SOIL RETENTION

DESIGNS INC.

Verdura® 40/60 Retaining Wall Feasibility Design and Response to Plan Review Comments from City of Lake Forest

Project:

Portola Center Project (North Parcel), TTM 17300
Lake Forest, CA

Prepared for:

USA Portola Properties, LLC
Attn: Mr. Scott Molloy
610 West Ash Street, Suite 1500
San Diego, CA 92101

SRD Project No: 0704-034B
August 10, 2012

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Date: August 10, 2012 SRD Project No: 0704-034B

To: USA Portola Properties, LLC.
Attn: Mr. Scott Molloy
610 West Ash Street, Suite 1500
San Diego, CA 92101
Phone: 619-234-4050

Subject: ***Verdura®*** 40/60 Retaining Wall Feasibility Design and Response to Plan Review Comments from the City of Lake Forest, Portola Center Project (North Parcel), TTM 17300, Lake Forest, CA

In accordance with your request, ***Soil Retention Designs, Inc. (SRD)*** has prepared this updated feasibility design report to address six representative wall geometries for the proposed ***Verdura®*** retaining walls at the subject site. The enclosed structural design is an updated feasibility study and includes structural wall calculations enclosed within this report and accompanying cross-section design wall drawings (***Verdura®*** Segmental Retaining Wall Drawings - Sheets 1 through 7). The subject structural design is based upon the Tentative Tract Map 17300, prepared by Hunsaker and Associates, dated April 27, 2012. Please note that this feasibility design is not intended to be a construction document; but is solely prepared to facilitate planning requirements for Tentative Tract Map processing.

In addition, review comments from the City of Lake Forest Planning Department, prepared by Interwest Consulting Group, have also been addressed. Our responses are provided on an item by item basis with the comment list attached for reference.

REFERENCED DOCUMENTS

The information provided for use in the enclosed structural analyses included the following:

1. "Geotechnical Investigation, Portola Center North, Tentative Map 17300, Lake Forest, California," prepared by Geocon, Incorporated, Project No. G1218-52-01, dated June 29, 2012.
2. Tentatvie Tract Map 17300, prepared by Hunsaker and Associates, dated April 27, 2012.
3. "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes," prepared by Federal Highway Administration, Publication No. FHWA-NHI-00-043.

SCOPE OF WORK

The scope of design services provided for this project included the following:

1. Review of the above referenced documents relative to obtaining necessary design parameters.
2. In-office analysis and design of the proposed ***Verdura®*** retaining walls to accommodate critical aspects of the proposed civil design.
3. Preparation of this report, which contains our calculations, associated specifications, and accompanying design drawings for the proposed ***Verdura®*** retaining walls.
4. Response to City of Lake Forest plan review comments, dated November 2011.

LIMITATIONS

The design and recommendations provided herein are applicable to the use of the ***Verdura®*** retaining wall products, which is of proprietary ownership by Soil Retention Products, Inc.

Note that the scope of services authorized and provided herein is limited to a structural design of the proposed ***Verdura®*** retaining wall system. ***SRD*** did not provide any on-site geotechnical services such as subsurface investigations or identification/testing of soil materials that may be used in or near the proposed ***Verdura®*** retaining walls. Information presented herein is based on data provided in the referenced documents. If the conditions differ from those presented in the referenced documents, the engineering design and analyses provided by ***SRD*** may no longer be valid and additional engineering and analysis may be required. Conditions noted above include, but are not limited to, slope configurations, wall system type, wall/slope heights, soil materials and structural and/or external loadings. In addition, it should be noted that ***SRD*** is the wall designer and not the geotechnical engineer-of-record.

RESPONSE TO CITY PLAN REVIEW COMMENTS

SRD Response #S1 – Please note the following with regards to UBC and CBC conformance of the ***Verdura®*** retaining wall:

The ER-5515 evaluation report was prepared to determine conformance with the 1997 Uniform Building Code – Standard 21-4, Hollow and Solid Load-Bearing Concrete Masonry Units (see attachment). The UBC Standard 21-4 solely addresses manufacturing specifications for the block units and is based on ASTM Standard C90. The 2010 California Building Code (CBC) also relies upon the **same ASTM standard** (see section 2103.1).

Additionally, the 2010 California Building Code (CBC) specifies that the system be designed per Allowable Stress Design (ASD) methodology (see section 2107). Site specific design calculations for the proposed walls at the subject site have been provided per nationally recognized methodologies (Federal Highway Administration [FHWA]), which utilizes ASD methodology.

Please note that the ***Verdura®*** retaining wall system is a CALTRANS-Approved wall system and is listed on the "Pre-Approved Alternate Earth Retaining Systems" as of April 2012, which can be obtained through the following link:

http://www.dot.ca.gov/hq/esc/approved_products_list/pdf/earth_retaining_syst.pdf

Soil Retention is currently working on updating the ICC evaluation to include additional reinforcement types and reference to the 2010 CBC. The ER-5515 remains active and is available through the ICC website.

SRD Response #S2 – This item is under the purview of the geotechnical engineer of record.

SRD Response #S3 – The requested inspections are included under Section 3.10 and 3.11 of the General Notes sheet of the provided drawings. Please note that the subject cross-sectional drawings are not considered full construction documents, but are intended to provide feasibility information as part of the planning stage of the project. Full construction drawings will be much more detailed showing specific wall profiles with structural detailing.

SRD Response #S4 – Please see the attached Figure #1 (rear of document) which shows the representative wall locations that this feasibility design addresses.

SRD Response #S5 – This item is under the purview of the civil and/or geotechnical engineer of record.

SRD Response #S6 – ***Verdura®*** retaining wall segmental blocks are manufactured with a proprietary concrete mix which is resistant to severe (or very severe) sulfate exposure and will perform superior to any Type V cement mix.

SRD Response #S6 (Duplicate Question #) – The proposed ***Verdura®*** retaining walls have a maximum exposed height of 30 feet; however the walls are designed in some cases in a superimposed (terraced) condition creating heights in excess of 60 feet due to the 2:1 separation slopes and required embedment depths. The structural design methodology for terraced wall and/or an overall single height wall design is controlled by the offset distance between the walls. The following relationship recommended by Federal Highway Administration (FHWA) determines the type of analysis performed:

$$D \leq [1/20 * (H1 + H_2)]$$

D = Offset Distance
H_1 = Height of Upper Wall
H_2 = Height of Lower Wall

Per the FHWA design manual, for small upper wall offsets (where D ≤ 1/20 * [maximum 36 + 34] ≈ 3.5 feet), it is "assumed that the failure surface does not fundamentally change…The walls should be designed as a single wall…" Please see the attached excerpt from the FHWA design manual at the rear of text that further details this information.

For the subject site, the minimum offset between walls is on the order of 20+ feet. The "D" equation is not satisfied with this geometry, so the walls are designed in a terraced condition and internal stresses within the wall are significantly reduced. Our feasibility design for the terraced condition incorporates the use of "high-strength" geogrid reinforcement for these lower stresses. Steel reinforcements are not necessary for the proposed wall geometries. Additional information regarding terraced wall or independent wall design is outlined within the body of this report.

SRD Response #S7 – The requested references have been added to the updated ***Verdura®*** Segmental Wall Drawings and this report.

SRD Response #S8 – Surcharge loadings for permanent structures and/or transient loading from road traffic are relatively small in comparison to the overall static loading of fill of the larger wall complexes. For this feasibility design, surcharge loading has not been incorporated, but may be appropriate during the construction permitting phase of the project.

SRD Response #S9 – Table 3 within the ***Verdura®*** Segmental Wall Drawings have been updated to correspond to the recommendations within the referenced geotechnical reports.

SRD Response #S10 – The subject walls were designed for a site acceleration of 0.36g.

SRD Response #S11 – Post-construction horizontal movements of ***Verdura®*** retaining walls are discussed in the "Structural Setbacks" portion of the report.

SRD Response #S12 – Analysis is provided within the later part of this report for the most current representative wall geometries (see the "Wall Design" section and the Appendix).

SRD Response #S13 – Wet-stamp and signature are provided for both the updated ***Verdura®*** Segmental Wall Drawings and this report.

VERDURA® RETAINING WALL DESIGN

General Wall Configurations – The subject site consists of two parcels separated by Saddleback Ranch Road, which are be designated as "West" and "East" for this report. The proposed "West" and "East" site designs consist of multiple ***Verdura®*** retaining walls located within the westerly, southerly and easterly perimeter slopes and within internal slopes of the project site. Proposed walls primarily consist of single and double-tiered walls positioned within 2:1 slopes which reach overall heights of up to 100 feet. One quadruple-tiered wall complex is positioned in a canyon fill area in the "West" parcel. Individual wall heights reach a maximum of 30 feet. Terraced walls are designed with 2:1 separation slopes or level areas between the walls typically 20 to 30 feet in horizontal distance.

Geotechnical Design Parameters - The geotechnical parameters used in design of the ***Verdura®*** retaining walls are based upon the recommendations from the geotechnical engineer of record within the Referenced Document #1 and are summarized as follows:

- Reinforced zone (cohesion [c]= 500 psf, friction angle [φ]=32°);
- Retained zone (c=500 psf, φ=28°); and,
- Foundation zone (c=500 psf, φ=28°).

In accordance with nationally recognized design methodology, **cohesion within the reinforced and retained soils is conservatively disregarded.** The materials used within the reinforced zone may consist of either select onsite and/or imported fill material, provided the following quality criteria are met:

- Friction angle $\geq$ 32 degrees;
- Percent passing #200 sieve $\leq$ 35 percent;
- Expansion index of $\leq$ 50; and,
- Plasticity index of $\leq$ 20.

Based upon review of Referenced Document #1, it appears that these materials may be generated from the Puente Formation – Soquel Member (Tps – sandstone portion) and potentially other onsite sources.

Seismic Design Parameters – The site acceleration of 0.36g was utilized for the subject wall design based on information provided within Referenced Document #1.

Wall Design – Feasibility designs for the proposed ***Verdura®*** retaining walls for the subject site have been designed for both static and pseudo-static conditions using computer program MSEW (Mechanically Stabilized Earth Wall) 3.0 design software, developed by ADAMA Engineering, Inc. The structural designs have been completed per the AASHTO 2002 (ASD) design methodology. Structural design calculations include internal, external and local stability analyses. In addition, compound stability analysis is also included. The design calculations are provided within the appendix of this report and are preceded by a summary page of the critical factors of safety for the structural design (rear of text).

Structural design of walls in a superimposed (terraced) condition is controlled by the offset distance between the walls and the relationship to the height of the lower wall. The determination of whether a single tiered design for a two-wall system or two independent designs are necessary is governed by the following relationship:

$$D \geq H_2 * \tan(90-\varphi_r)$$

D = Offset Distance
H_2 = Height of Lower Wall
φ_r = Friction Angle of Reinforced Backfill Soils

When "D" satisfies the above relationship, walls are not considered superimposed and the lower wall is designed as an independent wall with the upper wall modeled as a surcharge load. The upper wall is then designed without any influence from the wall below. When "D" does not satisfy the above relationship, walls are considered superimposed and a tiered design for a single system governs.

Additional details regarding the design of terraced walls are included in attached excerpts from the referenced FHWA design manual at the back of this report. The tiered-wall design methodology is limited to two-wall geometry. Third and/or fourth wall geometries are modeled as surcharge loads.

Our analyses consisted of eight (8) structural wall designs for six (6) of the proposed single-wall and tiered-wall geometries at the subject site and are representative of the more critical geometries within the subject site. The attached Figure #1 (rear of document) provides specific locations within the subject site as to where these designs are generally applicable. The structural designs are as follows:

- **Design 1 – Single 15-ft Wall with 2:1 Crest** - Design 1 accommodates a 15-ft high exposed height wall with a maximum 30-ft high 2:1 ascending slope at the crest. Embedment depth is a minimum of 3 feet. This design is broadly representative of the proposed single-tier wall layouts within the "West" and "East" parcels of the subject site. Specifically, this design is applicable to the proposed wall located within Lot "C" of the "West" parcel (see Figure #1).

- **Design 2 – Single 30-ft Wall with 2:1 Crest** - Design 2 accommodates a 30.3-ft high exposed height wall with a maximum 30-ft high 2:1 ascending slope at the crest. Embedment depth is a minimum of 5 feet. This design is representative of the maximum height proposed single-tier wall within the "East" parcel of the subject site. Specifically, this design is applicable to the proposed wall located within Lot "G", and the single wall segments towards the ends of longer tiered wall geometries (see Figure #1).

- **Design 3 – Tiered 25-ft over 30-ft Walls with 25-ft Separation** - Design 3 accommodates a 30-ft high exposed height lower wall and 25-ft high upper wall with a 10-ft high 2:1 separation slope and 25-ft offset between the tiered walls. Embedment depth for the lower wall is 6 feet and 9 feet for the upper wall. The crest of the upper wall has a 30-ft high 2:1 ascending slope. This design is representative of the wall layout within the "East" portion of the site within Lot "F" (see Figure #1).

- **Design 4 – Tiered 20-ft over 25-ft Walls with 25-ft Separation** - Design 4 accommodates a 25-ft high exposed height lower wall and 20-ft high upper wall with a 10-ft high 2:1 separation slope and 25-ft offset between the tiered walls. Embedment depth for the lower wall is 5 feet and 8 feet for the upper wall. The crest of the upper wall has a 30-ft high 2:1 ascending slope. This design is representative of the wall layout along the southerly slope within the "East" portion facing Glen Ranch Road within Lot "F" (see Figure #1).

- **Design 5 – Tiered 19-ft over 19-ft Walls with 20-ft Separation** - Design 5 accommodates 19-ft high exposed height lower and upper walls with a 6-ft high 2:1 separation slope and 20-ft offset between the tiered walls. Embedment depth is a minimum of 3 feet for both the upper and lower walls. The crest of the upper wall has a 5-ft high 2:1 ascending slope. This design is representative of the wall layout located within the middle of the "East" parcel within Lot "G" (see Figure #1).

- **Designs 6 through 8 – Quadruple-Tiered 11-ft to 20-ft Walls with 20-ft to 25-ft Separations** - This quadruple-tiered wall system must be addressed within three designs as previously discussed. Design 6 addresses the lower two walls, Design 7 addresses the middle two walls and Design 8 addresses the upper two walls of the quadruple-tiered system. This design is representative of the wall layout located within a canyon fill at the western end of the "West" parcel (see Figure #1). This design represents the only quadruple-tiered geometry within "West" parcel of the subject site within Lot "B".

  Design 6 accommodates 20-ft high exposed height lower and upper walls with a 10-ft high 2:1 separation slope and 25-ft offset between the tiered walls. Embedment depth for the lowest wall is 4 feet and 8 feet for the upper wall. The crest of the upper wall has a 10-ft high 2:1 ascending slope with the upper two walls (and slopes above) modeled as a 3,352 lb/ft^2 surcharge based upon the bearing pressures from Design 8.

Design 7 accommodates a 20-ft high exposed height lower wall and 11-ft high exposed height upper wall with a 10-ft high 2:1 separation slope and 25-ft offset between the tiered walls. Embedment depth for the lowest wall is 8 feet (per Design 6) and 5 feet for the upper wall. The crest of the upper wall is level for a trail path with the upper wall modeled as a 1,800 psf surcharge setback 20 feet from the top of the upper wall. This portion of the design is completed without influence from the lower wall.

Design 8 accommodates an 11-ft high exposed height lower wall and 15-ft high exposed height upper wall with a 20-ft level offset for a trail path. Embedment depth for the lower wall is 5 feet (per Design 7) and 1-ft for the upper wall. The crest of the upper wall is conservatively modeled with a 15-ft high 2:1 ascending slope; however, this slope is offset by 20 feet for a trail path for the majority of the wall length. This portion of the design is completed without influence from the lower two walls.

Minimum safety factors for external, internal, and local stability satisfy the following criteria:

External Stability Calculations		
	Static	***Pseudostatic***
Base Sliding	1.5	1.1
Bearing Capacity	2.0	1.5
Overturning	2.0	1.5
Compound Stability	1.5	1.1
Internal Stability Calculations		
	Static	***Pseudostatic***
Sliding	1.5	1.1
Geogrid Pullout	1.5	1.1
Geogrid Strength	1.5	1.1
Local Stability Calculations		
	Static	***Pseudostatic***
Geogrid – Block Connection	1.5	1.1

The accompanying design drawings (***Verdura®*** Segmental Retaining Wall Drawings - Sheets 1 through 7) depict cross-sections showing the geogrid lengths, strengths, and placement based upon these designs.

Wall Components – The proposed ***Verdura®*** retaining walls are designed using ***Verdura®*** 40 and 60 blocks, Miragrid geogrids and other accessory products, and described in "Part 2 – Products" of the "Specifications" of the accompanying design drawings (Sheet 1).

Toe embedment - Toe embedment (embedment of the wall base into the foundation soils) is typically provided to minimize the potential for erosion undermining of the wall base, enhance bearing capacity and enhance sliding resistance of the basal reinforcement layers. Embedment of the wall is accounted for in the calculations as part of the "total wall height". The embedment has no impact on the wall calculations (i.e. design methodology conservatively ignores passive earth pressures from soils in front of the wall and hence has no effect on the internal or external stability of the wall system/components).

Minimum requirements for wall embedment are summarized as follows:

MINIMUM EMBEDMENT REQUIREMENTS	
Sloping Condition at Toe of Wall	***Embedment Requirement****
Level	H/20 (Minimum 1-foot)
2H:1V	H/7 (Minimum 3 feet)

**Note: H equals the total height of an MSE wall.*

The toe embedment of the wall designs for the subject project are a minimum of 3 to 5 feet for the single height walls in Designs 1 and 2, and 3 to 6 feet for the lower walls within tiered walls in Designs 3 through 6. The designed embedment depths exceed the minimum nationally recognized standards. It should be noted that deeper embedment of up to 9 feet for the upper walls within Designs 3 through 7 are required per the analyses. These depths typical vary based upon the height of the walls and the slope between the walls. Within Design 8, the upper tiered wall has an embedment of 1-foot as a result of the level condition in front of the wall. Additionally, all walls with descending slopes at the toe shall have an embedment depth which provides a minimum 7-foot to daylight condition per the geotechnical engineer of record.

Typical Structural Setbacks – Structures located above the tops of ***Verdura®*** retaining walls that are over 30 feet in height should be setback behind a 1:1 (horizontal to vertical) structural influence line unless special foundation recommendations are employed (i.e. mat-type slabs, caisson footings, etc.), as directed by the geotechnical engineer of record. The 1:1 should be measured from the face of the wall and project upward to the slope/pad daylight.

Post-construction horizontal movements of ***Verdura®*** retaining walls over 30 feet in height are expected to be less than 1/2 inch for single-tier walls (approximately 0.1% of total wall height) and 1 inch for multi-tier walls (approximately 0.2% of total wall height). Walls lower than 30 feet in height should have negligible lateral deflections. Both vertical and horizontal slope deformations and/or fill settlement surrounding the subject walls are under the purview of the geotechnical engineer of record. Our estimated horizontal movements do not account for the surrounding slopes and/or any underlying materials, but are solely for the walls themselves. In addition, pseudo-static designs are modeled based upon a 75mm (3 inch) displacement for external stability.

Wall Backfill – Requirements for backfill materials surrounding the proposed wall are included in the specifications of the ***Verdura®*** Segmental Retaining Wall Drawings for this project. In summary, the materials should consist of engineered fill comprised of select onsite and/or imported soils accepted by the geotechnical engineer of record and having a minimum friction angle of 32 degrees shear strength when remolded to 90% of modified proctor density (ASTM D-1557). Soils within 6 inches of a reinforcing geosynthetic layer shall not contain particles larger than 4 inches in diameter.

Backfill Drainage – Retaining wall sub-drainage should be applied as shown on the accompanying design drawings and/or as directed by the geotechnical engineer of record. If groundwater conditions exist within the foundation soils below the proposed ***Verdura®*** retaining walls, adequate drainage measures as directed by the geotechnical engineer of record should be employed to remedy the condition.

Surface Water Drainage – Drainage and channeling of surface water from above walls and from surrounding improvements should be directed to collection devices away from the retaining wall structures. Where possible, surface water should be collected in v-ditches, swales, or other collection/channeling devices in order to contain and discharge water to either end of the wall or away from the structures. Berms, curbs, gutters, swales or other devices may be required to prevent an excessive amount of concentrated runoff from draining over the crest of the wall and creating erosion problems. In no case should large volumes of runoff or concentrated flows be allowed to cascade over the top of ***Verdura®*** retaining walls, discharge into the backfill or infill soils from which the wall is constructed or otherwise be allowed to saturate the structural fill of the wall.

Improvements Above Walls – The uppermost geosynthetic reinforcements are designed to be at least 2 feet beneath the top of wall elevations. The 2-foot zone is typically considered a suitable depth in which landscaping can be installed.

In general, ***SRD*** recommends placement of proposed improvements in areas that avoid conflicts with the geogrid reinforcements. Where there are planned improvements above walls, ***SRD*** recommends the use of a "buffer" slope atop the wall so that future excavations will avoid contact and/or potential damage to reinforcements for the walls. Based upon the current plan, a minimum "buffer" slope of 5 feet high is planned atop all walls, which would provide a minimum clearance of 7 feet to the uppermost geogrid reinforcement. Tree well and any pool excavations atop the walls should be planned to avoid cutting of reinforcements.

Root growth from trees and/or vegetation is not inhibited by or damaging to the geogrid reinforcement layers of the ***Verdura®*** Retaining Wall system. Trees should be properly sized by the landscape architect so that root masses do not impart additional pressures on the wall face and anticipated tree canopies do not extend over the wall face when located on top of the wall.

Fence post and/or cable railings located at the top of walls should be constructed with caisson-type excavations which do not remove more than 25% of the geogrid materials at the face of the wall (e.g. spacing and size limited to 1-foot diameter caissons located on 4-foot centers).

Screen walls, which require footings resistance to significant lateral loads (i.e. wind loads, seismic loads), should be constructed with caisson and grade beam type foundations when located directly atop ***Verdura®*** retaining walls. The following recommendations should be considered:

- Foundations systems located directly above ***Verdura®*** retaining walls should comply with the following:

    - Continuous trench foundations (and/or grade beams) shall be limited to 18 inches from top of wall elevations allowing for a minimum soil cover of 6 inches over geogrid reinforcement materials.

- Caisson foundations may be drilled vertically, but should not remove more than 25 percent of the geogrid materials (e.g. spacing and size limited to 2-foot diameter caissons located on 8-foot centers). Maximum diameter of caisson footings should be less than or equal to 3 feet.

- Foundation systems located closer than 5 feet from the top of ***Verdura®*** retaining walls shall not rely upon passive pressure (acting towards the face of the wall) within the upper 2 feet measured from the top of wall.

- Foundation systems located a minimum of 5 feet away from the tops of ***Verdura®*** retaining walls and/or located atop slopes above ***Verdura®*** retaining walls may use passive pressures as directed by the geotechnical engineer of record.

Maintenance and Access – Maintenance and access for the proposed ***Verdura®*** retaining walls should be provided per the direction of project planners. Planned ***Verdura®*** retaining walls should be included within typical slope maintenance program guidelines.

Design Details – Detailed specifications, relative to the design of the ***Verdura®*** retaining wall system, are provided on the accompanying drawings (***Verdura®*** Segmental Retaining Wall Drawings - Sheets 1 through 7). The length, strength and spacing of geosynthetic reinforcements are depicted on the wall cross sections. Geogrid spacing for all wall areas shall not be more than 3 block courses except for top of wall areas as noted on the accompanying design drawings.

GLOBAL STABILITY ANALYSES

Global stability of earthen slopes surcharged by retaining walls is independent of local structural design for retaining walls and hence has not been conducted as part of the design included herein. The global stability of the slope and retaining wall combination is the responsibility of the geotechnical engineer of record and should be provided under separate cover. Minimum safety factors for potential failure surfaces that may occur behind and beneath the ***Verdura®*** retaining wall within the surrounding slopes should be documented and approved by all appropriate reviewing agencies.

Modifications to geogrid lengths per the global stability analysis in the Referenced Document #1 have been broadly incorporated into the ***Verdura®*** retaining wall drawings. The global stability recommendations from the geotechnical engineer should be more detailed for specific walls during the preparation of construction documents within the next phase of the project.

GEOTECHNICAL ENGINEER OF RECORD

It is the project geotechnical engineer of record's responsibility to review the enclosed design calculations, plans, and specifications in order to ensure that the assumptions made herein are consistent with their intentions. The geotechnical engineer of record will be responsible for ensuring that the soil, materials, and methods used in construction of the proposed ***Verdura®*** retaining wall system are conducted in accordance with the specifications outlined herein.

CONCLUSIONS

Design of the above referenced ***Verdura***® retaining walls is feasible provided that the recommendations included herein and within the accompanying drawings are followed.

If you have any questions or wish additional information, please contact the undersigned.

