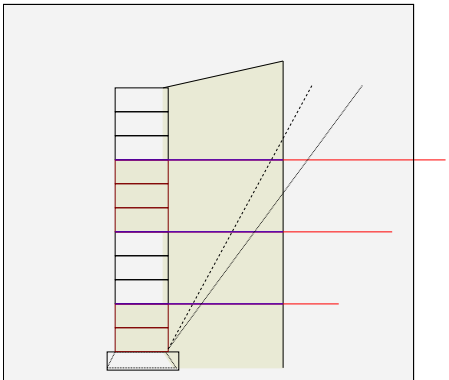
Code: NCMA

Criteria

Wall height (retained height), ft	7.33
Backfill slope	4:1
Backfill angle	14.0
Embedment	0.5

Soil data

External Soil, Phi_e	34
External soil density (In situ), pcf	135
Internal Soil, Phi_i	32
Internal soil density, pcf	135
Wall Soil Friction Angle	21
K_a(Horiz)	0.31
K_AE(Horiz)	0.40



Thumbnail

Stability

Overturning ratio	2.07
Sliding ratio	1.82
Overturning moment, ft-lbs	5,533
Resisting moment, ft-lbs	11,439
Total lateral/sliding force, lbs	1,730
Sliding Resistance, ft	3,143.44
Total vertical force, lbs	4,660
Base length, ft	4.70
Eccentricity on base, ft	1.08
Effective base length, ft	2.53
Soil bearing pressure, psf	1,838.88
Allowable soil bearing, psf	3,000.00
Soil Bearing Ratio	1.63

If seismic is included, the OTM and sliding ratios may be 1.1 per section 1807.2.3 of IBC 2009 or IBC 2012.

Loading

Dead load, psf	0
Live load, psf	0
Seismic Design Kh	0.10

Segmental block data

Vendor selection	'Keystone Retaining Wall Systems'
Vendor web address	'www.keystonewalls.com'
Block selection type	'Standard'
Block height, in	8.00
Block depth, in	18.00
Offset per block, in	0.00
Batter angle	0.00
Wall weight, psf	180.00
Hinge height, ft	0.00

Geogrid material

Vendor Selection	'Mirafi Geogrid'
Vendor web address	'www.mirafi.com'
Geogrid type	'Miragrid 10XT'
LTDS	4969.14
Factor of safety	1.50
LTADS	3312.76
Peak connection equation	1226 + 0.53N
Peak connection maximum	2896
Serviceability connection equation	1000 + 0.21N
Serviceability connection maximum	1766

Wall Analysis Table:

Block	Layer	Height above base Ft In	Dec	Tension Static	Seismic	Connection Peak	Serv	Embed Le	Vert N	S. F.	Required Extent, Ft*
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
2	1	1' 4"	1.33	414	111	1198.9	1226.8	2.21	1,080	2.28	4.70
Base		0' 0"	0.00						1,320		

* Extent of geogrid referenced from the front face of wall, FT

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Summary: Resisting / Overturning

Resisting Moments

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

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.
5. Cap blocks if used are above the retained height and are neglected in this design.
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.
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.

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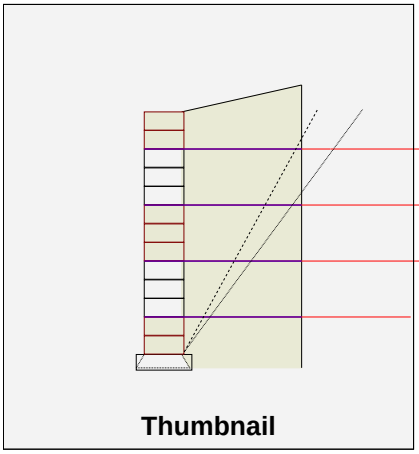
Segmental Retaining Wall with Geogrids

Code: NCMA

Criteria

Wall height (retained height), ft	8.67
Backfill slope	4:1
Backfill angle	14.0
Embedment	0.5



Thumbnail

Soil data

External Soil, Phi_e	34
External soil density (In situ), pcf	135
Internal Soil, Phi_i	32
Internal soil density, pcf	135
Wall Soil Friction Angle	21
K_a(Horiz)	0.31
K_AE(Horiz)	0.40

Stability

Overturning ratio	2.14
Sliding ratio	1.85
Overturning moment, ft-lbs	9,400
Resisting moment, ft-lbs	20,141
Total lateral/sliding force, lbs	2,465
Sliding Resistance, ft	4,567.01
Total vertical force, lbs	6,771
Base length, ft	5.70
Eccentricity on base, ft	1.26
Effective base length, ft	3.17
Soil bearing pressure, psf	2,133.99
Allowable soil bearing, psf	3,000.00
Soil Bearing Ratio	1.41

If seismic is included, the OTM and sliding ratios may be 1.1 per section 1807.2.3 of IBC 2009 or IBC 2012.

Loading

Dead load, psf	0
Live load, psf	0
Seismic Design Kh	0.10

Segmental block data

Vendor selection	'Keystone Retaining Wall Systems'
Vendor web address	'www.keystonewalls.com'
Block selection type	'Standard'
Block height, in	8.00
Block depth, in	18.00
Offset per block, in	0.00
Batter angle	0.00
Wall weight, psf	180.00
Hinge height, ft	0.00

Geogrid material

Vendor Selection	'Mirafi Geogrid'
Vendor web address	'www.mirafi.com'
Geogrid type	'Miragrid 10XT'
LTDS	4969.14
Factor of safety	1.50
LTADS	3312.76
Peak connection equation	1226 + 0.53N
Peak connection maximum	2896
Serviceability connection equation	1000 + 0.21N
Serviceability connection maximum	1766

Wall Analysis Table:

Block	Layer	Height above base Ft In	Dec	Tension Static	Seismic	Connection Peak	Serv	Embed Le	Vert N	S. F.	Required Extent, Ft*
13		8' 8"	8.67								
11	4	7' 4"	7.33	92	125	902.1	1050.4	1.26	240	4.15	5.70
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		

* Extent of geogrid referenced from the front face of wall, FT

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.
5. Cap blocks if used are above the retained height and are neglected in this design.
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.
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.