Respectfully Submitted,

Darien Osborne, RCE 64108
Senior Project Engineer

REGISTERED PROFESSIONAL ENGINEER
DARIEN A. OSBORNE
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EXP. 12/31/12
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Attachments: Design Summary Tables – Rear of Text
Appendix – ***Verdura***® Retaining Wall Design Calculations
Figure #1 – Wall Design Location Exhibit – Rear of Document
City of Lake Forest Plan Review Comments – Rear of Document
Uniform Building Code Standard 21-4 – Rear of Document
Excerpt from FHWA Design Manual "Superimposed Walls" – Rear of Document

Design Summary Table
Design 1
15' Single Wall with 2:1 Slope

Structure Geometry				
	Total Height	18' (15' Exposed with 3' Embedment)		
	Crest Condition	30' 2:1 Ascending Slope		
	Minimum Length/Height Ratio	18'/18' (1.00)		
Geotechnical Parameters		**Reinforced**	**Retained**	**Foundation**
	Friction angle, φ, degrees	32	28	28
	Dry Unit Weight, γ_d, pcf	120	120	120
	Cohesion, c, psf	500*	500*	500
	Seismic acceleration, g	0.36g		
Global Stability		**Per Geotechnical Engineer of Record**		

*** Note: Cohesion within the reinforced and retained soil zones is conservatively ignored within the analysis.**

Minimum Factor of Safety

		FS, Static		**FS, Seismic**	
External Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	2.10	≥1.5	1.38	≥1.1
	Overturning	4.76	≥2.0	2.76	≥1.5
	Bearing Capacity/Settlement	11.72	≥2.0	8.21	≥1.5
	Compound Stability	1.72	≥1.5	1.22	≥1.1
Internal Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.93	≥1.5	1.28	≥1.1
	Pullout	14.96	≥1.5	4.76	≥1.1
	Geogrid Strength	3.00	≥1.5	1.47	≥1.1
Local Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Geogrid to Block Connection	4.44	≥1.5	1.62	≥1.1

Design Summary Table
Design 2
30' Single Wall with 2:1 Slope

Structure Geometry				
	Total Height	35.3' (30.3' Exposed with 5' Embedment)		
	Crest Condition	30' 2:1 Ascending Slope		
	Minimum Length/Height Ratio	30'/35.3' (0.85)		
Geotechnical Parameters		**Reinforced**	**Retained**	**Foundation**
	Friction angle, φ, degrees	32	28	28
	Dry Unit Weight, γ_d, pcf	120	120	120
	Cohesion, c, psf	500*	500*	500
	Seismic acceleration, g	0.36g		
Global Stability		**Per Geotechnical Engineer of Record**		

*** Note: Cohesion within the reinforced and retained soil zones is conservatively ignored within the analysis.**

Minimum Factor of Safety

		FS, Static		**FS, Seismic**	
External Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	2.12	≥1.5	1.23	≥1.1
	Overturning	4.30	≥2.0	2.10	≥1.5
	Bearing Capacity/Settlement	9.04	≥2.0	4.32	≥1.5
	Compound Stability	1.58	≥1.5	1.12	≥1.1
Internal Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.94	≥1.5	1.13	≥1.1
	Pullout	12.49	≥1.5	4.88	≥1.1
	Geogrid Strength	2.49	≥1.5	1.22	≥1.1
Local Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Geogrid to Block Connection	3.25	≥1.5	1.19	≥1.1

Design Summary Table
Design 3
25' over 30' Tiered Walls with 25' 2:1 Slope Offset

Design for Both Walls in Tiered Condition

Structure Geometry				
	Total Height	71' Total Height Upper Wall – (25' Exposed with 9' Embedment) Lower Wall - (30' Exposed with 6' Embedment)		
	Tiered Condition	25' Offset – 10' 2:1 Separation Slope Between Walls		
	Crest Condition	30' 2:1 Ascending Slope		
	Minimum Length/Height Ratio	Tiered Wall - 65'/71' (0.92) Lower Wall – 65'/36' (1.81) Upper Wall – 40'/34' (1.18)		
Geotechnical Parameters		**Reinforced**	**Retained**	**Foundation**
	Friction angle, φ, degrees	32	28	28
	Dry Unit Weight, γ_d, pcf	120	120	120
	Cohesion, c, psf	500*	500*	500
	Seismic acceleration, g	0.36g		
Global Stability		**Per Geotechnical Engineer of Record**		

*** Note: Cohesion within the reinforced and retained soil zones is conservatively ignored within the analysis.**

Minimum Factor of Safety

		FS, Static		**FS, Seismic**	
External Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.74	≥1.5	1.23	≥1.1
	Overturning	3.88	≥2.0	2.54	≥1.5
	Bearing Capacity/Settlement	7.64	≥2.0	5.05	≥1.5
	Compound Stability	1.63	≥1.5	**Min 1.1 thru Geogrid Zone	≥1.1
Internal Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.67	≥1.5	1.18	≥1.1
	Pullout	3.19	≥1.5	1.99	≥1.1
	Geogrid Strength	1.60	≥1.5	1.36	≥1.1
Local Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Geogrid to Block Connection	1.69	≥1.5	1.29	≥1.1

**** Safety factor in output is shown for slope area above the wall. This condition is outside the purview of a wall designer; however, consider that compound stability does not consider the use of cohesion in calculations.**

Design Summary Table
Design 4
20' over 25' Tiered Walls with 25' 2:1 Slope Offset

Design for Both Walls in Tiered Condition

Structure Geometry				
	Total Height	60' Total Height Upper Wall – (20' Exposed with 8' Embedment) Lower Wall - (25' Exposed with 5' Embedment)		
	Tiered Condition	25' Offset – 10' 2:1 Separation Slope Between Walls		
	Crest Condition	30' 2:1 Ascending Slope		
	Minimum Length/Height Ratio	Tiered Wall - 55'/60' (0.92) Lower Wall – 55'/30' (1.83) Upper Wall – 35'/28' (1.25)		
Geotechnical Parameters		**Reinforced**	**Retained**	**Foundation**
	Friction angle, φ, degrees	32	28	28
	Dry Unit Weight, γ_d, pcf	120	120	120
	Cohesion, c, psf	500*	500*	500
	Seismic acceleration, g	0.36g		
Global Stability		**Per Geotechnical Engineer of Record**		

*** Note: Cohesion within the reinforced and retained soil zones is conservatively ignored within the analysis.**

Minimum Factor of Safety

		FS, Static		**FS, Seismic**	
External Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.77	≥1.5	1.25	≥1.1
	Overturning	4.00	≥2.0	2.63	≥1.5
	Bearing Capacity/Settlement	8.50	≥2.0	5.71	≥1.5
	Compound Stability	1.55	≥1.5	**Min 1.1 thru Geogrid Zone	≥1.1
Internal Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.66	≥1.5	1.18	≥1.1
	Pullout	3.42	≥1.5	2.08	≥1.1
	Geogrid Strength	1.84	≥1.5	1.58	≥1.1
Local Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Geogrid to Block Connection	1.55	≥1.5	1.20	≥1.1

**** Safety factor in output is shown for slope area above the wall. This condition is outside the purview of a wall designer; however, consider that compound stability does not consider the use of cohesion in calculations.**

Design Summary Table
Design 5
19' over 19' Tiered Walls with 20' 2:1 Slope Offset

Design for Both Walls in Tiered Condition

Structure Geometry				
	Total Height	47' Total Height Upper Wall – (19' Exposed with 3' Embedment) Lower Wall - (19' Exposed with 3' Embedment)		
	Tiered Condition	20' Offset – 6' 2:1 Separation Slope Between Walls		
	Crest Condition	5' 2:1 Ascending Slope		
	Minimum Length/Height Ratio	Tiered Wall - 40'/47' (0.85) Lower Wall – 40'/22' (1.82) Upper Wall – 22'/22' (1.00)		
Geotechnical Parameters		**Reinforced**	**Retained**	**Foundation**
	Friction angle, φ, degrees	32	28	28
	Dry Unit Weight, γ_d, pcf	120	120	120
	Cohesion, c, psf	500*	500*	500
	Seismic acceleration, g	0.36g		
Global Stability		**Per Geotechnical Engineer of Record**		

*** Note: Cohesion within the reinforced and retained soil zones is conservatively ignored within the analysis.**

Minimum Factor of Safety

		FS, Static		**FS, Seismic**	
External Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	2.00	≥1.5	1.39	≥1.1
	Overturning	4.36	≥2.0	2.83	≥1.5
	Bearing Capacity/Settlement	9.64	≥2.0	7.04	≥1.5
	Compound Stability	1.69	≥1.5	1.11	≥1.1
Internal Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.81	≥1.5	1.27	≥1.1
	Pullout	3.72	≥1.5	2.00	≥1.1
	Geogrid Strength	1.60	≥1.5	1.28	≥1.1
Local Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Geogrid to Block Connection	1.55	≥1.5	1.16	≥1.1

Design Summary Table
Design 6
20' over 20' Tiered Walls with 25'Offset

Design for Lower Two Walls in Four-Tiered Condition

Structure Geometry				
	Total Height	54' Total Height Upper Wall – (20' Exposed with 8' Embedment) Lower Wall - (20' Exposed with 4' Embedment)		
	Tiered Condition	25' Offset – 10' 2:1 Separation Slope Between Walls		
	Crest Condition	10' 2:1 Ascending Slope with 3,352 psf Surcharge Load for Upper Two Walls and Slopes		
	Minimum Length/Height Ratio	Tiered Wall - 60'/54' (1.11) Lower Wall – 60'/24' (2.50) Upper Wall – 40'/28' (1.43)		
Geotechnical Parameters		**Reinforced**	**Retained**	**Foundation**
	Friction angle, φ, degrees	32	28	28
	Dry Unit Weight, γ_d, pcf	120	120	120
	Cohesion, c, psf	500*	500*	500
	Seismic acceleration, g	0.36g		
Global Stability		**Per Geotechnical Engineer of Record**		

*** Note: Cohesion within the reinforced and retained soil zones is conservatively ignored within the analysis.**

Minimum Factor of Safety

		FS, Static		**FS, Seismic**	
External Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.77	≥1.5	1.44	≥1.1
	Overturning	3.99	≥2.0	3.33	≥1.5
	Bearing Capacity/Settlement	9.82	≥2.0	8.52	≥1.5
	Compound Stability	1.62	≥1.5	1.20	≥1.1
Internal Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.66	≥1.5	1.36	≥1.1
	Pullout	2.39	≥1.5	1.21	≥1.1
	Geogrid Strength	1.96	≥1.5	1.65	≥1.1
Local Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Geogrid to Block Connection	1.61	≥1.5	1.19	≥1.1

Design Summary Table
Design 7
11' over 20' Tiered Walls with 25'Offset

Design for Middle Two Walls in Four-Tiered Condition

Structure Geometry				
	Total Height	49' Total Height Upper Wall – (11' Exposed with 5' Embedment) Lower Wall - (20' Exposed with 8' Embedment)		
	Tiered Condition	25' Offset – 10' 2:1 Separation Slope Between Walls		
	Crest Condition	Level Crest with 20-ft Offset to 1,800 psf Surcharge Load for 15-ft Wall and Slope		
	Minimum Length/Height Ratio	Tiered Wall - 40'/49' (0.82) Lower Wall – 40'/28' (1.43) Upper Wall – 35'/15' (2.33)		
Geotechnical Parameters		**Reinforced**	**Retained**	**Foundation**
	Friction angle, φ, degrees	32	28	28
	Dry Unit Weight, γ_d, pcf	120	120	120
	Cohesion, c, psf	500*	500*	500
	Seismic acceleration, g	0.36g		
Global Stability		**Per Geotechnical Engineer of Record**		

*** Note: Cohesion within the reinforced and retained soil zones is conservatively ignored within the analysis.**

Minimum Factor of Safety

		FS, Static		**FS, Seismic**	
External Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.82	≥1.5	1.46	≥1.1
	Overturning	3.93	≥2.0	3.09	≥1.5
	Bearing Capacity/Settlement	7.92	≥2.0	6.54	≥1.5
	Compound Stability	1.65	≥1.5	1.15	≥1.1
Internal Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.66	≥1.5	1.34	≥1.1
	Pullout	29.2	≥1.5	5.28	≥1.1
	Geogrid Strength	1.62	≥1.5	1.32	≥1.1
Local Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Geogrid to Block Connection	1.52	≥1.5	1.17	≥1.1

Design Summary Table
Design 8
15' over 11' Tiered Walls with 20'Offset

Design for Upper Two Walls in Four-Tiered Condition

Structure Geometry				
	Total Height	31' Total Height Upper Wall – (15' Exposed with 1' Embedment) Lower Wall - (11' Exposed with 5' Embedment)		
	Tiered Condition	20' Offset – Trail Access		
	Crest Condition	15' 2:1 Ascending Slope (Actual Slope Setback of 20')		
	Minimum Length/Height Ratio	Tiered Wall - 35'/33' (1.06) Lower Wall – 35'/18' (1.94) Upper Wall – 15'/16' (0.94)		
Geotechnical Parameters		**Reinforced**	**Retained**	**Foundation**
	Friction angle, φ, degrees	32	28	28
	Dry Unit Weight, γ_d, pcf	120	120	120
	Cohesion, c, psf	500*	500*	500
	Seismic acceleration, g	0.36g		
Global Stability		**Per Geotechnical Engineer of Record**		

*** Note: Cohesion within the reinforced and retained soil zones is conservatively ignored within the analysis.**

Minimum Factor of Safety

		FS, Static		**FS, Seismic**	
External Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	2.00	≥1.5	1.77	≥1.1
	Overturning	5.51	≥2.0	5.07	≥1.5
	Bearing Capacity/Settlement	14.41	≥2.0	15.14	≥1.5
	Compound Stability	1.69	≥1.5	1.11	≥1.1
Internal Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Sliding	1.81	≥1.5	1.61	≥1.1
	Pullout	3.10	≥1.5	1.96	≥1.1
	Geogrid Strength	1.72	≥1.5	1.49	≥1.1
Local Stability		**Actual FS**	**Target FS**	**Actual FS**	**Target FS**
	Geogrid to Block Connection	2.24	≥1.5	1.62	≥1.1

Appendix

Verdura® Retaining Wall Design Calculations

(100 Pages)

AASHTO 2002 ASD DESIGN METHOD
Portola Center - TTM 17300

MSEW(3.0): Update # 14.3

PROJECT IDENTIFICATION

Title: Portola Center - TTM 17300
Project Number: 0704 034B
Client: USA Portola Properties, LLC
Designer: DAO
Station Number: DESIGN 1

Description:

15 ft Total Height - Single Wall - 30 ft 2:1 Ascending Slope at Crest

Company's information:

Name: Soil Retention Designs, Inc.
Street: 2501 State Street

Carlsbad, CA 92008
Telephone #: 760-966-6090
Fax #: 760-966-6099
E-Mail: dosborne@soilretention.com

Original file path and name: C:\Users\dosborne\Desktop\Portola North Rev Design\Upda.....
.....pe - Single Wall.BEN
Original date and time of creating this file: Mon Nov 29 16:13:17 2010

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	28.0 °
Equivalent cohesion, $c_{equiv.}$	500.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2210 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 44.10° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.4206 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 25.80 N γ= 16.72

SEISMICITY

Maximum ground acceleration coefficient, A = 0.360
Design acceleration coefficient in Internal Stability: Kh = Am = 0.392
Design acceleration coefficient in External Stability: Kh_d = 0.175 => Kh = Am = 0.175
(Kh in External Stability is based on allowable displacement, d = 75 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.8349 Kae (Kh = 0) = 0.4206 Δ Kae = 0.4143
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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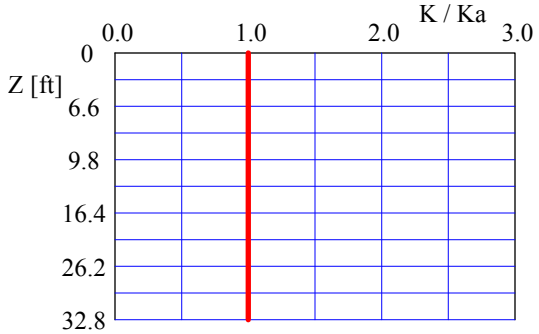
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3590.0	6230.0	8300.0	12420.0	
Durability reduction factor, RFd	1.10	1.10	1.10	1.10	
Installation-damage reduction factor, RFid	1.11	1.10	1.10	1.10	
Creep reduction factor, RFc	1.67	1.67	1.67	1.67	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	1.000	
Friction angle along geogrid-soil interface, ρ	29.40	29.40	29.40	29.40	
Pullout resistance factor, F*	0.90·tarϕ	0.90·tanþ	0.90·tanþ	0.90·tanþ	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Note: Z for calculating K/Ka and F* is measured from top of the wall at the face (AASHTO).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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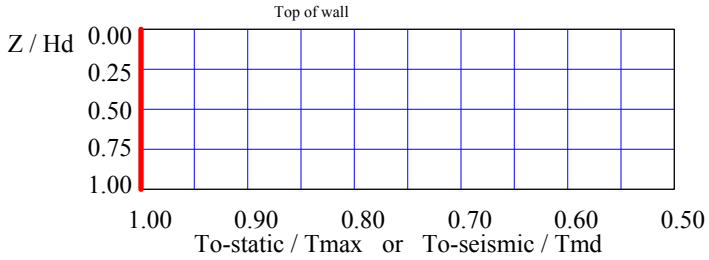
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.00/0.67 ft. Horizontal distance to Center of Gravity of block is 0.42 ft.
Average unit weight of block is γ_f = 117.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	V40 - 5XT	V40 - 8XT	V40 - 10XT	V40 - 20XT	N/A
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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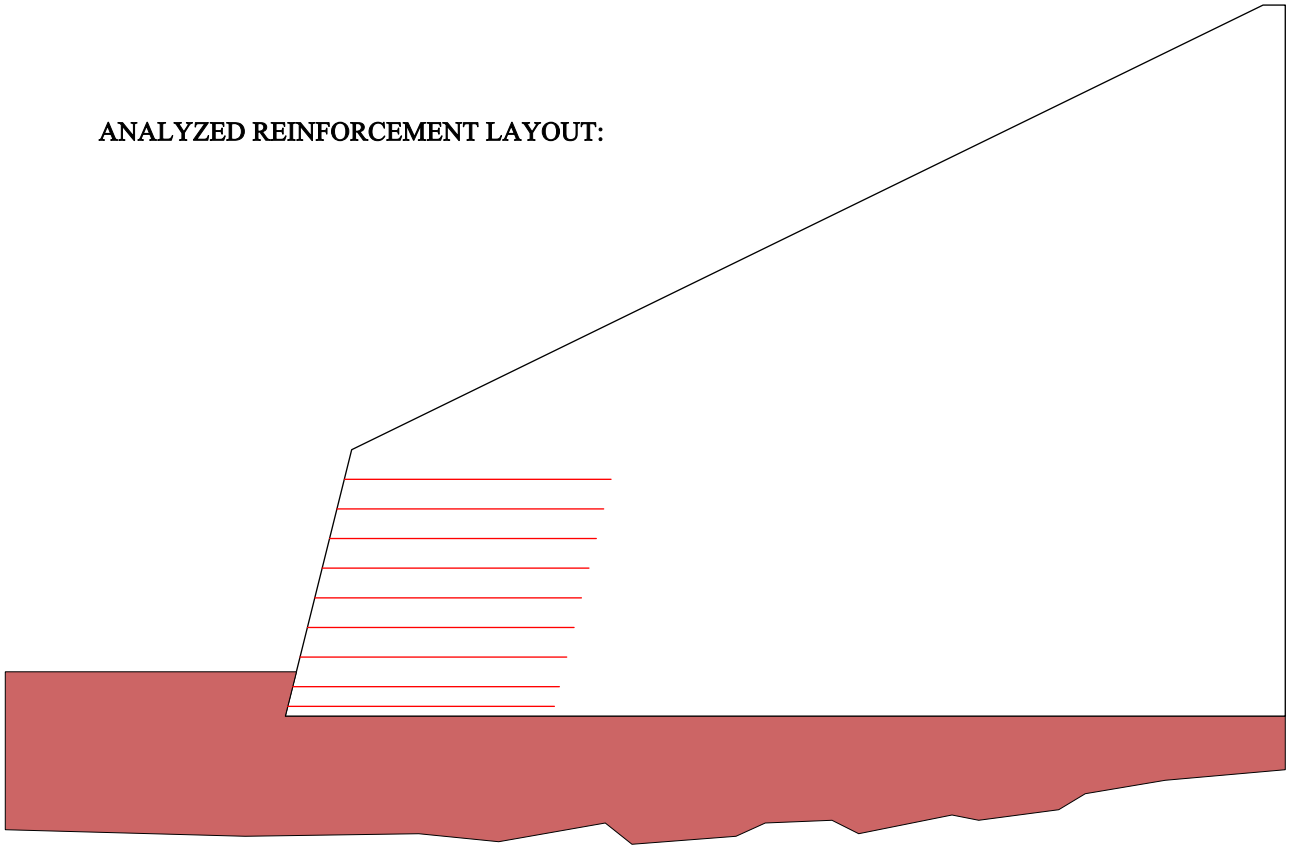
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	18.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 15.00 ft }
Batter, ω	14.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	30.0	[ft]	Broken back equivalent angle, I = 26.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 11.72, Meyerhof stress = 2611 lb/ft².
Foundation Interface: Direct sliding, Fs = 2.099, Eccentricity, e/L = -0.0099, Fs-overturning = 4.76

GEOGRID				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	18.00	2	5.57	4.27	4.268	47.757	1.932	-0.0138	V40 - 8XT
2	2.00	18.00	2	4.82	3.69	3.694	38.676	2.013	-0.0212	V40 - 8XT
3	4.00	18.00	2	4.44	3.41	3.405	30.911	2.147	-0.0319	V40 - 8XT
4	6.00	18.00	2	4.89	3.86	3.857	28.887	2.295	-0.0423	V40 - 8XT
5	8.00	18.00	2	5.38	4.45	4.447	26.878	2.461	-0.0526	V40 - 8XT
6	10.00	18.00	1	5.45	3.00	2.998	24.917	2.643	-0.0637	V40 - 5XT
7	12.00	18.00	1	6.65	3.66	3.659	23.079	2.841	-0.0767	V40 - 5XT
8	14.00	18.00	1	8.53	4.69	4.694	21.438	3.047	-0.0937	V40 - 5XT
9	16.00	18.00	1	8.79	4.84	4.840	14.962	3.234	-0.1196	V40 - 5XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 8.21, Meyerhof stress = 3343 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.383, Eccentricity, e/L = 0.0900, Fs-overturning = 2.76

GEOGRID				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	18.00	2	1.62	1.74	1.739	11.141	1.283	0.0792	V40 - 8XT
2	2.00	18.00	2	1.62	1.69	1.691	10.393	1.360	0.0587	V40 - 8XT
3	4.00	18.00	2	1.68	1.71	1.713	9.335	1.494	0.0301	V40 - 8XT
4	6.00	18.00	2	1.83	1.93	1.928	8.651	1.655	0.0041	V40 - 8XT
5	8.00	18.00	2	1.99	2.20	2.204	7.963	1.852	-0.0198	V40 - 8XT
6	10.00	18.00	1	1.99	1.47	1.468	7.276	2.094	-0.0421	V40 - 5XT
7	12.00	18.00	1	2.38	1.76	1.763	6.602	2.390	-0.0641	V40 - 5XT
8	14.00	18.00	1	2.95	2.20	2.205	5.943	2.743	-0.0879	V40 - 5XT
9	16.00	18.00	1	3.50	2.54	2.540	4.764	3.116	-0.1180	V40 - 5XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.721
(it corresponds to a critical circle at Xc = -8.00, Yc = 88.00 and R = 88.36 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.221
(it corresponds to a critical circle at Xc = -20.00, Yc = 136.00 and R = 137.46 [ft]).

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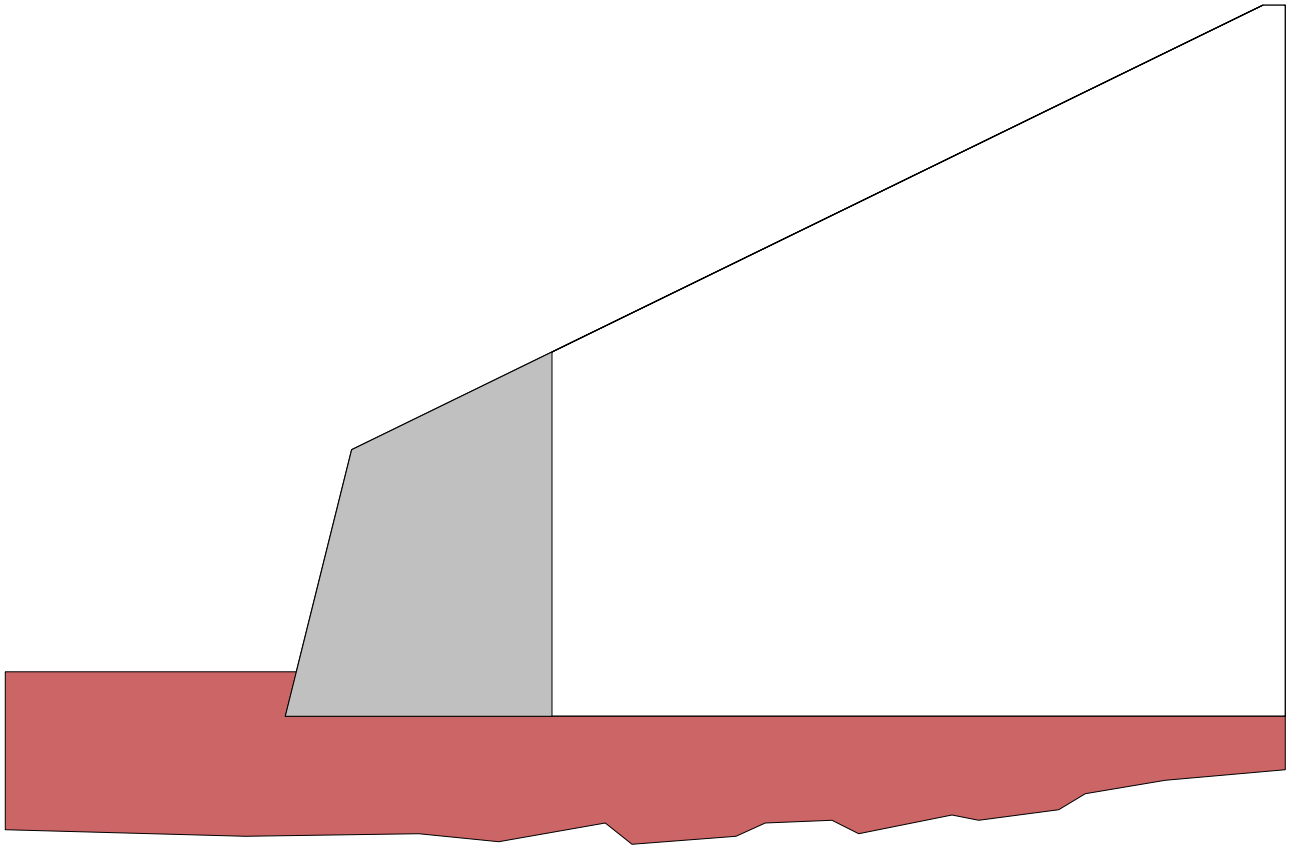
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	30600	27440	[lb/ft ²]
Meyerhof stress, σ_V	2610.7	3343	[lb/ft ²]
Eccentricity, e	-0.18	1.75	[ft]
Eccentricity, e/L	-0.010	0.097	
Fs calculated	11.72	8.21	
Base length	18.00	18.00	[ft]



SCALE:

0 2 4 6 8 10 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.099 and Fs-seismic = 1.383

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	18.00	1.932	1.283	2	V40 - 8XT
2	2.00	18.00	2.013	1.360	2	V40 - 8XT
3	4.00	18.00	2.147	1.494	2	V40 - 8XT
4	6.00	18.00	2.295	1.655	2	V40 - 8XT
5	8.00	18.00	2.461	1.852	2	V40 - 8XT
6	10.00	18.00	2.643	2.094	1	V40 - 5XT
7	12.00	18.00	2.841	2.390	1	V40 - 5XT
8	14.00	18.00	3.047	2.743	1	V40 - 5XT
9	16.00	18.00	3.234	3.116	1	V40 - 5XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = -0.0099, e/L seismic = 0.0900; Overturning: Fs-static = 4.76, Fs-seismic = 2.76

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	18.00	-0.0138	0.0792	2	V40 - 8XT
2	2.00	18.00	-0.0212	0.0587	2	V40 - 8XT
3	4.00	18.00	-0.0319	0.0301	2	V40 - 8XT
4	6.00	18.00	-0.0423	0.0041	2	V40 - 8XT
5	8.00	18.00	-0.0526	-0.0198	2	V40 - 8XT
6	10.00	18.00	-0.0637	-0.0421	1	V40 - 5XT
7	12.00	18.00	-0.0767	-0.0641	1	V40 - 5XT
8	14.00	18.00	-0.0937	-0.0879	1	V40 - 5XT
9	16.00	18.00	-0.1196	-0.1180	1	V40 - 5XT

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Tavailable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.67	3083	722.33	1754.77	N/A	4.268	N/A	1.739	V40 - 8XT
2	2.00	3083	834.66	1650.27	N/A	3.694	N/A	1.691	V40 - 8XT
3	4.00	3083	905.41	1493.11	N/A	3.405	N/A	1.713	V40 - 8XT
4	6.00	3083	799.34	1335.95	N/A	3.857	N/A	1.928	V40 - 8XT
5	8.00	3083	693.28	1178.80	N/A	4.447	N/A	2.204	V40 - 8XT
6	10.00	1761	587.21	1021.64	N/A	2.998	N/A	1.468	V40 - 5XT
7	12.00	1761	481.15	864.48	N/A	3.659	N/A	1.763	V40 - 5XT
8	14.00	1761	375.08	707.33	N/A	4.694	N/A	2.205	V40 - 5XT
9	16.00	1761	363.75	550.17	N/A	4.840	N/A	2.540	V40 - 5XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic Fs	Actual Seismic Fs
1	0.67	1.000	722.3	1754.8	17.48	0.52	34496.0	N/A	47.757	27596.8	N/A	11.141
2	2.00	1.000	834.7	1650.3	16.43	1.57	32280.9	N/A	38.676	25824.7	N/A	10.393
3	4.00	1.000	905.4	1493.1	14.87	3.13	27987.2	N/A	30.911	22389.7	N/A	9.335
4	6.00	1.000	799.3	1336.0	13.30	4.70	23090.7	N/A	28.887	18472.6	N/A	8.651
5	8.00	1.000	693.3	1178.8	11.74	6.26	18633.8	N/A	26.878	14907.0	N/A	7.963
6	10.00	1.000	587.2	1021.6	10.17	7.83	14631.5	N/A	24.917	11705.2	N/A	7.276
7	12.00	1.000	481.1	864.5	8.61	9.39	11104.2	N/A	23.079	8883.4	N/A	6.602
8	14.00	1.000	375.1	707.3	7.04	10.96	8041.2	N/A	21.438	6432.9	N/A	5.943
9	16.00	1.000	363.8	550.2	5.48	12.52	5442.4	N/A	14.962	4353.9	N/A	4.764

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	722	0.71	0.71	4021	3083	N/A	5.57	N/A	4.27	V40 - 8XT
2	2.00	835	0.71	0.71	4021	3083	N/A	4.82	N/A	3.69	V40 - 8XT
3	4.00	905	0.71	0.71	4021	3083	N/A	4.44	N/A	3.41	V40 - 8XT
4	6.00	799	0.69	0.69	3913	3083	N/A	4.89	N/A	3.86	V40 - 8XT
5	8.00	693	0.66	0.66	3733	3083	N/A	5.38	N/A	4.45	V40 - 8XT
6	10.00	587	0.98	0.98	3198	1761	N/A	5.45	N/A	3.00	V40 - 5XT
7	12.00	481	0.98	0.98	3198	1761	N/A	6.65	N/A	3.66	V40 - 5XT
8	14.00	375	0.98	0.98	3198	1761	N/A	8.53	N/A	4.69	V40 - 5XT
9	16.00	364	0.98	0.98	3198	1761	N/A	8.79	N/A	4.84	V40 - 5XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	2477	0.71	0.71	4021	3083	N/A	1.62	N/A	1.74	V40 - 8XT
2	2.00	2485	0.71	0.71	4021	3083	N/A	1.62	N/A	1.69	V40 - 8XT
3	4.00	2399	0.71	0.71	4021	3083	N/A	1.68	N/A	1.71	V40 - 8XT
4	6.00	2135	0.69	0.69	3913	3083	N/A	1.83	N/A	1.93	V40 - 8XT
5	8.00	1872	0.66	0.66	3733	3083	N/A	1.99	N/A	2.20	V40 - 8XT
6	10.00	1609	0.98	0.98	3198	1761	N/A	1.99	N/A	1.47	V40 - 5XT
7	12.00	1346	0.98	0.98	3198	1761	N/A	2.38	N/A	1.76	V40 - 5XT
8	14.00	1082	0.98	0.98	3198	1761	N/A	2.95	N/A	2.20	V40 - 5XT
9	16.00	914	0.98	0.98	3198	1761	N/A	3.50	N/A	2.54	V40 - 5XT

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GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.180 has been applied.
The seismic force is applied at the center of the sliding mass.

STATIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.721
(it corresponds to a critical circle at Xc = -8.00, Yc = 88.00 and R = 88.36 [ft] where (x=0, y=0) is taken at the TOE or Xc = 67.00, Yc = 1088.00 and R = 88.36 [ft] when the terrain coordinate system is used as shown in the table below.)

SEISMIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.221
(it corresponds to a critical circle at Xc = -20.00, Yc = 136.00 and R = 137.46 [ft] where (x=0, y=0) is taken at the TOE or Xc = 55.00, Yc = 1136.00 and R = 137.46 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Soil layer #1:	γ = 120.00 [lb/ft ³]			ϕ = 28.0°		c = 500.00 [lb/ft ²]					
x [ft]	0.0	10.0	15.0	20.0	50.0	95.0	115.0	150.0	200.0	275.0	300.0
y [ft]	1003.0	1003.0	1003.0	1003.0	1003.0	1000.0	1035.0	1050.0	1050.0	1050.0	1050.0

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AASHTO 2002 ASD DESIGN METHOD
Portola Center - TTM 17300

MSEW(3.0): Update # 14.3

PROJECT IDENTIFICATION

Title: Portola Center - TTM 17300
Project Number: 0704 034B
Client: USA Portola Properties, LLC
Designer: DAO
Station Number: DESIGN 2

Description:

30 ft Total Height - Single Wall - 30 ft 2:1 Ascending Slope at Crest

Company's information:

Name: Soil Retention Designs, Inc.
Street: 2501 State Street

Carlsbad, CA 92008
Telephone #: 760-966-6090
Fax #: 760-966-6099
E-Mail: dosborne@soilretention.com

Original file path and name: C:\Users\dosborne\Desktop\Portola North Rev Design\Upda.....
.....pe - Single Wall.BEN

Original date and time of creating this file: Mon Nov 29 16:13:17 2010

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	28.0 °
Equivalent cohesion, $c_{equiv.}$	500.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2210 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 44.10° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3555 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 25.80 N γ= 16.72

SEISMICITY

Maximum ground acceleration coefficient, A = 0.360
Design acceleration coefficient in Internal Stability: Kh = Am = 0.392
Design acceleration coefficient in External Stability: Kh_d = 0.175 => Kh = Am = 0.175
(Kh in External Stability is based on allowable displacement, d = 75 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.8189 Kae (Kh = 0) = 0.3555 Δ Kae = 0.4633
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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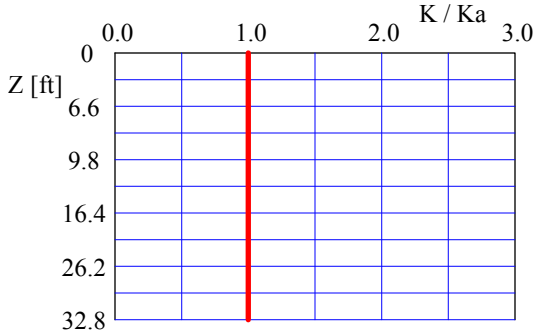
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3590.0	6230.0	8300.0	12420.0	
Durability reduction factor, RFd	1.10	1.10	1.10	1.10	
Installation-damage reduction factor, RFid	1.11	1.10	1.10	1.10	
Creep reduction factor, RFc	1.67	1.67	1.67	1.67	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	1.000	
Friction angle along geogrid-soil interface, ρ	29.40	29.40	29.40	29.40	
Pullout resistance factor, F*	0.90·tarϕ	0.90·tanϕ	0.90·tanϕ	0.90·tanϕ	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Note: Z for calculating K/Ka and F* is measured from top of the wall at the face (AASHTO).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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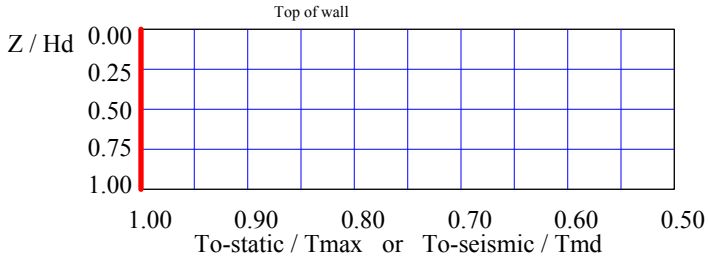
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.00/0.67 ft. Horizontal distance to Center of Gravity of block is 0.42 ft.
Average unit weight of block is γ_f = 117.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	V40 - 5XT	V40 - 8XT	V40 - 10XT	V40 - 20XT	N/A
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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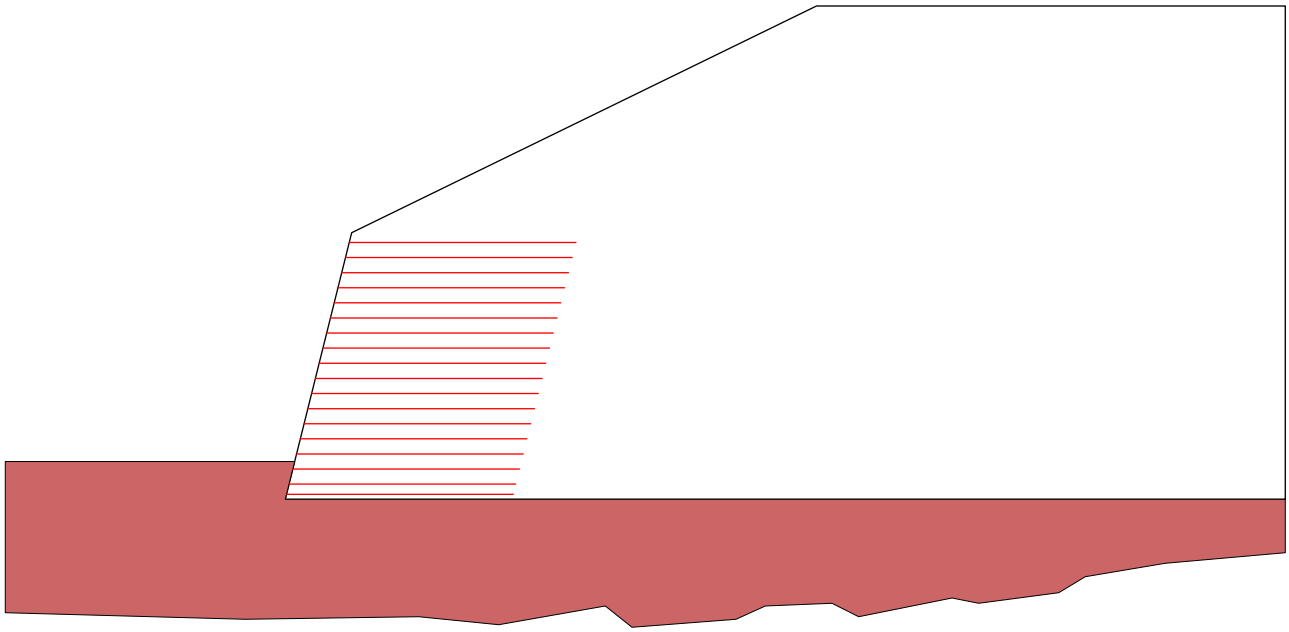
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	35.30	[ft]	{ Embedded depth is E = 5.00 ft, and height above top of finished bottom grade is H = 30.30 ft }
Batter, ω	14.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	30.0	[ft]	Broken back equivalent angle, I = 23.02° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 10 15 20 25 30 [ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 9.04, Meyerhof stress = 4705 lb/ft².
Foundation Interface: Direct sliding, Fs = 2.123, Eccentricity, e/L = 0.0077, Fs-overturning = 4.30

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	30.00	4	4.94	4.27	4.270	75.034	1.938	0.0053	V40 - 20XT
2	2.00	30.00	4	4.11	3.56	3.555	60.604	1.984	0.0005	V40 - 20XT
3	4.00	30.00	4	3.59	3.11	3.105	50.021	2.058	-0.0063	V40 - 20XT
4	6.00	30.00	4	3.80	3.28	3.281	49.164	2.136	-0.0129	V40 - 20XT
5	8.00	30.00	4	4.02	3.48	3.478	47.575	2.220	-0.0191	V40 - 20XT
6	10.00	30.00	4	4.28	3.70	3.700	45.320	2.309	-0.0252	V40 - 20XT
7	12.00	30.00	4	4.57	3.95	3.952	43.023	2.403	-0.0310	V40 - 20XT
8	14.00	30.00	4	4.91	4.24	4.241	40.711	2.504	-0.0368	V40 - 20XT
9	16.00	30.00	4	5.30	4.58	4.576	38.380	2.612	-0.0425	V40 - 20XT
10	18.00	30.00	2	3.25	2.49	2.492	36.025	2.727	-0.0484	V40 - 8XT
11	20.00	30.00	2	3.56	2.73	2.726	33.640	2.849	-0.0544	V40 - 8XT
12	22.00	30.00	2	3.92	3.01	3.008	31.216	2.978	-0.0610	V40 - 8XT
13	24.00	30.00	2	4.19	3.36	3.355	28.738	3.113	-0.0682	V40 - 8XT
14	26.00	30.00	2	4.51	3.79	3.793	26.219	3.254	-0.0765	V40 - 8XT
15	28.00	30.00	2	4.94	4.36	4.363	23.561	3.397	-0.0866	V40 - 8XT
16	30.00	30.00	2	5.51	5.13	5.133	20.739	3.536	-0.0994	V40 - 8XT
17	32.00	30.00	2	6.33	6.23	6.234	17.648	3.660	-0.1165	V40 - 8XT
18	34.00	30.00	2	6.74	7.04	7.045	12.487	3.749	-0.1410	V40 - 8XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 4.32, Meyerhof stress = 7544 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.233, Eccentricity, e/L = 0.1641, Fs-overturning = 2.09

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	30.00	4	1.31	1.61	1.606	15.916	1.130	0.1559	V40 - 20XT
2	2.00	30.00	4	1.28	1.52	1.524	15.030	1.167	0.1402	V40 - 20XT
3	4.00	30.00	4	1.27	1.48	1.479	14.106	1.228	0.1175	V40 - 20XT
4	6.00	30.00	4	1.34	1.57	1.566	13.908	1.295	0.0961	V40 - 20XT
5	8.00	30.00	4	1.43	1.67	1.665	13.507	1.369	0.0758	V40 - 20XT
6	10.00	30.00	4	1.53	1.78	1.777	12.920	1.452	0.0567	V40 - 20XT
7	12.00	30.00	4	1.64	1.91	1.906	12.322	1.545	0.0388	V40 - 20XT
8	14.00	30.00	4	1.77	2.05	2.054	11.722	1.650	0.0219	V40 - 20XT
9	16.00	30.00	4	1.92	2.23	2.227	11.120	1.769	0.0059	V40 - 20XT
10	18.00	30.00	2	1.19	1.22	1.220	10.515	1.903	-0.0092	V40 - 8XT
11	20.00	30.00	2	1.31	1.34	1.344	9.905	2.058	-0.0235	V40 - 8XT
12	22.00	30.00	2	1.46	1.50	1.496	9.291	2.234	-0.0374	V40 - 8XT
13	24.00	30.00	2	1.58	1.69	1.687	8.668	2.437	-0.0509	V40 - 8XT
14	26.00	30.00	2	1.73	1.93	1.933	8.045	2.669	-0.0647	V40 - 8XT
15	28.00	30.00	2	1.94	2.26	2.263	7.395	2.930	-0.0791	V40 - 8XT
16	30.00	30.00	2	2.23	2.73	2.730	6.718	3.213	-0.0953	V40 - 8XT
17	32.00	30.00	2	2.68	3.44	3.440	5.991	3.495	-0.1149	V40 - 8XT
18	34.00	30.00	2	3.29	4.33	4.327	4.875	3.715	-0.1407	V40 - 8XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.575
(it corresponds to a critical circle at Xc = -8.00, Yc = 100.00 and R = 100.32 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.122
(it corresponds to a critical circle at Xc = -20.00, Yc = 148.00 and R = 149.35 [ft]).

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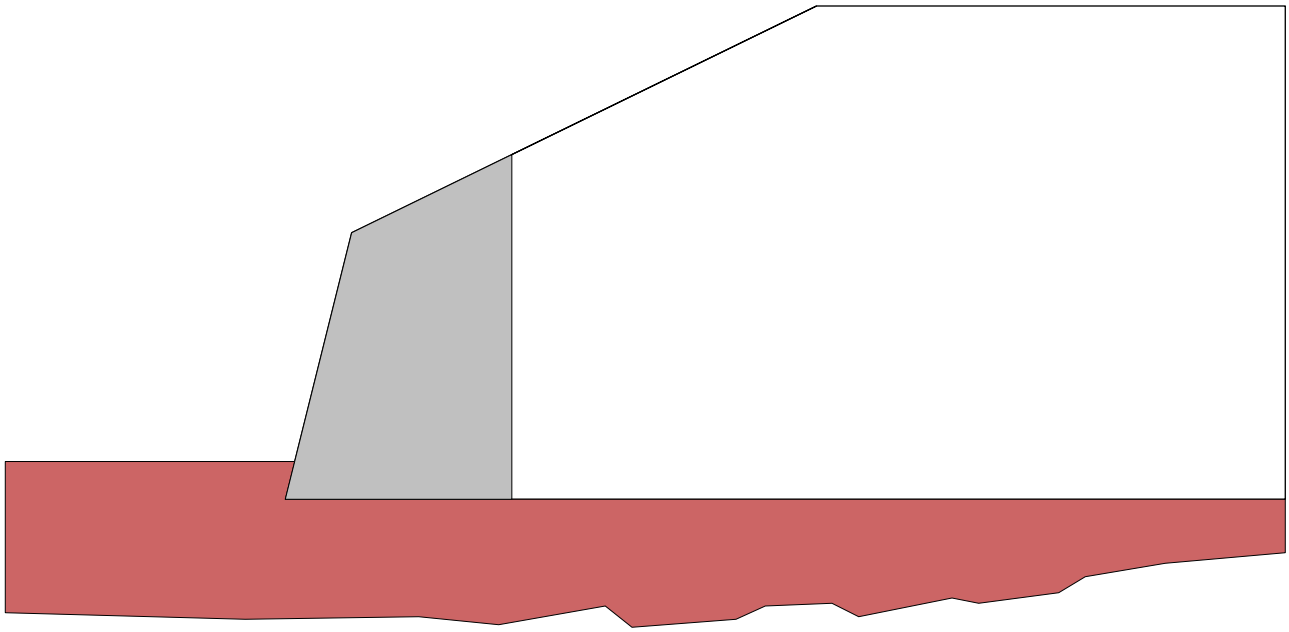
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	42527	32595	[lb/ft ²]
Meyerhof stress, σ_V	4705.0	7544	[lb/ft ²]
Eccentricity, e	0.23	5.18	[ft]
Eccentricity, e/L	0.008	0.173	
Fs calculated	9.04	4.32	
Base length	30.00	30.00	[ft]



SCALE:

0 5 10 15 20 25 30 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.123 and Fs-seismic = 1.233

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	30.00	1.938	1.130	4	V40 - 20XT
2	2.00	30.00	1.984	1.167	4	V40 - 20XT
3	4.00	30.00	2.058	1.228	4	V40 - 20XT
4	6.00	30.00	2.136	1.295	4	V40 - 20XT
5	8.00	30.00	2.220	1.369	4	V40 - 20XT
6	10.00	30.00	2.309	1.452	4	V40 - 20XT
7	12.00	30.00	2.403	1.545	4	V40 - 20XT
8	14.00	30.00	2.504	1.650	4	V40 - 20XT
9	16.00	30.00	2.612	1.769	4	V40 - 20XT
10	18.00	30.00	2.727	1.903	2	V40 - 8XT
11	20.00	30.00	2.849	2.058	2	V40 - 8XT
12	22.00	30.00	2.978	2.234	2	V40 - 8XT
13	24.00	30.00	3.113	2.437	2	V40 - 8XT
14	26.00	30.00	3.254	2.669	2	V40 - 8XT
15	28.00	30.00	3.397	2.930	2	V40 - 8XT
16	30.00	30.00	3.536	3.213	2	V40 - 8XT
17	32.00	30.00	3.660	3.495	2	V40 - 8XT
18	34.00	30.00	3.749	3.715	2	V40 - 8XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0077, e/L seismic = 0.1641; Overturning: Fs-static = 4.30, Fs-seismic = 2.09

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	30.00	0.0053	0.1559	4	V40 - 20XT
2	2.00	30.00	0.0005	0.1402	4	V40 - 20XT
3	4.00	30.00	-0.0063	0.1175	4	V40 - 20XT
4	6.00	30.00	-0.0129	0.0961	4	V40 - 20XT
5	8.00	30.00	-0.0191	0.0758	4	V40 - 20XT
6	10.00	30.00	-0.0252	0.0567	4	V40 - 20XT
7	12.00	30.00	-0.0310	0.0388	4	V40 - 20XT
8	14.00	30.00	-0.0368	0.0219	4	V40 - 20XT
9	16.00	30.00	-0.0425	0.0059	4	V40 - 20XT
10	18.00	30.00	-0.0484	-0.0092	2	V40 - 8XT
11	20.00	30.00	-0.0544	-0.0235	2	V40 - 8XT
12	22.00	30.00	-0.0610	-0.0374	2	V40 - 8XT
13	24.00	30.00	-0.0682	-0.0509	2	V40 - 8XT
14	26.00	30.00	-0.0765	-0.0647	2	V40 - 8XT
15	28.00	30.00	-0.0866	-0.0791	2	V40 - 8XT
16	30.00	30.00	-0.0994	-0.0953	2	V40 - 8XT
17	32.00	30.00	-0.1165	-0.1149	2	V40 - 8XT
18	34.00	30.00	-0.1410	-0.1407	2	V40 - 8XT

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Tavailable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.67	6146	1439.28	3988.86	N/A	4.270	N/A	1.606	V40 - 20XT
2	2.00	6146	1728.83	3848.01	N/A	3.555	N/A	1.524	V40 - 20XT
3	4.00	6146	1979.49	3636.21	N/A	3.105	N/A	1.479	V40 - 20XT
4	6.00	6146	1873.42	3424.41	N/A	3.281	N/A	1.566	V40 - 20XT
5	8.00	6146	1767.36	3212.61	N/A	3.478	N/A	1.665	V40 - 20XT
6	10.00	6146	1661.29	3000.80	N/A	3.700	N/A	1.777	V40 - 20XT
7	12.00	6146	1555.23	2789.00	N/A	3.952	N/A	1.906	V40 - 20XT
8	14.00	6146	1449.16	2577.20	N/A	4.241	N/A	2.054	V40 - 20XT
9	16.00	6146	1343.10	2365.40	N/A	4.576	N/A	2.227	V40 - 20XT
10	18.00	3083	1237.03	2153.59	N/A	2.492	N/A	1.220	V40 - 8XT
11	20.00	3083	1130.97	1941.79	N/A	2.726	N/A	1.344	V40 - 8XT
12	22.00	3083	1024.90	1729.99	N/A	3.008	N/A	1.496	V40 - 8XT
13	24.00	3083	918.84	1518.19	N/A	3.355	N/A	1.687	V40 - 8XT
14	26.00	3083	812.77	1306.39	N/A	3.793	N/A	1.933	V40 - 8XT
15	28.00	3083	706.71	1094.58	N/A	4.363	N/A	2.263	V40 - 8XT
16	30.00	3083	600.64	882.78	N/A	5.133	N/A	2.730	V40 - 8XT
17	32.00	3083	494.58	670.98	N/A	6.234	N/A	3.440	V40 - 8XT
18	34.00	3083	437.64	459.18	N/A	7.045	N/A	4.327	V40 - 8XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic Fs	Actual Seismic Fs
1	0.67	1.000	1439.3	3988.9	29.48	0.52	107994.9	N/A	75.034	86396.0	N/A	15.916
2	2.00	1.000	1728.8	3848.0	28.43	1.57	104774.1	N/A	60.604	83819.3	N/A	15.030
3	4.00	1.000	1979.5	3636.2	26.87	3.13	99016.3	N/A	50.021	79213.0	N/A	14.106
4	6.00	1.000	1873.4	3424.4	25.30	4.70	92104.6	N/A	49.164	73683.7	N/A	13.908
5	8.00	1.000	1767.4	3212.6	23.74	6.26	84082.9	N/A	47.575	67266.3	N/A	13.507
6	10.00	1.000	1661.3	3000.8	22.17	7.83	75290.1	N/A	45.320	60232.1	N/A	12.920
7	12.00	1.000	1555.2	2789.0	20.61	9.39	66910.7	N/A	43.023	53528.6	N/A	12.322
8	14.00	1.000	1449.2	2577.2	19.04	10.96	58996.6	N/A	40.711	47197.3	N/A	11.722
9	16.00	1.000	1343.1	2365.4	17.48	12.52	51547.8	N/A	38.380	41238.3	N/A	11.120
10	18.00	1.000	1237.0	2153.6	15.91	14.09	44564.3	N/A	36.025	35651.4	N/A	10.515
11	20.00	1.000	1131.0	1941.8	14.35	15.65	38046.0	N/A	33.640	30436.8	N/A	9.905
12	22.00	1.000	1024.9	1730.0	12.78	17.22	31993.1	N/A	31.216	25594.5	N/A	9.291
13	24.00	1.000	918.8	1518.2	11.22	18.78	26405.4	N/A	28.738	21124.3	N/A	8.668
14	26.00	1.000	812.8	1306.4	9.65	20.35	21310.1	N/A	26.219	17048.1	N/A	8.045
15	28.00	1.000	706.7	1094.6	8.09	21.91	16650.9	N/A	23.561	13320.7	N/A	7.395
16	30.00	1.000	600.6	882.8	6.52	23.48	12457.0	N/A	20.739	9965.6	N/A	6.718
17	32.00	1.000	494.6	671.0	4.96	25.04	8728.3	N/A	17.648	6982.7	N/A	5.991
18	34.00	1.000	437.6	459.2	3.39	26.61	5465.0	N/A	12.487	4372.0	N/A	4.875

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	1439	0.63	0.63	7113	6146	N/A	4.94	N/A	4.27	V40 - 20XT
2	2.00	1729	0.63	0.63	7113	6146	N/A	4.11	N/A	3.56	V40 - 20XT
3	4.00	1979	0.63	0.63	7113	6146	N/A	3.59	N/A	3.11	V40 - 20XT
4	6.00	1873	0.63	0.63	7113	6146	N/A	3.80	N/A	3.28	V40 - 20XT
5	8.00	1767	0.63	0.63	7113	6146	N/A	4.02	N/A	3.48	V40 - 20XT
6	10.00	1661	0.63	0.63	7113	6146	N/A	4.28	N/A	3.70	V40 - 20XT
7	12.00	1555	0.63	0.63	7113	6146	N/A	4.57	N/A	3.95	V40 - 20XT
8	14.00	1449	0.63	0.63	7113	6146	N/A	4.91	N/A	4.24	V40 - 20XT
9	16.00	1343	0.63	0.63	7113	6146	N/A	5.30	N/A	4.58	V40 - 20XT
10	18.00	1237	0.71	0.71	4021	3083	N/A	3.25	N/A	2.49	V40 - 8XT
11	20.00	1131	0.71	0.71	4021	3083	N/A	3.56	N/A	2.73	V40 - 8XT
12	22.00	1025	0.71	0.71	4021	3083	N/A	3.92	N/A	3.01	V40 - 8XT
13	24.00	919	0.68	0.68	3850	3083	N/A	4.19	N/A	3.36	V40 - 8XT
14	26.00	813	0.65	0.65	3669	3083	N/A	4.51	N/A	3.79	V40 - 8XT
15	28.00	707	0.62	0.62	3489	3083	N/A	4.94	N/A	4.36	V40 - 8XT
16	30.00	601	0.58	0.58	3309	3083	N/A	5.51	N/A	5.13	V40 - 8XT
17	32.00	495	0.55	0.55	3129	3083	N/A	6.33	N/A	6.23	V40 - 8XT
18	34.00	438	0.52	0.52	2949	3083	N/A	6.74	N/A	7.04	V40 - 8XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	5428	0.63	0.63	7113	6146	N/A	1.31	N/A	1.61	V40 - 20XT
2	2.00	5577	0.63	0.63	7113	6146	N/A	1.28	N/A	1.52	V40 - 20XT
3	4.00	5616	0.63	0.63	7113	6146	N/A	1.27	N/A	1.48	V40 - 20XT
4	6.00	5298	0.63	0.63	7113	6146	N/A	1.34	N/A	1.57	V40 - 20XT
5	8.00	4980	0.63	0.63	7113	6146	N/A	1.43	N/A	1.67	V40 - 20XT
6	10.00	4662	0.63	0.63	7113	6146	N/A	1.53	N/A	1.78	V40 - 20XT
7	12.00	4344	0.63	0.63	7113	6146	N/A	1.64	N/A	1.91	V40 - 20XT
8	14.00	4026	0.63	0.63	7113	6146	N/A	1.77	N/A	2.05	V40 - 20XT
9	16.00	3708	0.63	0.63	7113	6146	N/A	1.92	N/A	2.23	V40 - 20XT
10	18.00	3391	0.71	0.71	4021	3083	N/A	1.19	N/A	1.22	V40 - 8XT
11	20.00	3073	0.71	0.71	4021	3083	N/A	1.31	N/A	1.34	V40 - 8XT
12	22.00	2755	0.71	0.71	4021	3083	N/A	1.46	N/A	1.50	V40 - 8XT
13	24.00	2437	0.68	0.68	3850	3083	N/A	1.58	N/A	1.69	V40 - 8XT
14	26.00	2119	0.65	0.65	3669	3083	N/A	1.73	N/A	1.93	V40 - 8XT
15	28.00	1801	0.62	0.62	3489	3083	N/A	1.94	N/A	2.26	V40 - 8XT
16	30.00	1483	0.58	0.58	3309	3083	N/A	2.23	N/A	2.73	V40 - 8XT
17	32.00	1166	0.55	0.55	3129	3083	N/A	2.68	N/A	3.44	V40 - 8XT
18	34.00	897	0.52	0.52	2949	3083	N/A	3.29	N/A	4.33	V40 - 8XT

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GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.180 has been applied.
The seismic force is applied at the center of the sliding mass.

STATIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.575
(it corresponds to a critical circle at Xc = -8.00, Yc = 100.00 and R = 100.32 [ft] where (x=0, y=0) is taken at the TOE or Xc = 67.00, Yc = 1100.00 and R = 100.32 [ft] when the terrain coordinate system is used as shown in the table below.)

SEISMIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.122
(it corresponds to a critical circle at Xc = -20.00, Yc = 148.00 and R = 149.35 [ft] where (x=0, y=0) is taken at the TOE or Xc = 55.00, Yc = 1148.00 and R = 149.35 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Soil layer #1:	γ = 120.00 [lb/ft ³]			ϕ = 28.0°		c = 500.00 [lb/ft ²]					
x [ft]	0.0	10.0	15.0	20.0	50.0	110.0	140.0	150.0	200.0	275.0	300.0
y [ft]	1005.0	1005.0	1005.0	1005.0	1005.0	1000.0	1060.0	1065.0	1070.0	1070.0	1070.0

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AASHTO 2002 ASD DESIGN METHOD
Portola Center - TTM 17300

MSEW(3.0): Update # 14.3

PROJECT IDENTIFICATION

Title: Portola Center - TTM 17300
Project Number: 0704 034A
Client: USA Portola Properties, LLC
Designer: DAO
Station Number: DESIGN 3

Description:

Tiered 25 ft over 30 ft Wall Height - 10 ft 2:1 Separation Slope - Offset of 25 ft - 30 ft Ascending Slope at Crest

Company's information:

Name: Soil Retention Designs, Inc.
Street: 2501 State Street

Carlsbad, CA 92008
Telephone #: 760-966-6090
Fax #: 760-966-6099
E-Mail: dosborne@soilretention.com

Original file path and name: C:\Users\dosborne\Desktop\Portola North Rev Design\Upda..... ..... 1 slope - 30 ft.BEN

Original date and time of creating this file: Mon Nov 29 16:13:17 2010

PROGRAM MODE: ANALYSIS of SUPERIMPOSED WALL using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	28.0 °
Equivalent cohesion, $c_{equiv.}$	500.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3892 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 25.80 N γ= 16.72

SEISMICITY

Maximum ground acceleration coefficient, A = 0.360
Design acceleration coefficient in Internal Stability: Kh = Am = 0.392
Design acceleration coefficient in External Stability: Kh_d = 0.175 => Kh = Am = 0.175
(Kh in External Stability is based on allowable displacement, d = 75 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.6084 Kae (Kh = 0) = 0.3892 Δ Kae = 0.2192
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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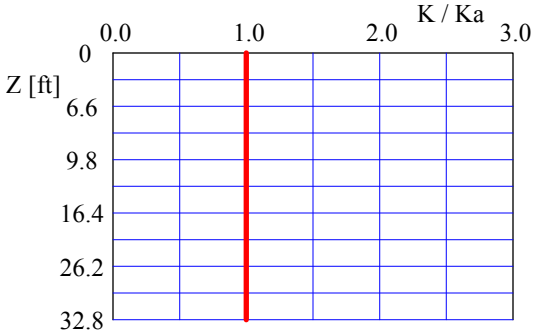
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3590.0	6230.0	8300.0	12420.0	
Durability reduction factor, RFd	1.10	1.10	1.10	1.10	
Installation-damage reduction factor, RFid	1.11	1.10	1.10	1.10	
Creep reduction factor, RFc	1.67	1.67	1.67	1.67	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	1.000	
Friction angle along geogrid-soil interface, ρ	29.40	29.40	29.40	29.40	
Pullout resistance factor, F*	0.90·tarϕ	0.90·tanϕ	0.90·tanϕ	0.90·tanϕ	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Note: Z for calculating K/Ka and F* is measured from top of the wall at the face (AASHTO).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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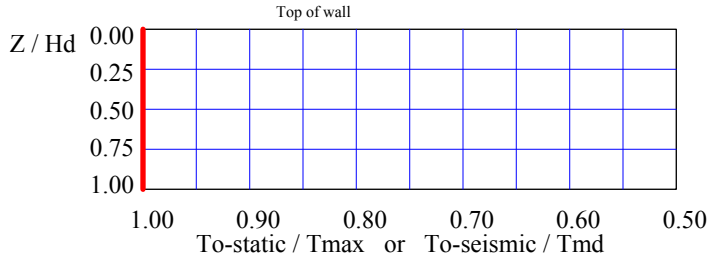
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.00/0.67 ft. Horizontal distance to Center of Gravity of block is 0.42 ft.
Average unit weight of block is γ_f = 117.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	V40 - 5XT	V40 - 8XT	V40 - 10XT	V40 - 20XT	N/A
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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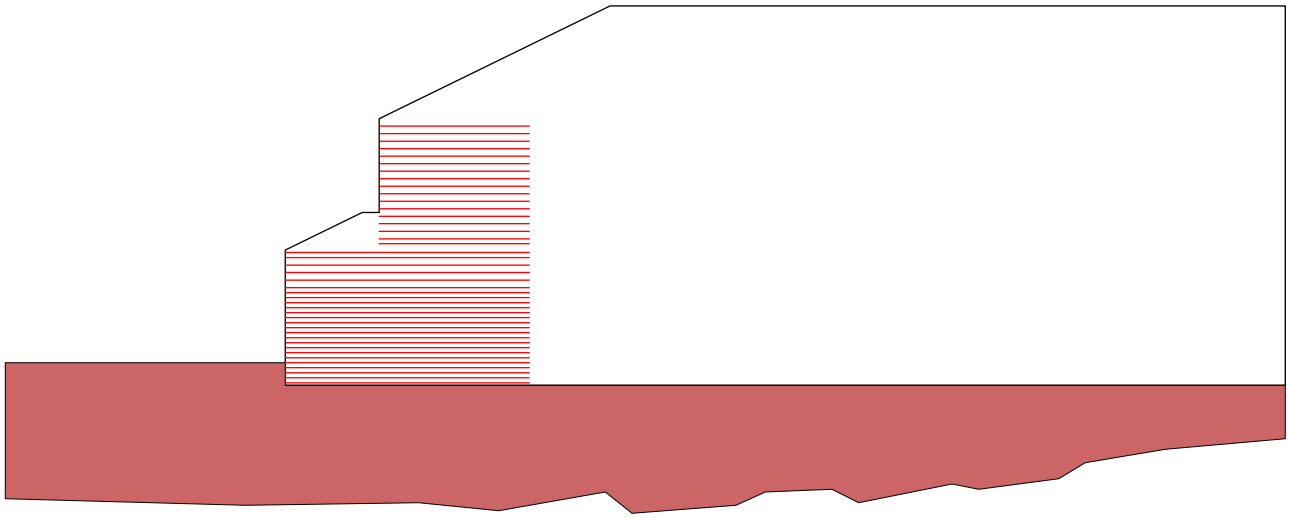
INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

Design height, Hd	71.00	[ft]	{ Embedded depth is E = 6.00 ft, and height above top of finished bottom grade is H = 65.00 ft, where H1 = 25.00 and H2 = 30.00 }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	30.0	[ft]	Broken back equivalent angle, I = 11.93° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 25.0 ft, Blackslope2 = 26.0 deg. and Backslope rise, S2 = 10.0 ft.

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 1(1;2(2;30 [ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 7.64, Meyerhof stress = 9407 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.744, Eccentricity, e/L = 0.0479, Fs-overturning = 3.88

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	65.00	4	2.07	1.79	1.790	155.106	1.672	0.0455	V40 - 20XT
2	2.00	65.00	4	2.12	1.83	1.831	154.334	1.686	0.0406	V40 - 20XT
3	3.33	65.00	4	2.15	1.86	1.861	152.415	1.700	0.0356	V40 - 20XT
4	4.67	65.00	4	2.20	1.90	1.898	151.010	1.715	0.0307	V40 - 20XT
5	6.00	65.00	4	2.25	1.94	1.945	150.254	1.730	0.0257	V40 - 20XT
6	7.33	65.00	4	2.29	1.98	1.978	148.385	1.745	0.0207	V40 - 20XT
7	8.67	65.00	4	2.34	2.02	2.021	147.015	1.760	0.0156	V40 - 20XT
8	10.00	65.00	4	2.40	2.07	2.074	146.282	1.775	0.0105	V40 - 20XT
9	11.33	65.00	4	2.44	2.11	2.112	144.468	1.791	0.0053	V40 - 20XT
10	12.67	65.00	4	2.50	2.16	2.161	143.206	1.806	0.0001	V40 - 20XT
11	14.00	65.00	4	2.57	2.22	2.221	142.439	1.822	-0.0052	V40 - 20XT
12	15.33	65.00	4	2.62	2.27	2.266	140.689	1.837	-0.0106	V40 - 20XT
13	16.67	65.00	4	2.69	2.32	2.322	139.480	1.853	-0.0161	V40 - 20XT
14	18.00	65.00	4	2.77	2.39	2.390	138.755	1.868	-0.0217	V40 - 20XT
15	19.33	65.00	4	2.83	2.44	2.443	137.080	1.884	-0.0274	V40 - 20XT
16	20.67	65.00	4	2.82	2.51	2.508	135.937	1.899	-0.0332	V40 - 20XT
17	22.00	65.00	4	2.80	2.59	2.587	135.270	1.915	-0.0392	V40 - 20XT
18	23.33	65.00	4	2.75	2.65	2.650	133.685	1.930	-0.0453	V40 - 20XT
19	24.67	65.00	4	2.71	2.73	2.728	132.626	1.945	-0.0516	V40 - 20XT
20	26.00	65.00	4	2.15	2.26	2.261	105.926	1.959	-0.0581	V40 - 20XT
21	28.00	65.00	4	1.74	1.96	1.964	86.853	1.980	-0.0683	V40 - 20XT
22	30.00	65.00	4	1.69	2.06	2.061	85.919	2.000	-0.0791	V40 - 20XT
23	32.00	65.00	4	2.90	3.84	3.837	150.534	2.019	-0.0907	V40 - 20XT
24	34.00	65.00	4	21.80	31.61	31.609	1164.810	2.035	-0.1031	V40 - 20XT
25	35.33	65.00	4	1.90	2.95	2.947	104.002	2.045	-0.1120	V40 - 20XT
26	37.67	40.00	4	3.18	2.75	2.747	63.741	1.946	0.0615	V40 - 20XT
27	39.00	40.00	4	2.64	2.28	2.278	49.778	1.982	0.0554	V40 - 20XT
28	41.00	40.00	4	2.29	1.98	1.979	39.384	2.039	0.0463	V40 - 20XT
29	43.00	40.00	4	2.40	2.08	2.078	37.457	2.099	0.0373	V40 - 20XT
30	45.00	40.00	4	2.53	2.19	2.187	35.498	2.163	0.0283	V40 - 20XT
31	47.00	40.00	4	2.67	2.31	2.308	33.503	2.230	0.0193	V40 - 20XT
32	49.00	40.00	4	2.83	2.44	2.443	31.484	2.301	0.0103	V40 - 20XT
33	51.00	40.00	4	3.00	2.59	2.595	29.393	2.375	0.0011	V40 - 20XT
34	53.00	40.00	4	3.20	2.77	2.767	27.239	2.454	-0.0082	V40 - 20XT
35	55.00	40.00	4	3.40	2.96	2.964	25.011	2.537	-0.0179	V40 - 20XT
36	57.00	40.00	2	2.09	1.60	1.601	22.689	2.623	-0.0280	V40 - 8XT
37	59.00	40.00	2	2.20	1.73	1.733	20.252	2.713	-0.0389	V40 - 8XT
38	61.00	40.00	2	2.29	1.89	1.890	17.669	2.804	-0.0506	V40 - 8XT
39	63.00	40.00	2	2.39	2.08	2.078	14.894	2.896	-0.0638	V40 - 8XT
40	65.00	40.00	2	2.52	2.31	2.307	11.866	2.985	-0.0789	V40 - 8XT
41	67.00	40.00	2	2.69	2.59	2.594	8.489	3.065	-0.0970	V40 - 8XT
42	69.00	40.00	2	2.00	2.05	2.046	3.190	3.127	-0.1198	V40 - 8XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.630
(it corresponds to a critical circle at Xc = -8.00, Yc = 146.00 and R = 146.22 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.058
(it corresponds to a critical circle at Xc = -8.00, Yc = 234.00 and R = 168.27 [ft]).

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ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 5.05, Meyerhof stress = 11916 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.226, Eccentricity, e/L = 0.1311, Fs-overturning = 2.54

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	65.00	4	1.52	1.47	1.469	90.981	1.181	0.1265	V40 - 20XT
2	2.00	65.00	4	1.55	1.50	1.500	90.248	1.199	0.1174	V40 - 20XT
3	3.33	65.00	4	1.57	1.52	1.523	89.023	1.218	0.1084	V40 - 20XT
4	4.67	65.00	4	1.60	1.55	1.552	88.005	1.237	0.0994	V40 - 20XT
5	6.00	65.00	4	1.63	1.59	1.586	87.270	1.257	0.0906	V40 - 20XT
6	7.33	65.00	4	1.66	1.61	1.612	86.063	1.278	0.0818	V40 - 20XT
7	8.67	65.00	4	1.69	1.64	1.644	85.055	1.300	0.0731	V40 - 20XT
8	10.00	65.00	4	1.73	1.68	1.683	84.320	1.322	0.0644	V40 - 20XT
9	11.33	65.00	4	1.76	1.71	1.712	83.133	1.345	0.0558	V40 - 20XT
10	12.67	65.00	4	1.79	1.75	1.748	82.172	1.369	0.0472	V40 - 20XT
11	14.00	65.00	4	1.84	1.79	1.792	81.401	1.394	0.0387	V40 - 20XT
12	15.33	65.00	4	1.87	1.83	1.825	80.236	1.420	0.0303	V40 - 20XT
13	16.67	65.00	4	1.91	1.87	1.867	79.288	1.447	0.0218	V40 - 20XT
14	18.00	65.00	4	1.96	1.92	1.915	78.520	1.475	0.0134	V40 - 20XT
15	19.33	65.00	4	1.99	1.95	1.955	77.379	1.504	0.0050	V40 - 20XT
16	20.67	65.00	4	1.98	2.00	2.002	76.446	1.535	-0.0035	V40 - 20XT
17	22.00	65.00	4	1.96	2.06	2.058	75.685	1.808	-0.0323	V40 - 20XT
18	23.33	65.00	4	1.92	2.10	2.104	74.572	1.829	-0.0386	V40 - 20XT
19	24.67	65.00	4	1.88	2.16	2.158	73.658	1.850	-0.0450	V40 - 20XT
20	26.00	65.00	4	1.58	1.86	1.860	62.315	1.869	-0.0515	V40 - 20XT
21	28.00	65.00	4	1.33	1.66	1.660	53.216	1.897	-0.0616	V40 - 20XT
22	30.00	65.00	4	1.29	1.73	1.735	52.325	1.923	-0.0723	V40 - 20XT
23	32.00	65.00	4	1.84	2.86	2.860	76.679	1.945	-0.0836	V40 - 20XT
24	34.00	65.00	4	3.90	8.43	8.433	166.706	1.962	-0.0957	V40 - 20XT
25	35.33	65.00	4	1.34	2.35	2.353	58.550	1.970	-0.1042	V40 - 20XT
26	37.67	40.00	4	2.37	2.28	2.280	37.983	1.333	0.1364	V40 - 20XT
27	39.00	40.00	4	2.06	1.95	1.952	31.143	1.370	0.1242	V40 - 20XT
28	41.00	40.00	4	1.85	1.73	1.735	25.507	1.431	0.1064	V40 - 20XT
29	43.00	40.00	4	1.94	1.82	1.817	24.171	1.496	0.0892	V40 - 20XT
30	45.00	40.00	4	2.03	1.91	1.907	22.816	1.568	0.0727	V40 - 20XT
31	47.00	40.00	4	2.14	2.01	2.007	21.439	1.647	0.0568	V40 - 20XT
32	49.00	40.00	4	2.25	2.12	2.118	20.049	1.733	0.0414	V40 - 20XT
33	51.00	40.00	4	2.38	2.24	2.242	18.615	1.829	0.0265	V40 - 20XT
34	53.00	40.00	4	2.52	2.38	2.381	17.145	1.934	0.0119	V40 - 20XT
35	55.00	40.00	4	2.65	2.54	2.538	15.632	2.050	-0.0023	V40 - 20XT
36	57.00	40.00	2	1.62	1.36	1.364	14.068	2.178	-0.0164	V40 - 8XT
37	59.00	40.00	2	1.69	1.47	1.468	12.441	2.318	-0.0306	V40 - 8XT
38	61.00	40.00	2	1.74	1.59	1.589	10.737	2.471	-0.0451	V40 - 8XT
39	63.00	40.00	2	1.80	1.73	1.732	8.935	2.634	-0.0604	V40 - 8XT
40	65.00	40.00	2	1.86	1.90	1.904	7.009	2.802	-0.0771	V40 - 8XT
41	67.00	40.00	2	1.95	2.11	2.113	4.920	2.964	-0.0963	V40 - 8XT
42	69.00	40.00	2	1.55	1.75	1.747	1.985	3.095	-0.1196	V40 - 8XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.630
(it corresponds to a critical circle at Xc = -8.00, Yc = 146.00 and R = 146.22 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.058
(it corresponds to a critical circle at Xc = -8.00, Yc = 234.00 and R = 168.27 [ft]).

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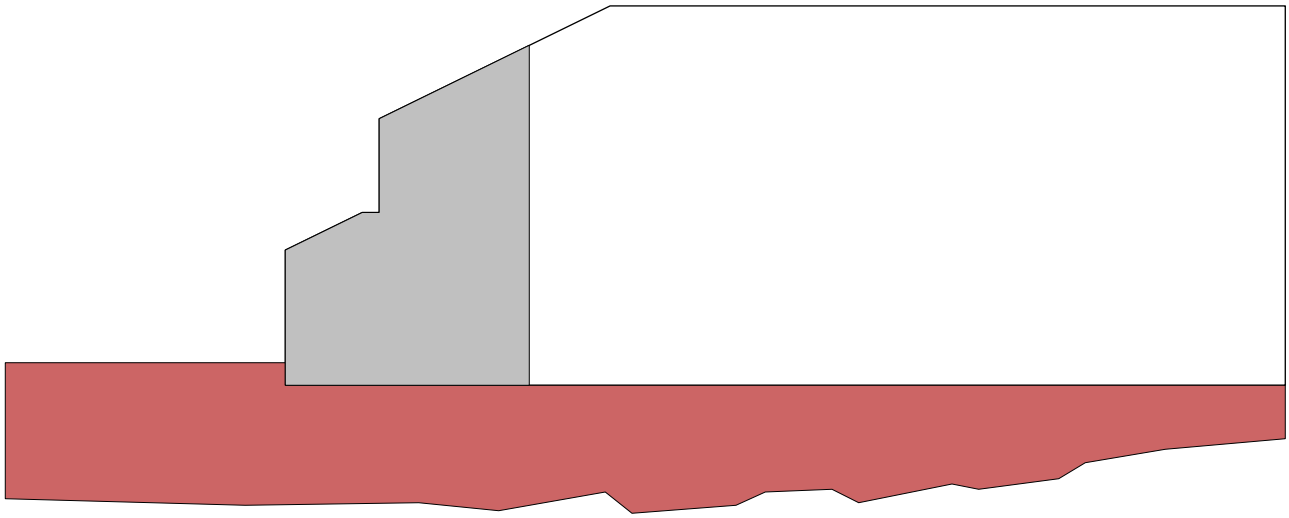
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	71850	60129	[lb/ft ²]
Meyerhof stress, σ_V	9407.0	11916	[lb/ft ²]
Eccentricity, e	3.11	8.96	[ft]
Eccentricity, e/L	0.048	0.138	
Fs calculated	7.64	5.05	
Base length	65.00	65.00	[ft]



SCALE:

0 5 10 15 20 25 30 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 1.744 and Fs-seismic = 1.226

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	65.00	1.672	1.181	4	V40 - 20XT
2	2.00	65.00	1.686	1.199	4	V40 - 20XT
3	3.33	65.00	1.700	1.218	4	V40 - 20XT
4	4.67	65.00	1.715	1.237	4	V40 - 20XT
5	6.00	65.00	1.730	1.257	4	V40 - 20XT
6	7.33	65.00	1.745	1.278	4	V40 - 20XT
7	8.67	65.00	1.760	1.300	4	V40 - 20XT
8	10.00	65.00	1.775	1.322	4	V40 - 20XT
9	11.33	65.00	1.791	1.345	4	V40 - 20XT
10	12.67	65.00	1.806	1.369	4	V40 - 20XT
11	14.00	65.00	1.822	1.394	4	V40 - 20XT
12	15.33	65.00	1.837	1.420	4	V40 - 20XT
13	16.67	65.00	1.853	1.447	4	V40 - 20XT
14	18.00	65.00	1.868	1.475	4	V40 - 20XT
15	19.33	65.00	1.884	1.504	4	V40 - 20XT
16	20.67	65.00	1.899	1.535	4	V40 - 20XT
17	22.00	65.00	1.915	1.808	4	V40 - 20XT
18	23.33	65.00	1.930	1.829	4	V40 - 20XT
19	24.67	65.00	1.945	1.850	4	V40 - 20XT
20	26.00	65.00	1.959	1.869	4	V40 - 20XT
21	28.00	65.00	1.980	1.897	4	V40 - 20XT
22	30.00	65.00	2.000	1.923	4	V40 - 20XT
23	32.00	65.00	2.019	1.945	4	V40 - 20XT
24	34.00	65.00	2.035	1.962	4	V40 - 20XT
25	35.33	65.00	2.045	1.970	4	V40 - 20XT
26	37.67	40.00	1.946	1.333	4	V40 - 20XT
27	39.00	40.00	1.982	1.370	4	V40 - 20XT
28	41.00	40.00	2.039	1.431	4	V40 - 20XT
29	43.00	40.00	2.099	1.496	4	V40 - 20XT
30	45.00	40.00	2.163	1.568	4	V40 - 20XT
31	47.00	40.00	2.230	1.647	4	V40 - 20XT
32	49.00	40.00	2.301	1.733	4	V40 - 20XT
33	51.00	40.00	2.375	1.829	4	V40 - 20XT
34	53.00	40.00	2.454	1.934	4	V40 - 20XT
35	55.00	40.00	2.537	2.050	4	V40 - 20XT
36	57.00	40.00	2.623	2.178	2	V40 - 8XT
37	59.00	40.00	2.713	2.318	2	V40 - 8XT
38	61.00	40.00	2.804	2.471	2	V40 - 8XT
39	63.00	40.00	2.896	2.634	2	V40 - 8XT
40	65.00	40.00	2.985	2.802	2	V40 - 8XT
41	67.00	40.00	3.065	2.964	2	V40 - 8XT
42	69.00	40.00	3.127	3.095	2	V40 - 8XT

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ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0479, e/L seismic = 0.1311; Overturning: Fs-static = 3.88, Fs-seismic = 2.54

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	65.00	0.0455	0.1265	4	V40 - 20XT
2	2.00	65.00	0.0406	0.1174	4	V40 - 20XT
3	3.33	65.00	0.0356	0.1084	4	V40 - 20XT
4	4.67	65.00	0.0307	0.0994	4	V40 - 20XT
5	6.00	65.00	0.0257	0.0906	4	V40 - 20XT
6	7.33	65.00	0.0207	0.0818	4	V40 - 20XT
7	8.67	65.00	0.0156	0.0731	4	V40 - 20XT
8	10.00	65.00	0.0105	0.0644	4	V40 - 20XT
9	11.33	65.00	0.0053	0.0558	4	V40 - 20XT
10	12.67	65.00	0.0001	0.0472	4	V40 - 20XT
11	14.00	65.00	-0.0052	0.0387	4	V40 - 20XT
12	15.33	65.00	-0.0106	0.0303	4	V40 - 20XT
13	16.67	65.00	-0.0161	0.0218	4	V40 - 20XT
14	18.00	65.00	-0.0217	0.0134	4	V40 - 20XT
15	19.33	65.00	-0.0274	0.0050	4	V40 - 20XT
16	20.67	65.00	-0.0332	-0.0035	4	V40 - 20XT
17	22.00	65.00	-0.0392	-0.0323	4	V40 - 20XT
18	23.33	65.00	-0.0453	-0.0386	4	V40 - 20XT
19	24.67	65.00	-0.0516	-0.0450	4	V40 - 20XT
20	26.00	65.00	-0.0581	-0.0515	4	V40 - 20XT
21	28.00	65.00	-0.0683	-0.0616	4	V40 - 20XT
22	30.00	65.00	-0.0791	-0.0723	4	V40 - 20XT
23	32.00	65.00	-0.0907	-0.0836	4	V40 - 20XT
24	34.00	65.00	-0.1031	-0.0957	4	V40 - 20XT
25	35.33	65.00	-0.1120	-0.1042	4	V40 - 20XT
26	37.67	40.00	0.0615	0.1364	4	V40 - 20XT
27	39.00	40.00	0.0554	0.1242	4	V40 - 20XT
28	41.00	40.00	0.0463	0.1064	4	V40 - 20XT
29	43.00	40.00	0.0373	0.0892	4	V40 - 20XT
30	45.00	40.00	0.0283	0.0727	4	V40 - 20XT
31	47.00	40.00	0.0193	0.0568	4	V40 - 20XT
32	49.00	40.00	0.0103	0.0414	4	V40 - 20XT
33	51.00	40.00	0.0011	0.0265	4	V40 - 20XT
34	53.00	40.00	-0.0082	0.0119	4	V40 - 20XT
35	55.00	40.00	-0.0179	-0.0023	4	V40 - 20XT
36	57.00	40.00	-0.0280	-0.0164	2	V40 - 8XT
37	59.00	40.00	-0.0389	-0.0306	2	V40 - 8XT
38	61.00	40.00	-0.0506	-0.0451	2	V40 - 8XT
39	63.00	40.00	-0.0638	-0.0604	2	V40 - 8XT
40	65.00	40.00	-0.0789	-0.0771	2	V40 - 8XT
41	67.00	40.00	-0.0970	-0.0963	2	V40 - 8XT
42	69.00	40.00	-0.1198	-0.1196	2	V40 - 8XT

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Tavailable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.67	6146	3434.69	1249.75	N/A	1.790	N/A	1.469	V40 - 20XT
2	2.00	6146	3356.48	1235.49	N/A	1.831	N/A	1.500	V40 - 20XT
3	3.33	6146	3303.51	1221.24	N/A	1.861	N/A	1.523	V40 - 20XT
4	4.67	6146	3237.80	1206.87	N/A	1.898	N/A	1.552	V40 - 20XT
5	6.00	6146	3160.33	1192.62	N/A	1.945	N/A	1.586	V40 - 20XT
6	7.33	6146	3106.62	1178.36	N/A	1.978	N/A	1.612	V40 - 20XT
7	8.67	6146	3040.91	1164.00	N/A	2.021	N/A	1.644	V40 - 20XT
8	10.00	6146	2964.17	1149.74	N/A	2.074	N/A	1.683	V40 - 20XT
9	11.33	6146	2909.73	1135.49	N/A	2.112	N/A	1.712	V40 - 20XT
10	12.67	6146	2844.01	1121.12	N/A	2.161	N/A	1.748	V40 - 20XT
11	14.00	6146	2768.02	1106.87	N/A	2.221	N/A	1.792	V40 - 20XT
12	15.33	6146	2712.84	1092.61	N/A	2.266	N/A	1.825	V40 - 20XT
13	16.67	6146	2647.12	1078.25	N/A	2.322	N/A	1.867	V40 - 20XT
14	18.00	6146	2571.86	1063.99	N/A	2.390	N/A	1.915	V40 - 20XT
15	19.33	6146	2515.94	1049.74	N/A	2.443	N/A	1.955	V40 - 20XT
16	20.67	6146	2450.23	1035.37	N/A	2.508	N/A	2.002	V40 - 20XT
17	22.00	6146	2375.71	1021.12	N/A	2.587	N/A	2.058	V40 - 20XT
18	23.33	6146	2319.05	1006.86	N/A	2.650	N/A	2.104	V40 - 20XT
19	24.67	6146	2253.34	992.50	N/A	2.728	N/A	2.158	V40 - 20XT
20	26.00	6146	2718.26	978.24	N/A	2.261	N/A	1.860	V40 - 20XT
21	28.00	6146	3130.05	956.80	N/A	1.964	N/A	1.660	V40 - 20XT
22	30.00	6146	2982.56	935.37	N/A	2.061	N/A	1.735	V40 - 20XT
23	32.00	6146	1601.89	913.93	N/A	3.837	N/A	2.860	V40 - 20XT
24	34.00	6146	194.45	892.49	N/A	31.609	N/A	8.433	V40 - 20XT
25	35.33	6146	2085.81	878.23	N/A	2.947	N/A	2.353	V40 - 20XT
26	37.67	6146	2237.36	766.31	N/A	2.747	N/A	2.280	V40 - 20XT
27	39.00	6146	2698.27	752.06	N/A	2.278	N/A	1.952	V40 - 20XT
28	41.00	6146	3106.03	730.62	N/A	1.979	N/A	1.735	V40 - 20XT
29	43.00	6146	2958.54	709.18	N/A	2.078	N/A	1.817	V40 - 20XT
30	45.00	6146	2811.06	687.75	N/A	2.187	N/A	1.907	V40 - 20XT
31	47.00	6146	2663.57	666.31	N/A	2.308	N/A	2.007	V40 - 20XT
32	49.00	6146	2516.09	644.87	N/A	2.443	N/A	2.118	V40 - 20XT
33	51.00	6146	2368.61	623.43	N/A	2.595	N/A	2.242	V40 - 20XT
34	53.00	6146	2221.12	601.99	N/A	2.767	N/A	2.381	V40 - 20XT
35	55.00	6146	2073.64	580.56	N/A	2.964	N/A	2.538	V40 - 20XT
36	57.00	3083	1926.15	559.12	N/A	1.601	N/A	1.364	V40 - 8XT
37	59.00	3083	1778.67	537.68	N/A	1.733	N/A	1.468	V40 - 8XT
38	61.00	3083	1631.18	516.24	N/A	1.890	N/A	1.589	V40 - 8XT
39	63.00	3083	1483.70	494.80	N/A	2.078	N/A	1.732	V40 - 8XT
40	65.00	3083	1336.22	473.37	N/A	2.307	N/A	1.904	V40 - 8XT
41	67.00	3083	1188.73	451.93	N/A	2.594	N/A	2.113	V40 - 8XT
42	69.00	3083	1506.57	430.49	N/A	2.046	N/A	1.747	V40 - 8XT

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RESULTS for PULLOUT Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic Fs	Actual Seismic Fs
1	0.67	1.000	3434.7	1249.8	64.63	0.37	532742.3	N/A	155.106	426193.8	N/A	90.981
2	2.00	1.000	3356.5	1235.5	63.89	1.11	518018.8	N/A	154.334	414415.0	N/A	90.248
3	3.33	1.000	3303.5	1221.2	63.15	1.85	503505.6	N/A	152.415	402804.5	N/A	89.023
4	4.67	1.000	3237.8	1206.9	62.41	2.59	488941.2	N/A	151.010	391152.9	N/A	88.005
5	6.00	1.000	3160.3	1192.6	61.67	3.33	474852.5	N/A	150.254	379882.0	N/A	87.270
6	7.33	1.000	3106.6	1178.4	60.94	4.06	460974.3	N/A	148.385	368779.4	N/A	86.063
7	8.67	1.000	3040.9	1164.0	60.19	4.81	447057.8	N/A	147.015	357646.3	N/A	85.055
8	10.00	1.000	2964.2	1149.7	59.46	5.54	433604.9	N/A	146.282	346883.9	N/A	84.320
9	11.33	1.000	2909.7	1135.5	58.72	6.28	420362.2	N/A	144.468	336289.7	N/A	83.133
10	12.67	1.000	2844.0	1121.1	57.98	7.02	407278.9	N/A	143.206	325823.1	N/A	82.172
11	14.00	1.000	2768.0	1106.9	57.24	7.76	394274.2	N/A	142.439	315419.4	N/A	81.401
12	15.33	1.000	2712.8	1092.6	56.50	8.50	381666.3	N/A	140.689	305333.0	N/A	80.236
13	16.67	1.000	2647.1	1078.2	55.76	9.24	369220.1	N/A	139.480	295376.1	N/A	79.288
14	18.00	1.000	2571.9	1064.0	55.02	9.98	356859.7	N/A	138.755	285487.8	N/A	78.520
15	19.33	1.000	2515.9	1049.7	54.29	10.71	344886.5	N/A	137.080	275909.2	N/A	77.379
16	20.67	1.000	2450.2	1035.4	53.54	11.46	333077.5	N/A	135.937	266462.0	N/A	76.446
17	22.00	1.000	2375.7	1021.1	52.81	12.19	321361.5	N/A	135.270	257089.2	N/A	75.685
18	23.33	1.000	2319.1	1006.9	52.07	12.93	310023.0	N/A	133.685	248018.4	N/A	74.572
19	24.67	1.000	2253.3	992.5	51.33	13.67	298851.1	N/A	132.626	239080.9	N/A	73.658
20	26.00	1.000	2718.3	978.2	50.59	14.41	287933.9	N/A	105.926	230347.1	N/A	62.315
21	28.00	1.000	3130.0	956.8	49.48	15.52	271855.3	N/A	86.853	217484.3	N/A	53.216
22	30.00	1.000	2982.6	935.4	48.37	16.63	256258.5	N/A	85.919	205006.8	N/A	52.325
23	32.00	1.000	1601.9	913.9	47.26	17.74	241139.6	N/A	150.534	192911.7	N/A	76.679
24	34.00	1.000	194.5	892.5	46.15	18.85	226499.2	N/A	1164.810	181199.4	N/A	166.706
25	35.33	1.000	2085.8	878.2	45.42	19.58	216929.6	N/A	104.002	173543.7	N/A	58.550
26	37.67	1.000	2237.4	766.3	39.63	0.37	142612.6	N/A	63.741	114090.1	N/A	37.983
27	39.00	1.000	2698.3	752.1	38.89	1.11	134315.2	N/A	49.778	107452.2	N/A	31.143
28	41.00	1.000	3106.0	730.6	37.78	2.22	122326.9	N/A	39.384	97861.5	N/A	25.507
29	43.00	1.000	2958.5	709.2	36.67	3.33	110817.7	N/A	37.457	88654.2	N/A	24.171
30	45.00	1.000	2811.1	687.7	35.57	4.43	99787.7	N/A	35.498	79830.2	N/A	22.816
31	47.00	1.000	2663.6	666.3	34.46	5.54	89236.8	N/A	33.503	71389.5	N/A	21.439
32	49.00	1.000	2516.1	644.9	33.35	6.65	79217.8	N/A	31.484	63374.2	N/A	20.049
33	51.00	1.000	2368.6	623.4	32.24	7.76	69620.4	N/A	29.393	55696.3	N/A	18.615
34	53.00	1.000	2221.1	602.0	31.13	8.87	60502.2	N/A	27.239	48401.8	N/A	17.145
35	55.00	1.000	2073.6	580.6	30.02	9.98	51863.2	N/A	25.011	41490.5	N/A	15.632
36	57.00	1.000	1926.2	559.1	28.91	11.09	43703.2	N/A	22.689	34962.6	N/A	14.068
37	59.00	1.000	1778.7	537.7	27.81	12.19	36022.5	N/A	20.252	28818.0	N/A	12.441
38	61.00	1.000	1631.2	516.2	26.70	13.30	28820.8	N/A	17.669	23056.7	N/A	10.737
39	63.00	1.000	1483.7	494.8	25.59	14.41	22098.4	N/A	14.894	17678.7	N/A	8.935
40	65.00	1.000	1336.2	473.4	24.48	15.52	15855.1	N/A	11.866	12684.0	N/A	7.009
41	67.00	1.000	1188.7	451.9	23.37	16.63	10090.9	N/A	8.489	8072.7	N/A	4.920
42	69.00	1.000	1506.6	430.5	22.26	17.74	4805.9	N/A	3.190	3844.7	N/A	1.985

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	3435	0.63	0.63	7113	6146	N/A	2.07	N/A	1.79	V40 - 20XT
2	2.00	3356	0.63	0.63	7113	6146	N/A	2.12	N/A	1.83	V40 - 20XT
3	3.33	3304	0.63	0.63	7113	6146	N/A	2.15	N/A	1.86	V40 - 20XT
4	4.67	3238	0.63	0.63	7113	6146	N/A	2.20	N/A	1.90	V40 - 20XT
5	6.00	3160	0.63	0.63	7113	6146	N/A	2.25	N/A	1.94	V40 - 20XT
6	7.33	3107	0.63	0.63	7113	6146	N/A	2.29	N/A	1.98	V40 - 20XT
7	8.67	3041	0.63	0.63	7113	6146	N/A	2.34	N/A	2.02	V40 - 20XT
8	10.00	2964	0.63	0.63	7113	6146	N/A	2.40	N/A	2.07	V40 - 20XT
9	11.33	2910	0.63	0.63	7113	6146	N/A	2.44	N/A	2.11	V40 - 20XT
10	12.67	2844	0.63	0.63	7113	6146	N/A	2.50	N/A	2.16	V40 - 20XT
11	14.00	2768	0.63	0.63	7113	6146	N/A	2.57	N/A	2.22	V40 - 20XT
12	15.33	2713	0.63	0.63	7113	6146	N/A	2.62	N/A	2.27	V40 - 20XT
13	16.67	2647	0.63	0.63	7113	6146	N/A	2.69	N/A	2.32	V40 - 20XT
14	18.00	2572	0.63	0.63	7113	6146	N/A	2.77	N/A	2.39	V40 - 20XT
15	19.33	2516	0.63	0.63	7113	6146	N/A	2.83	N/A	2.44	V40 - 20XT
16	20.67	2450	0.61	0.61	6907	6146	N/A	2.82	N/A	2.51	V40 - 20XT
17	22.00	2376	0.59	0.59	6641	6146	N/A	2.80	N/A	2.59	V40 - 20XT
18	23.33	2319	0.56	0.56	6375	6146	N/A	2.75	N/A	2.65	V40 - 20XT
19	24.67	2253	0.54	0.54	6107	6146	N/A	2.71	N/A	2.73	V40 - 20XT
20	26.00	2718	0.52	0.52	5840	6146	N/A	2.15	N/A	2.26	V40 - 20XT
21	28.00	3130	0.48	0.48	5440	6146	N/A	1.74	N/A	1.96	V40 - 20XT
22	30.00	2983	0.45	0.45	5040	6146	N/A	1.69	N/A	2.06	V40 - 20XT
23	32.00	1602	0.41	0.41	4640	6146	N/A	2.90	N/A	3.84	V40 - 20XT
24	34.00	194	0.38	0.38	4239	6146	N/A	21.80	N/A	31.61	V40 - 20XT
25	35.33	2086	0.35	0.35	3973	6146	N/A	1.90	N/A	2.95	V40 - 20XT
26	37.67	2237	0.63	0.63	7113	6146	N/A	3.18	N/A	2.75	V40 - 20XT
27	39.00	2698	0.63	0.63	7113	6146	N/A	2.64	N/A	2.28	V40 - 20XT
28	41.00	3106	0.63	0.63	7113	6146	N/A	2.29	N/A	1.98	V40 - 20XT
29	43.00	2959	0.63	0.63	7113	6146	N/A	2.40	N/A	2.08	V40 - 20XT
30	45.00	2811	0.63	0.63	7113	6146	N/A	2.53	N/A	2.19	V40 - 20XT
31	47.00	2664	0.63	0.63	7113	6146	N/A	2.67	N/A	2.31	V40 - 20XT
32	49.00	2516	0.63	0.63	7113	6146	N/A	2.83	N/A	2.44	V40 - 20XT
33	51.00	2369	0.63	0.63	7113	6146	N/A	3.00	N/A	2.59	V40 - 20XT
34	53.00	2221	0.63	0.63	7113	6146	N/A	3.20	N/A	2.77	V40 - 20XT
35	55.00	2074	0.62	0.62	7041	6146	N/A	3.40	N/A	2.96	V40 - 20XT
36	57.00	1926	0.71	0.71	4021	3083	N/A	2.09	N/A	1.60	V40 - 8XT
37	59.00	1779	0.69	0.69	3913	3083	N/A	2.20	N/A	1.73	V40 - 8XT
38	61.00	1631	0.66	0.66	3733	3083	N/A	2.29	N/A	1.89	V40 - 8XT
39	63.00	1484	0.63	0.63	3552	3083	N/A	2.39	N/A	2.08	V40 - 8XT
40	65.00	1336	0.60	0.60	3372	3083	N/A	2.52	N/A	2.31	V40 - 8XT
41	67.00	1189	0.56	0.56	3192	3083	N/A	2.69	N/A	2.59	V40 - 8XT
42	69.00	1507	0.53	0.53	3012	3083	N/A	2.00	N/A	2.05	V40 - 8XT

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RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	4684	0.63	0.63	7113	6146	N/A	1.52	N/A	1.47	V40 - 20XT
2	2.00	4592	0.63	0.63	7113	6146	N/A	1.55	N/A	1.50	V40 - 20XT
3	3.33	4525	0.63	0.63	7113	6146	N/A	1.57	N/A	1.52	V40 - 20XT
4	4.67	4445	0.63	0.63	7113	6146	N/A	1.60	N/A	1.55	V40 - 20XT
5	6.00	4353	0.63	0.63	7113	6146	N/A	1.63	N/A	1.59	V40 - 20XT
6	7.33	4285	0.63	0.63	7113	6146	N/A	1.66	N/A	1.61	V40 - 20XT
7	8.67	4205	0.63	0.63	7113	6146	N/A	1.69	N/A	1.64	V40 - 20XT
8	10.00	4114	0.63	0.63	7113	6146	N/A	1.73	N/A	1.68	V40 - 20XT
9	11.33	4045	0.63	0.63	7113	6146	N/A	1.76	N/A	1.71	V40 - 20XT
10	12.67	3965	0.63	0.63	7113	6146	N/A	1.79	N/A	1.75	V40 - 20XT
11	14.00	3875	0.63	0.63	7113	6146	N/A	1.84	N/A	1.79	V40 - 20XT
12	15.33	3805	0.63	0.63	7113	6146	N/A	1.87	N/A	1.83	V40 - 20XT
13	16.67	3725	0.63	0.63	7113	6146	N/A	1.91	N/A	1.87	V40 - 20XT
14	18.00	3636	0.63	0.63	7113	6146	N/A	1.96	N/A	1.92	V40 - 20XT
15	19.33	3566	0.63	0.63	7113	6146	N/A	1.99	N/A	1.95	V40 - 20XT
16	20.67	3486	0.61	0.61	6907	6146	N/A	1.98	N/A	2.00	V40 - 20XT
17	22.00	3397	0.59	0.59	6641	6146	N/A	1.96	N/A	2.06	V40 - 20XT
18	23.33	3326	0.56	0.56	6375	6146	N/A	1.92	N/A	2.10	V40 - 20XT
19	24.67	3246	0.54	0.54	6107	6146	N/A	1.88	N/A	2.16	V40 - 20XT
20	26.00	3697	0.52	0.52	5840	6146	N/A	1.58	N/A	1.86	V40 - 20XT
21	28.00	4087	0.48	0.48	5440	6146	N/A	1.33	N/A	1.66	V40 - 20XT
22	30.00	3918	0.45	0.45	5040	6146	N/A	1.29	N/A	1.73	V40 - 20XT
23	32.00	2516	0.41	0.41	4640	6146	N/A	1.84	N/A	2.86	V40 - 20XT
24	34.00	1087	0.38	0.38	4239	6146	N/A	3.90	N/A	8.43	V40 - 20XT
25	35.33	2964	0.35	0.35	3973	6146	N/A	1.34	N/A	2.35	V40 - 20XT
26	37.67	3004	0.63	0.63	7113	6146	N/A	2.37	N/A	2.28	V40 - 20XT
27	39.00	3450	0.63	0.63	7113	6146	N/A	2.06	N/A	1.95	V40 - 20XT
28	41.00	3837	0.63	0.63	7113	6146	N/A	1.85	N/A	1.73	V40 - 20XT
29	43.00	3668	0.63	0.63	7113	6146	N/A	1.94	N/A	1.82	V40 - 20XT
30	45.00	3499	0.63	0.63	7113	6146	N/A	2.03	N/A	1.91	V40 - 20XT
31	47.00	3330	0.63	0.63	7113	6146	N/A	2.14	N/A	2.01	V40 - 20XT
32	49.00	3161	0.63	0.63	7113	6146	N/A	2.25	N/A	2.12	V40 - 20XT
33	51.00	2992	0.63	0.63	7113	6146	N/A	2.38	N/A	2.24	V40 - 20XT
34	53.00	2823	0.63	0.63	7113	6146	N/A	2.52	N/A	2.38	V40 - 20XT
35	55.00	2654	0.62	0.62	7041	6146	N/A	2.65	N/A	2.54	V40 - 20XT
36	57.00	2485	0.71	0.71	4021	3083	N/A	1.62	N/A	1.36	V40 - 8XT
37	59.00	2316	0.69	0.69	3913	3083	N/A	1.69	N/A	1.47	V40 - 8XT
38	61.00	2147	0.66	0.66	3733	3083	N/A	1.74	N/A	1.59	V40 - 8XT
39	63.00	1979	0.63	0.63	3552	3083	N/A	1.80	N/A	1.73	V40 - 8XT
40	65.00	1810	0.60	0.60	3372	3083	N/A	1.86	N/A	1.90	V40 - 8XT
41	67.00	1641	0.56	0.56	3192	3083	N/A	1.95	N/A	2.11	V40 - 8XT
42	69.00	1937	0.53	0.53	3012	3083	N/A	1.55	N/A	1.75	V40 - 8XT

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GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.180 has been applied.
The seismic force is applied at the center of the sliding mass.

STATIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.630
(it corresponds to a critical circle at Xc = -8.00, Yc = 146.00 and R = 146.22 [ft] where (x=0, y=0) is taken at the TOE or Xc = 92.00, Yc = 1146.00 and R = 146.22 [ft] when the terrain coordinate system is used as shown in the table below.)

SEISMIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.058
(it corresponds to a critical circle at Xc = -8.00, Yc = 234.00 and R = 168.27 [ft] where (x=0, y=0) is taken at the TOE or Xc = 92.00, Yc = 1234.00 and R = 168.27 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Soil layer #1:	γ = 120.00 [lb/ft ³]		ϕ = 28.0°		c = 500.00 [lb/ft ²]						
x [ft]	0.0	15.0	20.0	50.0	190.0	210.0	300.0	350.0	400.0	450.0	500.0
y [ft]	1006.0	1006.0	1006.0	1006.0	1000.0	1100.0	1100.0	1100.0	1105.0	1105.0	1110.0

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AASHTO 2002 ASD DESIGN METHOD
Portola Center - TTM 17300

MSEW(3.0): Update # 14.3

PROJECT IDENTIFICATION

Title: Portola Center - TTM 17300
Project Number: 0704 034A
Client: USA Portola Properties, LLC
Designer: DAO
Station Number: DESIGN 4

Description:

Tiered 20 ft over 25 ft Wall Height - 10 ft 2:1 Separation Slope - Offset of 25 ft - 20 ft Ascending Slope at Crest

Company's information:

Name: Soil Retention Designs, Inc.
Street: 2501 State Street

Carlsbad, CA 92008
Telephone #: 760-966-6090
Fax #: 760-966-6099
E-Mail: dosborne@soilretention.com

Original file path and name: C:\Users\dosborne\Desktop\Portola North Rev Design\Upda..... ..... 1 slope - 20 ft.BEN

Original date and time of creating this file: Mon Nov 29 16:13:17 2010

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	28.0 °
Equivalent cohesion, $c_{equiv.}$	500.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.4017 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 25.80 N γ= 16.72

SEISMICITY

Maximum ground acceleration coefficient, A = 0.360
Design acceleration coefficient in Internal Stability: Kh = Am = 0.392
Design acceleration coefficient in External Stability: Kh_d = 0.175 => Kh = Am = 0.175
(Kh in External Stability is based on allowable displacement, d = 75 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.6634 Kae (Kh = 0) = 0.4017 Δ Kae = 0.2617
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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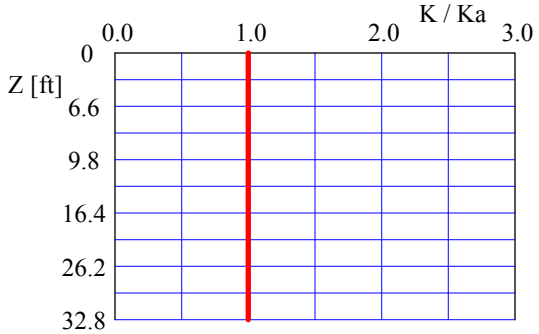
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3590.0	6230.0	8300.0	12420.0	
Durability reduction factor, RFd	1.10	1.10	1.10	1.10	
Installation-damage reduction factor, RFid	1.11	1.10	1.10	1.10	
Creep reduction factor, RFc	1.67	1.67	1.67	1.67	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	1.000	
Friction angle along geogrid-soil interface, ρ	29.40	29.40	29.40	29.40	
Pullout resistance factor, F*	0.90·tarϕ	0.90·tan$\flat$	0.90·tan$\flat$	0.90·tan$\flat$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Note: Z for calculating K/Ka and F* is measured from top of the wall at the face (AASHTO).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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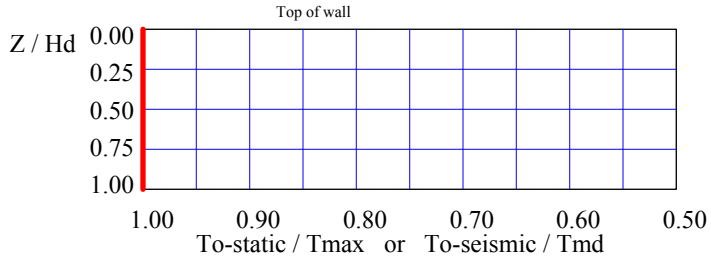
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.00/0.67 ft. Horizontal distance to Center of Gravity of block is 0.42 ft.
Average unit weight of block is γ_f = 117.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	V40 - 5XT	V40 - 8XT	V40 - 10XT	V40 - 20XT	N/A
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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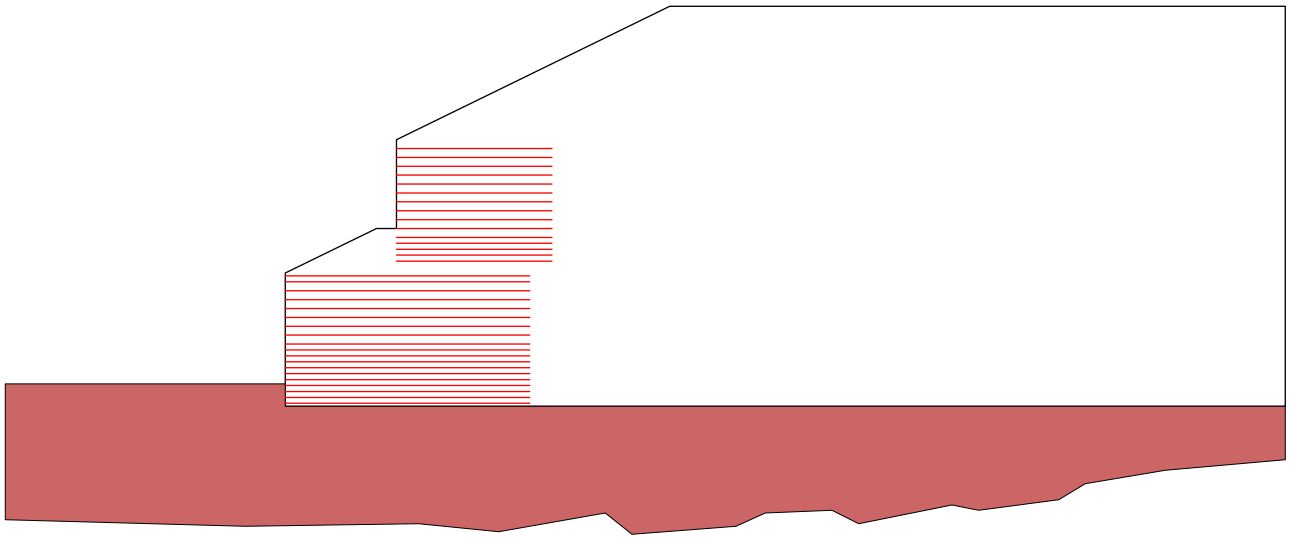
INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

Design height, Hd	60.00	[ft]	{ Embedded depth is E = 5.00 ft, and height above top of finished bottom grade is H = 55.00 ft, where H1 = 20.00 and H2 = 25.00 }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	30.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 25.0 ft, Blackslope2 = 26.0 deg. and Backslope rise, S2 = 10.0 ft.

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 10 15 20 25 30 [ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 8.50, Meyerhof stress = 7521 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.773, Eccentricity, e/L = 0.0376, Fs-overturning = 4.00

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	55.00	4	2.75	2.37	2.375	144.348	1.663	0.0347	V40 - 20XT
2	2.00	55.00	4	2.83	2.45	2.446	143.718	1.679	0.0289	V40 - 20XT
3	3.33	55.00	4	2.90	2.50	2.502	141.976	1.696	0.0231	V40 - 20XT
4	4.67	55.00	4	2.97	2.57	2.570	140.843	1.712	0.0171	V40 - 20XT
5	6.00	55.00	4	3.07	2.65	2.653	140.216	1.729	0.0112	V40 - 20XT
6	7.33	55.00	4	3.15	2.72	2.720	138.626	1.746	0.0052	V40 - 20XT
7	8.67	55.00	4	3.24	2.80	2.801	137.581	1.763	-0.0010	V40 - 20XT
8	10.00	55.00	4	3.35	2.90	2.898	137.035	1.779	-0.0072	V40 - 20XT
9	11.33	55.00	4	3.45	2.98	2.979	135.563	1.796	-0.0135	V40 - 20XT
10	12.67	55.00	4	3.56	3.08	3.077	134.569	1.813	-0.0200	V40 - 20XT
11	14.00	55.00	4	2.94	2.56	2.562	107.658	1.830	-0.0266	V40 - 20XT
12	16.00	55.00	4	2.42	2.24	2.238	88.409	1.854	-0.0368	V40 - 20XT
13	18.00	55.00	4	2.40	2.36	2.365	87.665	1.878	-0.0476	V40 - 20XT
14	20.00	55.00	4	2.38	2.51	2.507	87.025	1.901	-0.0589	V40 - 20XT
15	22.00	55.00	4	2.36	2.67	2.667	86.465	1.923	-0.0710	V40 - 20XT
16	24.00	55.00	4	2.34	2.85	2.850	86.101	1.942	-0.0840	V40 - 20XT
17	26.00	55.00	4	3.78	5.01	5.014	140.832	1.959	-0.0982	V40 - 20XT
18	28.00	55.00	4	16.57	24.02	24.024	625.610	1.972	-0.1138	V40 - 20XT
19	29.33	55.00	4	1.55	2.40	2.404	59.452	1.978	-0.1252	V40 - 20XT
20	32.67	35.00	3	2.94	2.22	2.221	55.224	1.982	0.0478	V40 - 10XT
21	34.00	35.00	3	3.06	2.31	2.311	53.519	2.025	0.0410	V40 - 10XT
22	35.33	35.00	3	3.16	2.39	2.390	51.389	2.070	0.0343	V40 - 10XT
23	36.67	35.00	3	3.29	2.49	2.485	49.387	2.117	0.0275	V40 - 10XT
24	38.00	35.00	3	2.76	2.09	2.086	38.205	2.165	0.0207	V40 - 10XT
25	40.00	35.00	3	2.44	1.84	1.842	29.595	2.242	0.0106	V40 - 10XT
26	42.00	35.00	3	2.61	1.97	1.972	27.489	2.324	0.0003	V40 - 10XT
27	44.00	35.00	3	2.81	2.12	2.123	25.293	2.411	-0.0102	V40 - 10XT
28	46.00	35.00	3	2.83	2.30	2.298	23.022	2.503	-0.0211	V40 - 10XT
29	48.00	35.00	3	2.81	2.50	2.504	20.633	2.600	-0.0326	V40 - 10XT
30	50.00	35.00	3	2.78	2.75	2.752	18.093	2.701	-0.0450	V40 - 10XT
31	52.00	35.00	3	2.75	3.05	3.053	15.351	2.803	-0.0588	V40 - 10XT
32	54.00	35.00	3	2.71	3.43	3.429	12.333	2.905	-0.0747	V40 - 10XT
33	56.00	35.00	3	2.66	3.91	3.911	8.921	2.998	-0.0939	V40 - 10XT
34	58.00	35.00	3	1.80	3.16	3.162	3.423	3.073	-0.1185	V40 - 10XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.555
(it corresponds to a critical circle at Xc = -8.00, Yc = 212.00 and R = 157.50 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.003
(it corresponds to a critical circle at Xc = -8.00, Yc = 212.00 and R = 157.50 [ft]).

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ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 5.71, Meyerhof stress = 9481 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.249, Eccentricity, e/L = 0.1182, Fs-overturning = 2.63

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	55.00	4	1.94	1.90	1.900	81.450	1.179	0.1127	V40 - 20XT
2	2.00	55.00	4	1.99	1.95	1.950	80.715	1.201	0.1020	V40 - 20XT
3	3.33	55.00	4	2.03	1.99	1.991	79.527	1.224	0.0913	V40 - 20XT
4	4.67	55.00	4	2.07	2.04	2.040	78.583	1.248	0.0807	V40 - 20XT
5	6.00	55.00	4	2.13	2.10	2.098	77.819	1.273	0.0703	V40 - 20XT
6	7.33	55.00	4	2.18	2.15	2.146	76.690	1.299	0.0599	V40 - 20XT
7	8.67	55.00	4	2.23	2.20	2.204	75.762	1.326	0.0496	V40 - 20XT
8	10.00	55.00	4	2.29	2.27	2.271	75.006	1.354	0.0393	V40 - 20XT
9	11.33	55.00	4	2.35	2.33	2.328	73.906	1.631	-0.0026	V40 - 20XT
10	12.67	55.00	4	2.41	2.40	2.395	72.966	1.655	-0.0097	V40 - 20XT
11	14.00	55.00	4	2.11	2.08	2.077	61.973	1.679	-0.0168	V40 - 20XT
12	16.00	55.00	4	1.81	1.87	1.866	53.081	1.715	-0.0277	V40 - 20XT
13	18.00	55.00	4	1.79	1.96	1.962	52.226	1.750	-0.0389	V40 - 20XT
14	20.00	55.00	4	1.76	2.07	2.068	51.398	1.784	-0.0505	V40 - 20XT
15	22.00	55.00	4	1.73	2.19	2.186	50.576	1.816	-0.0627	V40 - 20XT
16	24.00	55.00	4	1.69	2.32	2.319	49.817	1.845	-0.0756	V40 - 20XT
17	26.00	55.00	4	2.29	3.60	3.601	68.061	1.868	-0.0895	V40 - 20XT
18	28.00	55.00	4	4.09	8.49	8.492	123.446	1.885	-0.1046	V40 - 20XT
19	29.33	55.00	4	1.20	2.04	2.038	36.587	1.892	-0.1155	V40 - 20XT
20	32.67	35.00	3	2.14	1.82	1.817	32.234	1.362	0.1177	V40 - 10XT
21	34.00	35.00	3	2.22	1.89	1.885	31.083	1.408	0.1041	V40 - 10XT
22	35.33	35.00	3	2.29	1.95	1.945	29.750	1.457	0.0908	V40 - 10XT
23	36.67	35.00	3	2.37	2.02	2.017	28.461	1.509	0.0779	V40 - 10XT
24	38.00	35.00	3	2.09	1.75	1.752	23.183	1.565	0.0653	V40 - 10XT
25	40.00	35.00	3	1.92	1.58	1.584	18.624	1.658	0.0471	V40 - 10XT
26	42.00	35.00	3	2.04	1.69	1.689	17.182	1.761	0.0296	V40 - 10XT
27	44.00	35.00	3	2.18	1.81	1.809	15.686	1.877	0.0126	V40 - 10XT
28	46.00	35.00	3	2.17	1.95	1.946	14.150	2.006	-0.0039	V40 - 10XT
29	48.00	35.00	3	2.13	2.11	2.107	12.549	2.152	-0.0202	V40 - 10XT
30	50.00	35.00	3	2.09	2.30	2.296	10.868	2.314	-0.0367	V40 - 10XT
31	52.00	35.00	3	2.03	2.52	2.522	9.084	2.492	-0.0537	V40 - 10XT
32	54.00	35.00	3	1.97	2.80	2.798	7.166	2.682	-0.0720	V40 - 10XT
33	56.00	35.00	3	1.89	3.14	3.142	5.066	2.871	-0.0928	V40 - 10XT
34	58.00	35.00	3	1.37	2.66	2.662	2.084	3.031	-0.1182	V40 - 10XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.555
(it corresponds to a critical circle at Xc = -8.00, Yc = 212.00 and R = 157.50 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.003
(it corresponds to a critical circle at Xc = -8.00, Yc = 212.00 and R = 157.50 [ft]).

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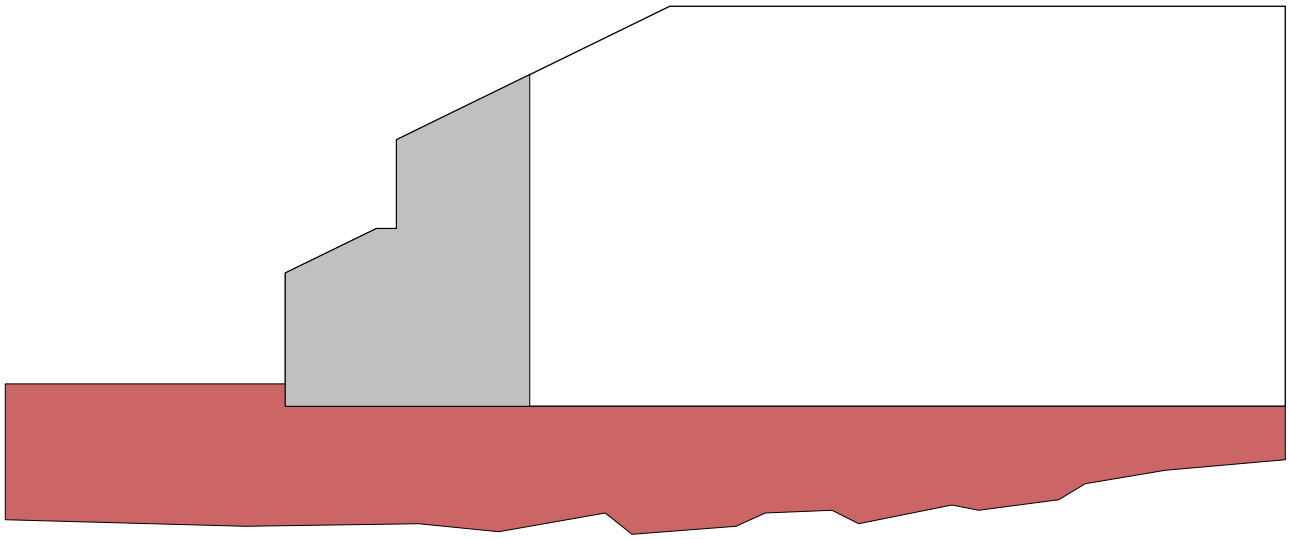
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	63924	54183	[lb/ft ²]
Meyerhof stress, σ_V	7521.2	9481	[lb/ft ²]
Eccentricity, e	2.07	6.92	[ft]
Eccentricity, e/L	0.038	0.126	
Fs calculated	8.50	5.71	
Base length	55.00	55.00	[ft]



SCALE:

0 5 10 15 20 25 30 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 1.773 and Fs-seismic = 1.249

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	55.00	1.663	1.179	4	V40 - 20XT
2	2.00	55.00	1.679	1.201	4	V40 - 20XT
3	3.33	55.00	1.696	1.224	4	V40 - 20XT
4	4.67	55.00	1.712	1.248	4	V40 - 20XT
5	6.00	55.00	1.729	1.273	4	V40 - 20XT
6	7.33	55.00	1.746	1.299	4	V40 - 20XT
7	8.67	55.00	1.763	1.326	4	V40 - 20XT
8	10.00	55.00	1.779	1.354	4	V40 - 20XT
9	11.33	55.00	1.796	1.631	4	V40 - 20XT
10	12.67	55.00	1.813	1.655	4	V40 - 20XT
11	14.00	55.00	1.830	1.679	4	V40 - 20XT
12	16.00	55.00	1.854	1.715	4	V40 - 20XT
13	18.00	55.00	1.878	1.750	4	V40 - 20XT
14	20.00	55.00	1.901	1.784	4	V40 - 20XT
15	22.00	55.00	1.923	1.816	4	V40 - 20XT
16	24.00	55.00	1.942	1.845	4	V40 - 20XT
17	26.00	55.00	1.959	1.868	4	V40 - 20XT
18	28.00	55.00	1.972	1.885	4	V40 - 20XT
19	29.33	55.00	1.978	1.892	4	V40 - 20XT
20	32.67	35.00	1.982	1.362	3	V40 - 10XT
21	34.00	35.00	2.025	1.408	3	V40 - 10XT
22	35.33	35.00	2.070	1.457	3	V40 - 10XT
23	36.67	35.00	2.117	1.509	3	V40 - 10XT
24	38.00	35.00	2.165	1.565	3	V40 - 10XT
25	40.00	35.00	2.242	1.658	3	V40 - 10XT
26	42.00	35.00	2.324	1.761	3	V40 - 10XT
27	44.00	35.00	2.411	1.877	3	V40 - 10XT
28	46.00	35.00	2.503	2.006	3	V40 - 10XT
29	48.00	35.00	2.600	2.152	3	V40 - 10XT
30	50.00	35.00	2.701	2.314	3	V40 - 10XT
31	52.00	35.00	2.803	2.492	3	V40 - 10XT
32	54.00	35.00	2.905	2.682	3	V40 - 10XT
33	56.00	35.00	2.998	2.871	3	V40 - 10XT
34	58.00	35.00	3.073	3.031	3	V40 - 10XT

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ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0376, e/L seismic = 0.1182; Overturning: Fs-static = 4.00, Fs-seismic = 2.63

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	55.00	0.0347	0.1127	4	V40 - 20XT
2	2.00	55.00	0.0289	0.1020	4	V40 - 20XT
3	3.33	55.00	0.0231	0.0913	4	V40 - 20XT
4	4.67	55.00	0.0171	0.0807	4	V40 - 20XT
5	6.00	55.00	0.0112	0.0703	4	V40 - 20XT
6	7.33	55.00	0.0052	0.0599	4	V40 - 20XT
7	8.67	55.00	-0.0010	0.0496	4	V40 - 20XT
8	10.00	55.00	-0.0072	0.0393	4	V40 - 20XT
9	11.33	55.00	-0.0135	-0.0026	4	V40 - 20XT
10	12.67	55.00	-0.0200	-0.0097	4	V40 - 20XT
11	14.00	55.00	-0.0266	-0.0168	4	V40 - 20XT
12	16.00	55.00	-0.0368	-0.0277	4	V40 - 20XT
13	18.00	55.00	-0.0476	-0.0389	4	V40 - 20XT
14	20.00	55.00	-0.0589	-0.0505	4	V40 - 20XT
15	22.00	55.00	-0.0710	-0.0627	4	V40 - 20XT
16	24.00	55.00	-0.0840	-0.0756	4	V40 - 20XT
17	26.00	55.00	-0.0982	-0.0895	4	V40 - 20XT
18	28.00	55.00	-0.1138	-0.1046	4	V40 - 20XT
19	29.33	55.00	-0.1252	-0.1155	4	V40 - 20XT
20	32.67	35.00	0.0478	0.1177	3	V40 - 10XT
21	34.00	35.00	0.0410	0.1041	3	V40 - 10XT
22	35.33	35.00	0.0343	0.0908	3	V40 - 10XT
23	36.67	35.00	0.0275	0.0779	3	V40 - 10XT
24	38.00	35.00	0.0207	0.0653	3	V40 - 10XT
25	40.00	35.00	0.0106	0.0471	3	V40 - 10XT
26	42.00	35.00	0.0003	0.0296	3	V40 - 10XT
27	44.00	35.00	-0.0102	0.0126	3	V40 - 10XT
28	46.00	35.00	-0.0211	-0.0039	3	V40 - 10XT
29	48.00	35.00	-0.0326	-0.0202	3	V40 - 10XT
30	50.00	35.00	-0.0450	-0.0367	3	V40 - 10XT
31	52.00	35.00	-0.0588	-0.0537	3	V40 - 10XT
32	54.00	35.00	-0.0747	-0.0720	3	V40 - 10XT
33	56.00	35.00	-0.0939	-0.0928	3	V40 - 10XT
34	58.00	35.00	-0.1185	-0.1182	3	V40 - 10XT

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Tavailable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.67	6146	2588.10	1081.27	N/A	2.375	N/A	1.900	V40 - 20XT
2	2.00	6146	2513.06	1066.68	N/A	2.446	N/A	1.950	V40 - 20XT
3	3.33	6146	2456.92	1052.08	N/A	2.502	N/A	1.991	V40 - 20XT
4	4.67	6146	2391.21	1037.38	N/A	2.570	N/A	2.040	V40 - 20XT
5	6.00	6146	2316.91	1022.79	N/A	2.653	N/A	2.098	V40 - 20XT
6	7.33	6146	2260.03	1008.20	N/A	2.720	N/A	2.146	V40 - 20XT
7	8.67	6146	2194.31	993.50	N/A	2.801	N/A	2.204	V40 - 20XT
8	10.00	6146	2120.75	978.90	N/A	2.898	N/A	2.271	V40 - 20XT
9	11.33	6146	2063.14	964.31	N/A	2.979	N/A	2.328	V40 - 20XT
10	12.67	6146	1997.42	949.61	N/A	3.077	N/A	2.395	V40 - 20XT
11	14.00	6146	2399.08	935.02	N/A	2.562	N/A	2.077	V40 - 20XT
12	16.00	6146	2746.65	913.07	N/A	2.238	N/A	1.866	V40 - 20XT
13	18.00	6146	2599.16	891.13	N/A	2.365	N/A	1.962	V40 - 20XT
14	20.00	6146	2451.68	869.19	N/A	2.507	N/A	2.068	V40 - 20XT
15	22.00	6146	2304.20	847.25	N/A	2.667	N/A	2.186	V40 - 20XT
16	24.00	6146	2156.71	825.30	N/A	2.850	N/A	2.319	V40 - 20XT
17	26.00	6146	1225.84	803.36	N/A	5.014	N/A	3.601	V40 - 20XT
18	28.00	6146	255.84	781.42	N/A	24.024	N/A	8.492	V40 - 20XT
19	29.33	6146	2556.25	766.83	N/A	2.404	N/A	2.038	V40 - 20XT
20	32.67	4107	1849.59	685.41	N/A	2.221	N/A	1.817	V40 - 10XT
21	34.00	4107	1777.27	670.81	N/A	2.311	N/A	1.885	V40 - 10XT
22	35.33	4107	1718.36	656.22	N/A	2.390	N/A	1.945	V40 - 10XT
23	36.67	4107	1652.65	641.52	N/A	2.485	N/A	2.017	V40 - 10XT
24	38.00	4107	1969.09	626.93	N/A	2.086	N/A	1.752	V40 - 10XT
25	40.00	4107	2230.13	604.98	N/A	1.842	N/A	1.584	V40 - 10XT
26	42.00	4107	2082.65	583.04	N/A	1.972	N/A	1.689	V40 - 10XT
27	44.00	4107	1935.17	561.10	N/A	2.123	N/A	1.809	V40 - 10XT
28	46.00	4107	1787.68	539.16	N/A	2.298	N/A	1.946	V40 - 10XT
29	48.00	4107	1640.20	517.21	N/A	2.504	N/A	2.107	V40 - 10XT
30	50.00	4107	1492.71	495.27	N/A	2.752	N/A	2.296	V40 - 10XT
31	52.00	4107	1345.23	473.33	N/A	3.053	N/A	2.522	V40 - 10XT
32	54.00	4107	1197.75	451.38	N/A	3.429	N/A	2.798	V40 - 10XT
33	56.00	4107	1050.26	429.44	N/A	3.911	N/A	3.142	V40 - 10XT
34	58.00	4107	1298.86	407.50	N/A	3.162	N/A	2.662	V40 - 10XT

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RESULTS for PULLOUT Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic Fs	Actual Seismic Fs
1	0.67	1.000	2588.1	1081.3	54.63	0.37	373587.2	N/A	144.348	298869.8	N/A	81.450
2	2.00	1.000	2513.1	1066.7	53.89	1.11	361173.0	N/A	143.718	288938.4	N/A	80.715
3	3.33	1.000	2456.9	1052.1	53.15	1.85	348823.4	N/A	141.976	279058.7	N/A	79.527
4	4.67	1.000	2391.2	1037.4	52.41	2.59	336784.8	N/A	140.843	269427.9	N/A	78.583
5	6.00	1.000	2316.9	1022.8	51.67	3.33	324866.6	N/A	140.216	259893.2	N/A	77.819
6	7.33	1.000	2260.0	1008.2	50.94	4.06	313298.9	N/A	138.626	250639.2	N/A	76.690
7	8.67	1.000	2194.3	993.5	50.19	4.81	301894.9	N/A	137.581	241515.9	N/A	75.762
8	10.00	1.000	2120.8	978.9	49.46	5.54	290616.6	N/A	137.035	232493.3	N/A	75.006
9	11.33	1.000	2063.1	964.3	48.72	6.28	279683.9	N/A	135.563	223747.1	N/A	73.906
10	12.67	1.000	1997.4	949.6	47.98	7.02	268791.7	N/A	134.569	215033.4	N/A	72.966
11	14.00	1.000	2399.1	935.0	47.24	7.76	258280.5	N/A	107.658	206624.4	N/A	61.973
12	16.00	1.000	2746.6	913.1	46.13	8.87	242829.2	N/A	88.409	194263.4	N/A	53.081
13	18.00	1.000	2599.2	891.1	45.02	9.98	227855.3	N/A	87.665	182284.2	N/A	52.226
14	20.00	1.000	2451.7	869.2	43.91	11.09	213358.7	N/A	87.025	170686.9	N/A	51.398
15	22.00	1.000	2304.2	847.2	42.81	12.19	199232.9	N/A	86.465	159386.3	N/A	50.576
16	24.00	1.000	2156.7	825.3	41.70	13.30	185695.0	N/A	86.101	148556.0	N/A	49.817
17	26.00	1.000	1225.8	803.4	40.59	14.41	172637.4	N/A	140.832	138109.9	N/A	68.061
18	28.00	1.000	255.8	781.4	39.48	15.52	160057.1	N/A	625.610	128045.7	N/A	123.446
19	29.33	1.000	2556.3	766.8	38.74	16.26	151975.5	N/A	59.452	121580.4	N/A	36.587
20	32.67	1.000	1849.6	685.4	34.63	0.37	102142.2	N/A	55.224	81713.8	N/A	32.234
21	34.00	1.000	1777.3	670.8	33.89	1.11	95118.6	N/A	53.519	76094.9	N/A	31.083
22	35.33	1.000	1718.4	656.2	33.15	1.85	88305.0	N/A	51.389	70644.0	N/A	29.750
23	36.67	1.000	1652.6	641.5	32.41	2.59	81619.2	N/A	49.387	65295.4	N/A	28.461
24	38.00	1.000	1969.1	626.9	31.67	3.33	75229.2	N/A	38.205	60183.3	N/A	23.183
25	40.00	1.000	2230.1	605.0	30.57	4.43	66001.2	N/A	29.595	52800.9	N/A	18.624
26	42.00	1.000	2082.7	583.0	29.46	5.54	57251.0	N/A	27.489	45800.8	N/A	17.182
27	44.00	1.000	1935.2	561.1	28.35	6.65	48946.1	N/A	25.293	39156.9	N/A	15.686
28	46.00	1.000	1787.7	539.2	27.24	7.76	41155.6	N/A	23.022	32924.5	N/A	14.150
29	48.00	1.000	1640.2	517.2	26.13	8.87	33842.8	N/A	20.633	27074.2	N/A	12.549
30	50.00	1.000	1492.7	495.3	25.02	9.98	27007.8	N/A	18.093	21606.3	N/A	10.868
31	52.00	1.000	1345.2	473.3	23.91	11.09	20650.7	N/A	15.351	16520.5	N/A	9.084
32	54.00	1.000	1197.7	451.4	22.81	12.19	14771.3	N/A	12.333	11817.0	N/A	7.166
33	56.00	1.000	1050.3	429.4	21.70	13.30	9369.7	N/A	8.921	7495.8	N/A	5.066
34	58.00	1.000	1298.9	407.5	20.59	14.41	4446.0	N/A	3.423	3556.8	N/A	2.084

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	2588	0.63	0.63	7113	6146	N/A	2.75	N/A	2.37	V40 - 20XT
2	2.00	2513	0.63	0.63	7113	6146	N/A	2.83	N/A	2.45	V40 - 20XT
3	3.33	2457	0.63	0.63	7113	6146	N/A	2.90	N/A	2.50	V40 - 20XT
4	4.67	2391	0.63	0.63	7113	6146	N/A	2.97	N/A	2.57	V40 - 20XT
5	6.00	2317	0.63	0.63	7113	6146	N/A	3.07	N/A	2.65	V40 - 20XT
6	7.33	2260	0.63	0.63	7113	6146	N/A	3.15	N/A	2.72	V40 - 20XT
7	8.67	2194	0.63	0.63	7113	6146	N/A	3.24	N/A	2.80	V40 - 20XT
8	10.00	2121	0.63	0.63	7113	6146	N/A	3.35	N/A	2.90	V40 - 20XT
9	11.33	2063	0.63	0.63	7113	6146	N/A	3.45	N/A	2.98	V40 - 20XT
10	12.67	1997	0.63	0.63	7113	6146	N/A	3.56	N/A	3.08	V40 - 20XT
11	14.00	2399	0.62	0.62	7041	6146	N/A	2.94	N/A	2.56	V40 - 20XT
12	16.00	2747	0.59	0.59	6641	6146	N/A	2.42	N/A	2.24	V40 - 20XT
13	18.00	2599	0.55	0.55	6241	6146	N/A	2.40	N/A	2.36	V40 - 20XT
14	20.00	2452	0.52	0.52	5840	6146	N/A	2.38	N/A	2.51	V40 - 20XT
15	22.00	2304	0.48	0.48	5440	6146	N/A	2.36	N/A	2.67	V40 - 20XT
16	24.00	2157	0.45	0.45	5040	6146	N/A	2.34	N/A	2.85	V40 - 20XT
17	26.00	1226	0.41	0.41	4640	6146	N/A	3.78	N/A	5.01	V40 - 20XT
18	28.00	256	0.38	0.38	4239	6146	N/A	16.57	N/A	24.02	V40 - 20XT
19	29.33	2556	0.35	0.35	3973	6146	N/A	1.55	N/A	2.40	V40 - 20XT
20	32.67	1850	0.72	0.72	5433	4107	N/A	2.94	N/A	2.22	V40 - 10XT
21	34.00	1777	0.72	0.72	5433	4107	N/A	3.06	N/A	2.31	V40 - 10XT
22	35.33	1718	0.72	0.72	5433	4107	N/A	3.16	N/A	2.39	V40 - 10XT
23	36.67	1653	0.72	0.72	5433	4107	N/A	3.29	N/A	2.49	V40 - 10XT
24	38.00	1969	0.72	0.72	5433	4107	N/A	2.76	N/A	2.09	V40 - 10XT
25	40.00	2230	0.72	0.72	5433	4107	N/A	2.44	N/A	1.84	V40 - 10XT
26	42.00	2083	0.72	0.72	5433	4107	N/A	2.61	N/A	1.97	V40 - 10XT
27	44.00	1935	0.72	0.72	5433	4107	N/A	2.81	N/A	2.12	V40 - 10XT
28	46.00	1788	0.67	0.67	5059	4107	N/A	2.83	N/A	2.30	V40 - 10XT
29	48.00	1640	0.61	0.61	4606	4107	N/A	2.81	N/A	2.50	V40 - 10XT
30	50.00	1493	0.55	0.55	4152	4107	N/A	2.78	N/A	2.75	V40 - 10XT
31	52.00	1345	0.49	0.49	3699	4107	N/A	2.75	N/A	3.05	V40 - 10XT
32	54.00	1198	0.43	0.43	3246	4107	N/A	2.71	N/A	3.43	V40 - 10XT
33	56.00	1050	0.37	0.37	2793	4107	N/A	2.66	N/A	3.91	V40 - 10XT
34	58.00	1299	0.31	0.31	2340	4107	N/A	1.80	N/A	3.16	V40 - 10XT

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RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	3669	0.63	0.63	7113	6146	N/A	1.94	N/A	1.90	V40 - 20XT
2	2.00	3580	0.63	0.63	7113	6146	N/A	1.99	N/A	1.95	V40 - 20XT
3	3.33	3509	0.63	0.63	7113	6146	N/A	2.03	N/A	1.99	V40 - 20XT
4	4.67	3429	0.63	0.63	7113	6146	N/A	2.07	N/A	2.04	V40 - 20XT
5	6.00	3340	0.63	0.63	7113	6146	N/A	2.13	N/A	2.10	V40 - 20XT
6	7.33	3268	0.63	0.63	7113	6146	N/A	2.18	N/A	2.15	V40 - 20XT
7	8.67	3188	0.63	0.63	7113	6146	N/A	2.23	N/A	2.20	V40 - 20XT
8	10.00	3100	0.63	0.63	7113	6146	N/A	2.29	N/A	2.27	V40 - 20XT
9	11.33	3027	0.63	0.63	7113	6146	N/A	2.35	N/A	2.33	V40 - 20XT
10	12.67	2947	0.63	0.63	7113	6146	N/A	2.41	N/A	2.40	V40 - 20XT
11	14.00	3334	0.62	0.62	7041	6146	N/A	2.11	N/A	2.08	V40 - 20XT
12	16.00	3660	0.59	0.59	6641	6146	N/A	1.81	N/A	1.87	V40 - 20XT
13	18.00	3490	0.55	0.55	6241	6146	N/A	1.79	N/A	1.96	V40 - 20XT
14	20.00	3321	0.52	0.52	5840	6146	N/A	1.76	N/A	2.07	V40 - 20XT
15	22.00	3151	0.48	0.48	5440	6146	N/A	1.73	N/A	2.19	V40 - 20XT
16	24.00	2982	0.45	0.45	5040	6146	N/A	1.69	N/A	2.32	V40 - 20XT
17	26.00	2029	0.41	0.41	4640	6146	N/A	2.29	N/A	3.60	V40 - 20XT
18	28.00	1037	0.38	0.38	4239	6146	N/A	4.09	N/A	8.49	V40 - 20XT
19	29.33	3323	0.35	0.35	3973	6146	N/A	1.20	N/A	2.04	V40 - 20XT
20	32.67	2535	0.72	0.72	5433	4107	N/A	2.14	N/A	1.82	V40 - 10XT
21	34.00	2448	0.72	0.72	5433	4107	N/A	2.22	N/A	1.89	V40 - 10XT
22	35.33	2375	0.72	0.72	5433	4107	N/A	2.29	N/A	1.95	V40 - 10XT
23	36.67	2294	0.72	0.72	5433	4107	N/A	2.37	N/A	2.02	V40 - 10XT
24	38.00	2596	0.72	0.72	5433	4107	N/A	2.09	N/A	1.75	V40 - 10XT
25	40.00	2835	0.72	0.72	5433	4107	N/A	1.92	N/A	1.58	V40 - 10XT
26	42.00	2666	0.72	0.72	5433	4107	N/A	2.04	N/A	1.69	V40 - 10XT
27	44.00	2496	0.72	0.72	5433	4107	N/A	2.18	N/A	1.81	V40 - 10XT
28	46.00	2327	0.67	0.67	5059	4107	N/A	2.17	N/A	1.95	V40 - 10XT
29	48.00	2157	0.61	0.61	4606	4107	N/A	2.13	N/A	2.11	V40 - 10XT
30	50.00	1988	0.55	0.55	4152	4107	N/A	2.09	N/A	2.30	V40 - 10XT
31	52.00	1819	0.49	0.49	3699	4107	N/A	2.03	N/A	2.52	V40 - 10XT
32	54.00	1649	0.43	0.43	3246	4107	N/A	1.97	N/A	2.80	V40 - 10XT
33	56.00	1480	0.37	0.37	2793	4107	N/A	1.89	N/A	3.14	V40 - 10XT
34	58.00	1706	0.31	0.31	2340	4107	N/A	1.37	N/A	2.66	V40 - 10XT

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GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.180 has been applied.
The seismic force is applied at the center of the sliding mass.

STATIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.555
(it corresponds to a critical circle at Xc = -8.00, Yc = 212.00 and R = 157.50 [ft] where (x=0, y=0) is taken at the TOE or Xc = 92.00, Yc = 1212.00 and R = 157.50 [ft] when the terrain coordinate system is used as shown in the table below.)

SEISMIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.003
(it corresponds to a critical circle at Xc = -8.00, Yc = 212.00 and R = 157.50 [ft] where (x=0, y=0) is taken at the TOE or Xc = 92.00, Yc = 1212.00 and R = 157.50 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Soil layer #1:	γ = 120.00 [lb/ft ³]		ϕ = 28.0°		c = 500.00 [lb/ft ²]						
x [ft]	0.0	15.0	20.0	50.0	180.0	200.0	300.0	350.0	400.0	450.0	500.0
y [ft]	1005.0	1005.0	1005.0	1005.0	1000.0	1090.0	1090.0	1090.0	1090.0	1090.0	1100.0

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AASHTO 2002 ASD DESIGN METHOD
Portola Center - TTM 17300

MSEW(3.0): Update # 14.3

PROJECT IDENTIFICATION

Title: Portola Center - TTM 17300
Project Number: 0704 034A
Client: USA Portola Properties, LLC
Designer: DAO
Station Number: DESIGN 5

Description:

Tiered 19 ft over 19 ft Wall Height - 6 ft 2:1 Separation Slope - Offset of 20 ft - 5 ft Ascending Slope at Crest

Company's information:

Name: Soil Retention Designs, Inc.
Street: 2501 State Street

Carlsbad, CA 92008
Telephone #: 760-966-6090
Fax #: 760-966-6099
E-Mail: dosborne@soilretention.com

Original file path and name: C:\Users\dosborne\Desktop\Portola North Rev Design\Upda.....
.....o 1 slope - 5 ft.BEN

Original date and time of creating this file: Mon Nov 29 16:13:17 2010

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	28.0 °
Equivalent cohesion, $c_{equiv.}$	500.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3627 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 25.80 N γ= 16.72

SEISMICITY

Maximum ground acceleration coefficient, A = 0.360
Design acceleration coefficient in Internal Stability: Kh = Am = 0.392
Design acceleration coefficient in External Stability: Kh_d = 0.175 => Kh = Am = 0.175
(Kh in External Stability is based on allowable displacement, d = 75 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.5013 Kae (Kh = 0) = 0.3627 Δ Kae = 0.1386
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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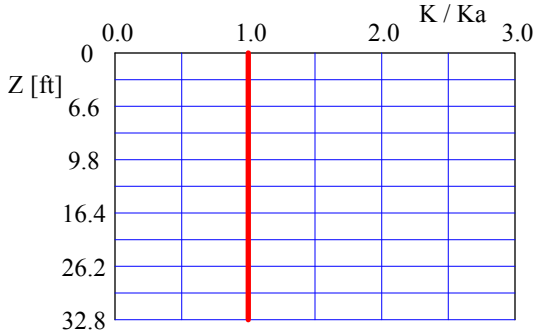
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3590.0	6230.0	8300.0	12420.0	
Durability reduction factor, RFd	1.10	1.10	1.10	1.10	
Installation-damage reduction factor, RFid	1.11	1.10	1.10	1.10	
Creep reduction factor, RFc	1.67	1.67	1.67	1.67	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	1.000	
Friction angle along geogrid-soil interface, ρ	29.40	29.40	29.40	29.40	
Pullout resistance factor, F*	0.90·tarϕ	0.90·tanþ	0.90·tanþ	0.90·tanþ	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Note: Z for calculating K/Ka and F* is measured from top of the wall at the face (AASHTO).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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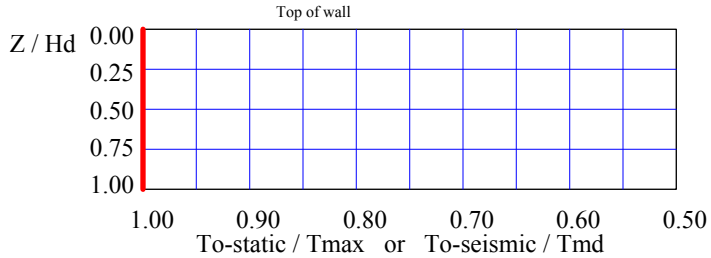
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.00/0.67 ft. Horizontal distance to Center of Gravity of block is 0.42 ft.
Average unit weight of block is γ_f = 117.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	V40 - 5XT	V40 - 8XT	V40 - 10XT	V40 - 20XT	N/A
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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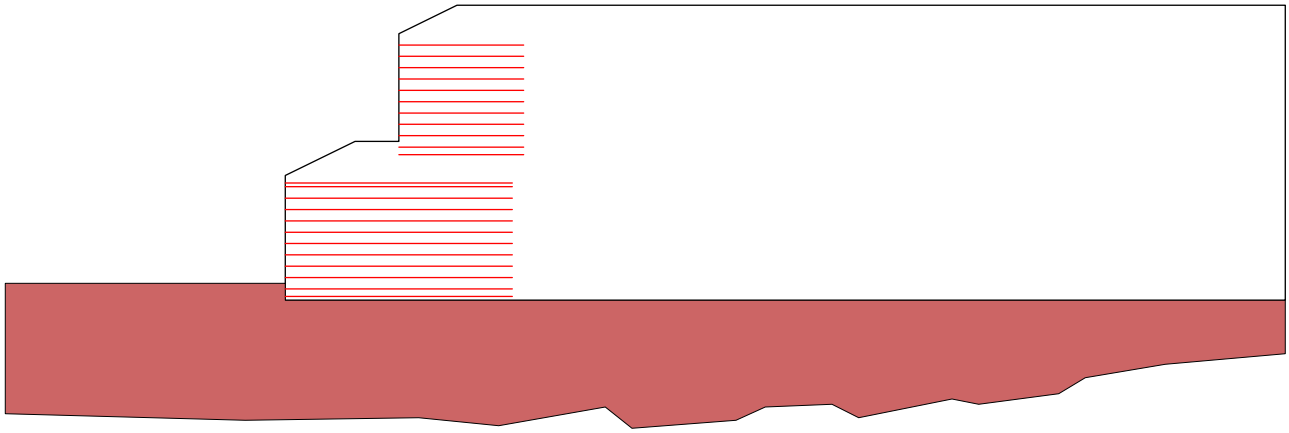
INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

Design height, Hd	47.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 44.00 ft, where H1 = 19.00 and H2 = 19.00 }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	5.0	[ft]	Broken back equivalent angle, I = 3.04° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 20.0 ft, Blackslope2 = 26.0 deg. and Backslope rise, S2 = 6.0 ft.

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 10 15 20 25 30 [ft]

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ANALYSIS: CALCULATED FACTORS (Static condition Bearing capacity, Fs = 9.64, Meyerhof stress = 5137 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.995, Eccentricity, e/L = 0.0434, Fs-overturning = 4.36

GEOGRID				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	40.00	3	2.89	2.18	2.183	109.603	1.814	0.0392	V40 - 10XT
2	2.00	40.00	3	2.41	1.82	1.821	87.328	1.844	0.0306	V40 - 10XT
3	4.00	40.00	3	2.11	1.60	1.596	71.270	1.890	0.0175	V40 - 10XT
4	6.00	40.00	3	2.24	1.69	1.693	70.201	1.938	0.0041	V40 - 10XT
5	8.00	40.00	3	2.22	1.80	1.803	69.236	1.987	-0.0097	V40 - 10XT
6	10.00	40.00	3	2.16	1.93	1.927	68.361	2.036	-0.0242	V40 - 10XT
7	12.00	40.00	3	2.09	2.07	2.071	67.563	2.086	-0.0395	V40 - 10XT
8	14.00	40.00	3	2.01	2.24	2.237	66.934	2.136	-0.0559	V40 - 10XT
9	16.00	40.00	3	1.92	2.43	2.432	66.442	2.185	-0.0737	V40 - 10XT
10	18.00	40.00	3	1.81	2.67	2.665	66.203	2.230	-0.0936	V40 - 10XT
11	20.00	40.00	3	3.87	6.79	6.794	152.656	2.271	-0.1161	V40 - 10XT
12	20.67	40.00	4	1.55	2.31	2.314	33.567	2.283	-0.1244	V40 - 20XT
13	25.67	22.00	2	3.20	2.45	2.451	39.587	2.515	0.0677	V40 - 8XT
14	27.00	22.00	2	2.72	2.09	2.088	30.544	2.640	0.0585	V40 - 8XT
15	29.00	22.00	2	2.45	1.88	1.882	23.449	2.855	0.0453	V40 - 8XT
16	31.00	22.00	2	2.70	2.07	2.068	21.629	3.109	0.0328	V40 - 8XT
17	33.00	22.00	2	2.99	2.29	2.295	19.746	3.412	0.0208	V40 - 8XT
18	35.00	22.00	2	3.27	2.58	2.577	17.819	3.781	0.0093	V40 - 8XT
19	37.00	22.00	2	3.56	2.94	2.940	15.788	4.239	-0.0021	V40 - 8XT
20	39.00	22.00	2	3.94	3.42	3.421	13.642	4.824	-0.0138	V40 - 8XT
21	41.00	22.00	2	4.47	4.09	4.091	11.287	5.594	-0.0265	V40 - 8XT
22	43.00	22.00	2	5.27	5.09	5.086	8.560	6.651	-0.0417	V40 - 8XT
23	45.00	22.00	2	4.76	4.87	4.872	3.724	8.181	-0.0631	V40 - 8XT

ANALYSIS: CALCULATED FACTORS (Seismic conditi Bearing capacity, Fs = 7.04, Meyerhof stress = 6174 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.391, Eccentricity, e/L = 0.1169, Fs-overturning = 2.83

GEOGRID				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	40.00	3	1.80	1.61	1.605	54.774	1.272	0.1090	V40 - 10XT
2	2.00	40.00	3	1.61	1.41	1.407	46.823	1.310	0.0936	V40 - 10XT
3	4.00	40.00	3	1.49	1.28	1.276	40.184	1.371	0.0706	V40 - 10XT
4	6.00	40.00	3	1.56	1.35	1.346	39.238	1.438	0.0479	V40 - 10XT
5	8.00	40.00	3	1.54	1.42	1.423	38.323	1.787	-0.0008	V40 - 10XT
6	10.00	40.00	3	1.48	1.51	1.510	37.425	1.854	-0.0168	V40 - 10XT
7	12.00	40.00	3	1.41	1.61	1.609	36.530	1.923	-0.0333	V40 - 10XT
8	14.00	40.00	3	1.34	1.72	1.721	35.676	1.993	-0.0506	V40 - 10XT
9	16.00	40.00	3	1.26	1.85	1.850	34.833	2.062	-0.0690	V40 - 10XT
10	18.00	40.00	3	1.16	2.00	2.000	34.042	2.128	-0.0892	V40 - 10XT
11	20.00	40.00	3	1.64	3.74	3.739	51.650	2.187	-0.1117	V40 - 10XT
12	20.67	40.00	4	1.18	1.96	1.955	20.553	2.204	-0.1200	V40 - 20XT
13	25.67	22.00	2	2.14	1.89	1.895	21.246	1.465	0.1734	V40 - 8XT
14	27.00	22.00	2	1.94	1.68	1.681	17.408	1.536	0.1546	V40 - 8XT
15	29.00	22.00	2	1.83	1.56	1.560	13.953	1.656	0.1278	V40 - 8XT
16	31.00	22.00	2	1.99	1.70	1.703	12.748	1.798	0.1027	V40 - 8XT
17	33.00	22.00	2	2.18	1.88	1.876	11.506	2.156	0.0608	V40 - 8XT
18	35.00	22.00	2	2.35	2.09	2.087	10.237	2.464	0.0377	V40 - 8XT
19	37.00	22.00	2	2.51	2.35	2.352	8.910	2.870	0.0168	V40 - 8XT
20	39.00	22.00	2	2.72	2.69	2.694	7.522	3.429	-0.0024	V40 - 8XT
21	41.00	22.00	2	2.99	3.15	3.152	6.031	4.239	-0.0206	V40 - 8XT
22	43.00	22.00	2	3.36	3.80	3.799	4.373	5.486	-0.0395	V40 - 8XT
23	45.00	22.00	2	3.19	3.76	3.763	1.997	7.521	-0.0627	V40 - 8XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.690
(it corresponds to a critical circle at Xc = -32.00, Yc = 124.00 and R = 128.06 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.108
(it corresponds to a critical circle at Xc = -80.00, Yc = 212.00 and R = 226.59 [ft]).

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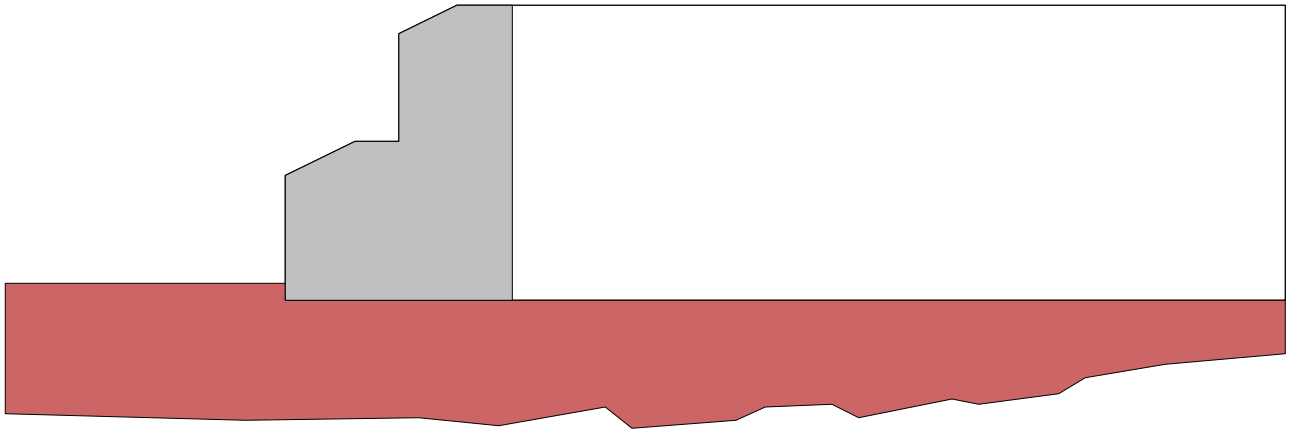
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	49537	43471	[lb/ft ²]
Meyerhof stress, σ_V	5136.7	6174	[lb/ft ²]
Eccentricity, e	1.74	4.76	[ft]
Eccentricity, e/L	0.043	0.119	
Fs calculated	9.64	7.04	
Base length	40.00	40.00	[ft]



SCALE:

0 5 10 15 20 25 30 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 1.995 and Fs-seismic = 1.391

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	40.00	1.814	1.272	3	V40 - 10XT
2	2.00	40.00	1.844	1.310	3	V40 - 10XT
3	4.00	40.00	1.890	1.371	3	V40 - 10XT
4	6.00	40.00	1.938	1.438	3	V40 - 10XT
5	8.00	40.00	1.987	1.787	3	V40 - 10XT
6	10.00	40.00	2.036	1.854	3	V40 - 10XT
7	12.00	40.00	2.086	1.923	3	V40 - 10XT
8	14.00	40.00	2.136	1.993	3	V40 - 10XT
9	16.00	40.00	2.185	2.062	3	V40 - 10XT
10	18.00	40.00	2.230	2.128	3	V40 - 10XT
11	20.00	40.00	2.271	2.187	3	V40 - 10XT
12	20.67	40.00	2.283	2.204	4	V40 - 20XT
13	25.67	22.00	2.515	1.465	2	V40 - 8XT
14	27.00	22.00	2.640	1.536	2	V40 - 8XT
15	29.00	22.00	2.855	1.656	2	V40 - 8XT
16	31.00	22.00	3.109	1.798	2	V40 - 8XT
17	33.00	22.00	3.412	2.156	2	V40 - 8XT
18	35.00	22.00	3.781	2.464	2	V40 - 8XT
19	37.00	22.00	4.239	2.870	2	V40 - 8XT
20	39.00	22.00	4.824	3.429	2	V40 - 8XT
21	41.00	22.00	5.594	4.239	2	V40 - 8XT
22	43.00	22.00	6.651	5.486	2	V40 - 8XT
23	45.00	22.00	8.181	7.521	2	V40 - 8XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0434, e/L seismic = 0.1169; Overturning: Fs-static = 4.36, Fs-seismic = 2.83

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	40.00	0.0392	0.1090	3	V40 - 10XT
2	2.00	40.00	0.0306	0.0936	3	V40 - 10XT
3	4.00	40.00	0.0175	0.0706	3	V40 - 10XT
4	6.00	40.00	0.0041	0.0479	3	V40 - 10XT
5	8.00	40.00	-0.0097	-0.0008	3	V40 - 10XT
6	10.00	40.00	-0.0242	-0.0168	3	V40 - 10XT
7	12.00	40.00	-0.0395	-0.0333	3	V40 - 10XT
8	14.00	40.00	-0.0559	-0.0506	3	V40 - 10XT
9	16.00	40.00	-0.0737	-0.0690	3	V40 - 10XT
10	18.00	40.00	-0.0936	-0.0892	3	V40 - 10XT
11	20.00	40.00	-0.1161	-0.1117	3	V40 - 10XT
12	20.67	40.00	-0.1244	-0.1200	4	V40 - 20XT
13	25.67	22.00	0.0677	0.1734	2	V40 - 8XT
14	27.00	22.00	0.0585	0.1546	2	V40 - 8XT
15	29.00	22.00	0.0453	0.1278	2	V40 - 8XT
16	31.00	22.00	0.0328	0.1027	2	V40 - 8XT
17	33.00	22.00	0.0208	0.0608	2	V40 - 8XT
18	35.00	22.00	0.0093	0.0377	2	V40 - 8XT
19	37.00	22.00	-0.0021	0.0168	2	V40 - 8XT
20	39.00	22.00	-0.0138	-0.0024	2	V40 - 8XT
21	41.00	22.00	-0.0265	-0.0206	2	V40 - 8XT
22	43.00	22.00	-0.0417	-0.0395	2	V40 - 8XT
23	45.00	22.00	-0.0631	-0.0627	2	V40 - 8XT

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Tavailable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.67	4107	1881.95	1130.67	N/A	2.183	N/A	1.605	V40 - 10XT
2	2.00	4107	2255.06	1109.63	N/A	1.821	N/A	1.407	V40 - 10XT
3	4.00	4107	2573.65	1078.00	N/A	1.596	N/A	1.276	V40 - 10XT
4	6.00	4107	2426.17	1046.37	N/A	1.693	N/A	1.346	V40 - 10XT
5	8.00	4107	2278.69	1014.74	N/A	1.803	N/A	1.423	V40 - 10XT
6	10.00	4107	2131.20	983.11	N/A	1.927	N/A	1.510	V40 - 10XT
7	12.00	4107	1983.72	951.48	N/A	2.071	N/A	1.609	V40 - 10XT
8	14.00	4107	1836.23	919.85	N/A	2.237	N/A	1.721	V40 - 10XT
9	16.00	4107	1688.75	888.22	N/A	2.432	N/A	1.850	V40 - 10XT
10	18.00	4107	1541.26	856.59	N/A	2.665	N/A	2.000	V40 - 10XT
11	20.00	4107	604.60	824.96	N/A	6.794	N/A	3.739	V40 - 10XT
12	20.67	6146	2656.23	814.36	N/A	2.314	N/A	1.955	V40 - 20XT
13	25.67	3083	1257.85	617.10	N/A	2.451	N/A	1.895	V40 - 8XT
14	27.00	3083	1476.65	596.06	N/A	2.088	N/A	1.681	V40 - 8XT
15	29.00	3083	1638.62	564.43	N/A	1.882	N/A	1.560	V40 - 8XT
16	31.00	3083	1491.14	532.80	N/A	2.068	N/A	1.703	V40 - 8XT
17	33.00	3083	1343.65	501.17	N/A	2.295	N/A	1.876	V40 - 8XT
18	35.00	3083	1196.17	469.54	N/A	2.577	N/A	2.087	V40 - 8XT
19	37.00	3083	1048.69	437.91	N/A	2.940	N/A	2.352	V40 - 8XT
20	39.00	3083	901.20	406.28	N/A	3.421	N/A	2.694	V40 - 8XT
21	41.00	3083	753.72	374.65	N/A	4.091	N/A	3.152	V40 - 8XT
22	43.00	3083	606.23	343.02	N/A	5.086	N/A	3.799	V40 - 8XT
23	45.00	3083	632.82	311.39	N/A	4.872	N/A	3.763	V40 - 8XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic Fs	Actual Seismic Fs
1	0.67	1.000	1881.9	1130.7	39.63	0.37	206267.3	N/A	109.603	165013.8	N/A	54.774
2	2.00	1.000	2255.1	1109.6	38.89	1.11	196929.4	N/A	87.328	157543.6	N/A	46.823
3	4.00	1.000	2573.7	1078.0	37.78	2.22	183423.6	N/A	71.270	146738.9	N/A	40.184
4	6.00	1.000	2426.2	1046.4	36.67	3.33	170318.4	N/A	70.201	136254.7	N/A	39.238
5	8.00	1.000	2278.7	1014.7	35.57	4.43	157767.3	N/A	69.236	126213.8	N/A	38.323
6	10.00	1.000	2131.2	983.1	34.46	5.54	145691.9	N/A	68.361	116553.6	N/A	37.425
7	12.00	1.000	1983.7	951.5	33.35	6.65	134026.8	N/A	67.563	107221.4	N/A	36.530
8	14.00	1.000	1836.2	919.8	32.24	7.76	122906.1	N/A	66.934	98324.9	N/A	35.676
9	16.00	1.000	1688.7	888.2	31.13	8.87	112204.1	N/A	66.442	89763.3	N/A	34.833
10	18.00	1.000	1541.3	856.6	30.02	9.98	102036.1	N/A	66.203	81628.9	N/A	34.042
11	20.00	1.000	604.6	825.0	28.91	11.09	92295.2	N/A	152.656	73836.2	N/A	51.650
12	20.67	1.000	2656.2	814.4	28.54	11.46	89162.0	N/A	33.567	71329.6	N/A	20.553
13	25.67	1.000	1257.8	617.1	21.63	0.37	49794.3	N/A	39.587	39835.4	N/A	21.246
14	27.00	1.000	1476.7	596.1	20.89	1.11	45103.5	N/A	30.544	36082.8	N/A	17.408
15	29.00	1.000	1638.6	564.4	19.78	2.22	38423.6	N/A	23.449	30738.9	N/A	13.953
16	31.00	1.000	1491.1	532.8	18.67	3.33	32251.2	N/A	21.629	25801.0	N/A	12.748
17	33.00	1.000	1343.7	501.2	17.57	4.43	26532.4	N/A	19.746	21225.9	N/A	11.506
18	35.00	1.000	1196.2	469.5	16.46	5.54	21314.7	N/A	17.819	17051.8	N/A	10.237
19	37.00	1.000	1048.7	437.9	15.35	6.65	16557.0	N/A	15.788	13245.6	N/A	8.910
20	39.00	1.000	901.2	406.3	14.24	7.76	12294.0	N/A	13.642	9835.2	N/A	7.522
21	41.00	1.000	753.7	374.6	13.13	8.87	8506.9	N/A	11.287	6805.5	N/A	6.031
22	43.00	1.000	606.2	343.0	12.02	9.98	5189.1	N/A	8.560	4151.3	N/A	4.373
23	45.00	1.000	632.8	311.4	10.91	11.09	2356.7	N/A	3.724	1885.3	N/A	1.997

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	1882	0.72	0.72	5433	4107	N/A	2.89	N/A	2.18	V40 - 10XT
2	2.00	2255	0.72	0.72	5433	4107	N/A	2.41	N/A	1.82	V40 - 10XT
3	4.00	2574	0.72	0.72	5433	4107	N/A	2.11	N/A	1.60	V40 - 10XT
4	6.00	2426	0.72	0.72	5433	4107	N/A	2.24	N/A	1.69	V40 - 10XT
5	8.00	2279	0.67	0.67	5059	4107	N/A	2.22	N/A	1.80	V40 - 10XT
6	10.00	2131	0.61	0.61	4606	4107	N/A	2.16	N/A	1.93	V40 - 10XT
7	12.00	1984	0.55	0.55	4152	4107	N/A	2.09	N/A	2.07	V40 - 10XT
8	14.00	1836	0.49	0.49	3699	4107	N/A	2.01	N/A	2.24	V40 - 10XT
9	16.00	1689	0.43	0.43	3246	4107	N/A	1.92	N/A	2.43	V40 - 10XT
10	18.00	1541	0.37	0.37	2793	4107	N/A	1.81	N/A	2.67	V40 - 10XT
11	20.00	605	0.31	0.31	2340	4107	N/A	3.87	N/A	6.79	V40 - 10XT
12	20.67	2656	0.36	0.36	4105	6146	N/A	1.55	N/A	2.31	V40 - 20XT
13	25.67	1258	0.71	0.71	4021	3083	N/A	3.20	N/A	2.45	V40 - 8XT
14	27.00	1477	0.71	0.71	4021	3083	N/A	2.72	N/A	2.09	V40 - 8XT
15	29.00	1639	0.71	0.71	4021	3083	N/A	2.45	N/A	1.88	V40 - 8XT
16	31.00	1491	0.71	0.71	4021	3083	N/A	2.70	N/A	2.07	V40 - 8XT
17	33.00	1344	0.71	0.71	4021	3083	N/A	2.99	N/A	2.29	V40 - 8XT
18	35.00	1196	0.69	0.69	3913	3083	N/A	3.27	N/A	2.58	V40 - 8XT
19	37.00	1049	0.66	0.66	3733	3083	N/A	3.56	N/A	2.94	V40 - 8XT
20	39.00	901	0.63	0.63	3552	3083	N/A	3.94	N/A	3.42	V40 - 8XT
21	41.00	754	0.60	0.60	3372	3083	N/A	4.47	N/A	4.09	V40 - 8XT
22	43.00	606	0.56	0.56	3192	3083	N/A	5.27	N/A	5.09	V40 - 8XT
23	45.00	633	0.53	0.53	3012	3083	N/A	4.76	N/A	4.87	V40 - 8XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	3013	0.72	0.72	5433	4107	N/A	1.80	N/A	1.61	V40 - 10XT
2	2.00	3365	0.72	0.72	5433	4107	N/A	1.61	N/A	1.41	V40 - 10XT
3	4.00	3652	0.72	0.72	5433	4107	N/A	1.49	N/A	1.28	V40 - 10XT
4	6.00	3473	0.72	0.72	5433	4107	N/A	1.56	N/A	1.35	V40 - 10XT
5	8.00	3293	0.67	0.67	5059	4107	N/A	1.54	N/A	1.42	V40 - 10XT
6	10.00	3114	0.61	0.61	4606	4107	N/A	1.48	N/A	1.51	V40 - 10XT
7	12.00	2935	0.55	0.55	4152	4107	N/A	1.41	N/A	1.61	V40 - 10XT
8	14.00	2756	0.49	0.49	3699	4107	N/A	1.34	N/A	1.72	V40 - 10XT
9	16.00	2577	0.43	0.43	3246	4107	N/A	1.26	N/A	1.85	V40 - 10XT
10	18.00	2398	0.37	0.37	2793	4107	N/A	1.16	N/A	2.00	V40 - 10XT
11	20.00	1430	0.31	0.31	2340	4107	N/A	1.64	N/A	3.74	V40 - 10XT
12	20.67	3471	0.36	0.36	4105	6146	N/A	1.18	N/A	1.96	V40 - 20XT
13	25.67	1875	0.71	0.71	4021	3083	N/A	2.14	N/A	1.89	V40 - 8XT
14	27.00	2073	0.71	0.71	4021	3083	N/A	1.94	N/A	1.68	V40 - 8XT
15	29.00	2203	0.71	0.71	4021	3083	N/A	1.83	N/A	1.56	V40 - 8XT
16	31.00	2024	0.71	0.71	4021	3083	N/A	1.99	N/A	1.70	V40 - 8XT
17	33.00	1845	0.71	0.71	4021	3083	N/A	2.18	N/A	1.88	V40 - 8XT
18	35.00	1666	0.69	0.69	3913	3083	N/A	2.35	N/A	2.09	V40 - 8XT
19	37.00	1487	0.66	0.66	3733	3083	N/A	2.51	N/A	2.35	V40 - 8XT
20	39.00	1307	0.63	0.63	3552	3083	N/A	2.72	N/A	2.69	V40 - 8XT
21	41.00	1128	0.60	0.60	3372	3083	N/A	2.99	N/A	3.15	V40 - 8XT
22	43.00	949	0.56	0.56	3192	3083	N/A	3.36	N/A	3.80	V40 - 8XT
23	45.00	944	0.53	0.53	3012	3083	N/A	3.19	N/A	3.76	V40 - 8XT

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GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.180 has been applied.
The seismic force is applied at the center of the sliding mass.

STATIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.690
(it corresponds to a critical circle at Xc = -32.00, Yc = 124.00 and R = 128.06 [ft] where (x=0, y=0) is taken at the TOE or Xc = 68.00, Yc = 1124.00 and R = 128.06 [ft] when the terrain coordinate system is used as shown in the table below.)

SEISMIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.108
(it corresponds to a critical circle at Xc = -80.00, Yc = 212.00 and R = 226.59 [ft] where (x=0, y=0) is taken at the TOE or Xc = 20.00, Yc = 1212.00 and R = 226.59 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Soil layer #1:	γ = 120.00 [lb/ft ³]		ϕ = 28.0°		c = 500.00 [lb/ft ²]						
x [ft]	0.0	15.0	20.0	50.0	160.0	180.0	300.0	350.0	400.0	450.0	500.0
y [ft]	1003.0	1003.0	1003.0	1003.0	1000.0	1050.0	1050.0	1050.0	1050.0	1050.0	1055.0

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AASHTO 2002 ASD DESIGN METHOD
Portola Center - TTM 17300

MSEW(3.0): Update # 14.3

PROJECT IDENTIFICATION

Title: Portola Center - TTM 17300
Project Number: 0704 034A
Client: USA Portola Properties, LLC
Designer: DAO
Station Number: DESIGN 6

Description:

Lower 2 Walls of 4-Tier - Tiered 20 ft over 20 ft Wall - 10 ft 2:1 Separation Slope - Offset of 25 ft - Upper Walls and Slopes Above Modeled as Surcharge Loading

Company's information:

Name: Soil Retention Designs, Inc.
Street: 2501 State Street

Carlsbad, CA 92008
Telephone #: 760-966-6090
Fax #: 760-966-6099
E-Mail: dosborne@soilretention.com

Original file path and name: C:\Users\dosborne\Desktop\Portola North Rev Design\Upda..... ..... Walls of 4-Tier.BEN

Original date and time of creating this file: Mon Nov 29 16:13:17 2010

PROGRAM MODE: ANALYSIS of SUPERIMPOSED WALL using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	125.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft ³
Design value of internal angle of friction, ϕ	28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	28.0 °
Equivalent cohesion, $c_{equiv.}$	500.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3661 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 25.80 N γ= 16.72

SEISMICITY

Maximum ground acceleration coefficient, A = 0.360
Design acceleration coefficient in Internal Stability: Kh = Am = 0.392
Design acceleration coefficient in External Stability: Kh_d = 0.175 => Kh = Am = 0.175
(Kh in External Stability is based on allowable displacement, d = 75 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.5177 Kae (Kh = 0) = 0.3661 Δ Kae = 0.1515
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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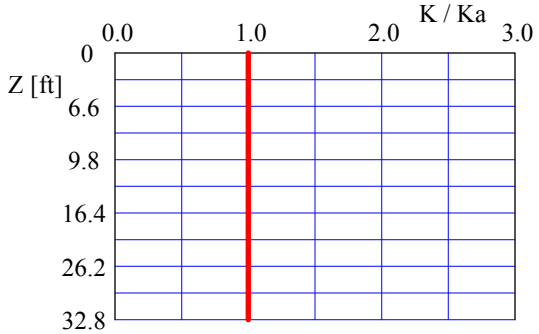
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3590.0	6230.0	8300.0	12420.0	
Durability reduction factor, RFd	1.10	1.10	1.10	1.10	
Installation-damage reduction factor, RFid	1.11	1.10	1.10	1.10	
Creep reduction factor, RFc	1.67	1.67	1.67	1.67	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	1.000	
Friction angle along geogrid-soil interface, ρ	29.40	29.40	29.40	29.40	
Pullout resistance factor, F*	0.90·tarϕ	0.90·tanþ	0.90·tanþ	0.90·tanþ	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Note: Z for calculating K/Ka and F* is measured from top of the wall at the face (AASHTO).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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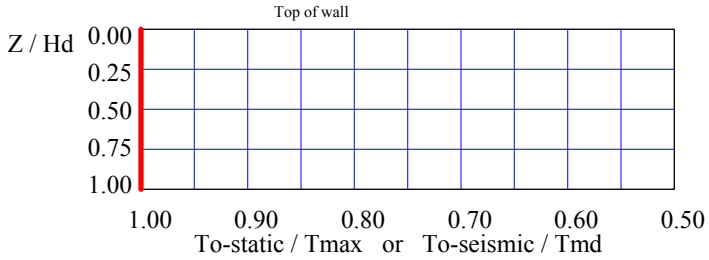
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.00/0.67 ft. Horizontal distance to Center of Gravity of block is 0.42 ft.
Average unit weight of block is γ_f = 117.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	V40 - 5XT	V40 - 8XT	V40 - 10XT	V40 - 20XT	N/A
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

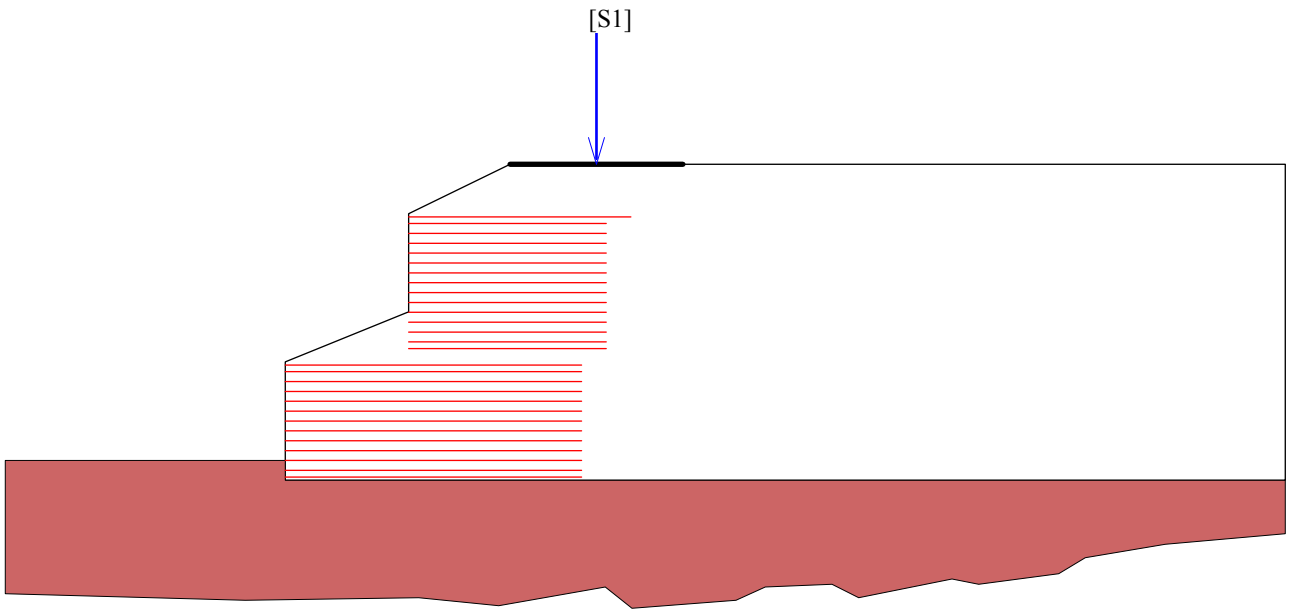
Design height, Hd	54.00	[ft]	{ Embedded depth is E = 4.00 ft, and height above top of finished bottom grade is H = 50.00 ft, where H1 = 20.00 and H2 = 20.00 }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	10.0	[ft]	Broken back equivalent angle, I = 5.29° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 25.0 ft, Blackslope2 = 22.0 deg. and Backslope rise, S2 = 10.0 ft.

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 3352.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=35.0 [ft]. Distance of center of footing from wall face, d = 38.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 1015202530 [ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 9.82, Meyerhof stress = 7372 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.772, Eccentricity, e/L = 0.0255, Fs-overturning = 3.99

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	60.00	4	3.67	3.17	3.175	224.684	1.661	0.0221	V40 - 20XT
2	2.00	60.00	4	3.07	2.65	2.651	181.827	1.673	0.0153	V40 - 20XT
3	4.00	60.00	4	2.69	2.32	2.324	152.024	1.691	0.0048	V40 - 20XT
4	6.00	60.00	4	2.86	2.47	2.468	153.684	1.709	-0.0059	V40 - 20XT
5	8.00	60.00	4	3.01	2.63	2.630	155.772	1.726	-0.0170	V40 - 20XT
6	10.00	60.00	4	3.04	2.82	2.815	158.728	1.743	-0.0285	V40 - 20XT
7	12.00	60.00	4	3.07	3.03	3.028	162.004	1.759	-0.0405	V40 - 20XT
8	14.00	60.00	4	3.11	3.28	3.276	166.078	1.775	-0.0531	V40 - 20XT
9	16.00	60.00	4	4.37	4.94	4.936	236.744	1.789	-0.0663	V40 - 20XT
10	18.00	60.00	4	8.20	10.00	10.002	453.457	1.802	-0.0803	V40 - 20XT
11	20.00	60.00	4	10.07	13.34	13.336	571.932	1.814	-0.0953	V40 - 20XT
12	22.00	60.00	4	15.91	23.06	23.063	931.772	1.823	-0.1115	V40 - 20XT
13	23.33	60.00	4	1.61	2.48	2.485	96.428	1.828	-0.1230	V40 - 20XT
14	26.67	40.00	4	4.01	3.46	3.462	68.613	2.192	0.0162	V40 - 20XT
15	28.00	40.00	4	3.36	2.90	2.902	53.683	2.238	0.0082	V40 - 20XT
16	30.00	40.00	4	2.96	2.56	2.557	42.419	2.311	-0.0039	V40 - 20XT
17	32.00	40.00	4	3.16	2.73	2.732	40.332	2.391	-0.0161	V40 - 20XT
18	34.00	40.00	3	2.59	1.96	1.960	38.158	2.477	-0.0286	V40 - 10XT
19	36.00	40.00	3	2.80	2.11	2.115	35.897	2.571	-0.0413	V40 - 10XT
20	38.00	40.00	3	3.04	2.30	2.296	33.546	2.675	-0.0544	V40 - 10XT
21	40.00	40.00	3	3.09	2.51	2.512	31.038	2.791	-0.0680	V40 - 10XT
22	42.00	40.00	3	3.11	2.77	2.772	28.348	2.922	-0.0821	V40 - 10XT
23	44.00	40.00	3	3.13	3.09	3.093	25.427	3.072	-0.0969	V40 - 10XT
24	46.00	40.00	3	3.15	3.50	3.498	22.149	3.247	-0.1127	V40 - 10XT
25	48.00	40.00	3	3.18	4.02	4.024	18.376	3.457	-0.1296	V40 - 10XT
26	50.00	40.00	3	3.22	4.74	4.737	13.852	3.715	-0.1480	V40 - 10XT
27	52.00	40.00	3	3.87	6.79	6.793	9.518	4.045	-0.1683	V40 - 10XT
28	53.33	45.00	4	4.21	6.52	6.521	2.385	5.506	-0.1692	V40 - 20XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.616
(it corresponds to a critical circle at Xc = -8.00, Yc = 112.00 and R = 112.29 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.196
(it corresponds to a critical circle at Xc = -8.00, Yc = 112.00 and R = 112.29 [ft]).

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ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 8.52, Meyerhof stress = 7983 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.439, Eccentricity, e/L = 0.0576, Fs-overturning = 3.33

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	60.00	4	2.34	2.37	2.370	114.691	1.357	0.0527	V40 - 20XT
2	2.00	60.00	4	2.09	2.07	2.071	99.104	1.380	0.0430	V40 - 20XT
3	4.00	60.00	4	1.92	1.87	1.873	86.721	1.417	0.0285	V40 - 20XT
4	6.00	60.00	4	2.01	1.97	1.973	86.640	1.606	-0.0002	V40 - 20XT
5	8.00	60.00	4	2.10	2.08	2.084	86.668	1.633	-0.0118	V40 - 20XT
6	10.00	60.00	4	2.08	2.21	2.208	87.015	1.659	-0.0238	V40 - 20XT
7	12.00	60.00	4	2.07	2.35	2.348	87.332	1.684	-0.0362	V40 - 20XT
8	14.00	60.00	4	2.06	2.51	2.507	87.826	1.707	-0.0490	V40 - 20XT
9	16.00	60.00	4	2.49	3.40	3.397	107.848	1.729	-0.0623	V40 - 20XT
10	18.00	60.00	4	3.28	5.27	5.271	145.162	1.749	-0.0764	V40 - 20XT
11	20.00	60.00	4	3.41	6.14	6.145	154.868	1.766	-0.0913	V40 - 20XT
12	22.00	60.00	4	3.70	7.74	7.744	173.217	1.779	-0.1073	V40 - 20XT
13	23.33	60.00	4	1.19	2.05	2.054	57.125	1.785	-0.1187	V40 - 20XT
14	26.67	40.00	4	2.84	2.78	2.778	38.899	1.694	0.0503	V40 - 20XT
15	28.00	40.00	4	2.51	2.41	2.413	32.094	1.749	0.0385	V40 - 20XT
16	30.00	40.00	4	2.30	2.18	2.180	26.316	1.838	0.0211	V40 - 20XT
17	32.00	40.00	4	2.43	2.32	2.316	24.816	1.936	0.0041	V40 - 20XT
18	34.00	40.00	3	1.97	1.65	1.651	23.259	2.045	-0.0125	V40 - 10XT
19	36.00	40.00	3	2.11	1.77	1.769	21.647	2.166	-0.0289	V40 - 10XT
20	38.00	40.00	3	2.26	1.90	1.905	19.978	2.301	-0.0451	V40 - 10XT
21	40.00	40.00	3	2.27	2.06	2.063	18.216	2.454	-0.0613	V40 - 10XT
22	42.00	40.00	3	2.24	2.25	2.251	16.351	2.627	-0.0776	V40 - 10XT
23	44.00	40.00	3	2.21	2.48	2.476	14.362	2.825	-0.0941	V40 - 10XT
24	46.00	40.00	3	2.17	2.75	2.751	12.192	3.054	-0.1110	V40 - 10XT
25	48.00	40.00	3	2.12	3.09	3.095	9.790	3.321	-0.1288	V40 - 10XT
26	50.00	40.00	3	2.06	3.54	3.536	7.072	3.638	-0.1477	V40 - 10XT
27	52.00	40.00	3	2.17	4.63	4.632	4.279	4.019	-0.1683	V40 - 10XT
28	53.33	45.00	4	2.66	4.83	4.833	1.205	5.502	-0.1692	V40 - 20XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.616
(it corresponds to a critical circle at Xc = -8.00, Yc = 112.00 and R = 112.29 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.196
(it corresponds to a critical circle at Xc = -8.00, Yc = 112.00 and R = 112.29 [ft]).

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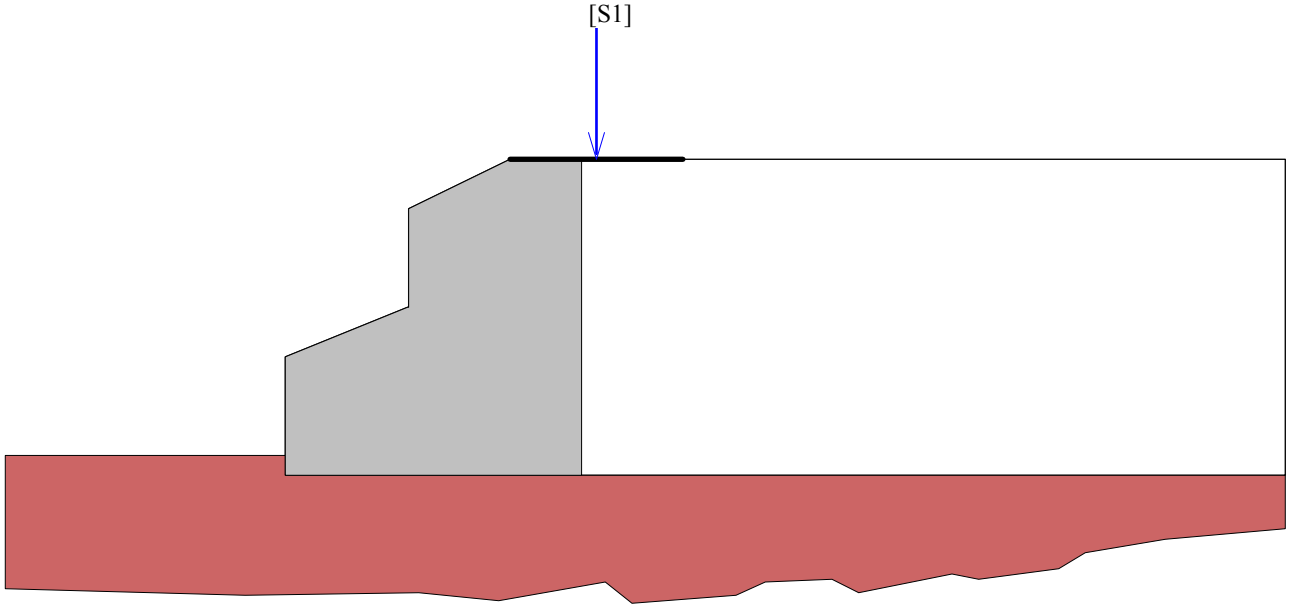
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	72395	68019	[lb/ft ²]
Meyerhof stress, σ_V	7372.5	7983	[lb/ft ²]
Eccentricity, e	1.53	3.62	[ft]
Eccentricity, e/L	0.025	0.060	
Fs calculated	9.82	8.52	
Base length	60.00	60.00	[ft]



SCALE:

0 5 1015202530 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 1.772 and Fs-seismic = 1.439

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	60.00	1.661	1.357	4	V40 - 20XT
2	2.00	60.00	1.673	1.380	4	V40 - 20XT
3	4.00	60.00	1.691	1.417	4	V40 - 20XT
4	6.00	60.00	1.709	1.606	4	V40 - 20XT
5	8.00	60.00	1.726	1.633	4	V40 - 20XT
6	10.00	60.00	1.743	1.659	4	V40 - 20XT
7	12.00	60.00	1.759	1.684	4	V40 - 20XT
8	14.00	60.00	1.775	1.707	4	V40 - 20XT
9	16.00	60.00	1.789	1.729	4	V40 - 20XT
10	18.00	60.00	1.802	1.749	4	V40 - 20XT
11	20.00	60.00	1.814	1.766	4	V40 - 20XT
12	22.00	60.00	1.823	1.779	4	V40 - 20XT
13	23.33	60.00	1.828	1.785	4	V40 - 20XT
14	26.67	40.00	2.192	1.694	4	V40 - 20XT
15	28.00	40.00	2.238	1.749	4	V40 - 20XT
16	30.00	40.00	2.311	1.838	4	V40 - 20XT
17	32.00	40.00	2.391	1.936	4	V40 - 20XT
18	34.00	40.00	2.477	2.045	3	V40 - 10XT
19	36.00	40.00	2.571	2.166	3	V40 - 10XT
20	38.00	40.00	2.675	2.301	3	V40 - 10XT
21	40.00	40.00	2.791	2.454	3	V40 - 10XT
22	42.00	40.00	2.922	2.627	3	V40 - 10XT
23	44.00	40.00	3.072	2.825	3	V40 - 10XT
24	46.00	40.00	3.247	3.054	3	V40 - 10XT
25	48.00	40.00	3.457	3.321	3	V40 - 10XT
26	50.00	40.00	3.715	3.638	3	V40 - 10XT
27	52.00	40.00	4.045	4.019	3	V40 - 10XT
28	53.33	45.00	5.506	5.502	4	V40 - 20XT

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ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0255, e/L seismic = 0.0576; Overturning: Fs-static = 3.99, Fs-seismic = 3.33

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	60.00	0.0221	0.0527	4	V40 - 20XT
2	2.00	60.00	0.0153	0.0430	4	V40 - 20XT
3	4.00	60.00	0.0048	0.0285	4	V40 - 20XT
4	6.00	60.00	-0.0059	-0.0002	4	V40 - 20XT
5	8.00	60.00	-0.0170	-0.0118	4	V40 - 20XT
6	10.00	60.00	-0.0285	-0.0238	4	V40 - 20XT
7	12.00	60.00	-0.0405	-0.0362	4	V40 - 20XT
8	14.00	60.00	-0.0531	-0.0490	4	V40 - 20XT
9	16.00	60.00	-0.0663	-0.0623	4	V40 - 20XT
10	18.00	60.00	-0.0803	-0.0764	4	V40 - 20XT
11	20.00	60.00	-0.0953	-0.0913	4	V40 - 20XT
12	22.00	60.00	-0.1115	-0.1073	4	V40 - 20XT
13	23.33	60.00	-0.1230	-0.1187	4	V40 - 20XT
14	26.67	40.00	0.0162	0.0503	4	V40 - 20XT
15	28.00	40.00	0.0082	0.0385	4	V40 - 20XT
16	30.00	40.00	-0.0039	0.0211	4	V40 - 20XT
17	32.00	40.00	-0.0161	0.0041	4	V40 - 20XT
18	34.00	40.00	-0.0286	-0.0125	3	V40 - 10XT
19	36.00	40.00	-0.0413	-0.0289	3	V40 - 10XT
20	38.00	40.00	-0.0544	-0.0451	3	V40 - 10XT
21	40.00	40.00	-0.0680	-0.0613	3	V40 - 10XT
22	42.00	40.00	-0.0821	-0.0776	3	V40 - 10XT
23	44.00	40.00	-0.0969	-0.0941	3	V40 - 10XT
24	46.00	40.00	-0.1127	-0.1110	3	V40 - 10XT
25	48.00	40.00	-0.1296	-0.1288	3	V40 - 10XT
26	50.00	40.00	-0.1480	-0.1477	3	V40 - 10XT
27	52.00	40.00	-0.1683	-0.1683	3	V40 - 10XT
28	53.33	45.00	-0.1692	-0.1692	4	V40 - 20XT

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Tavailable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.67	6146	1935.87	1098.09	N/A	3.175	N/A	2.370	V40 - 20XT
2	2.00	6146	2318.48	1084.51	N/A	2.651	N/A	2.071	V40 - 20XT
3	4.00	6146	2644.20	1064.09	N/A	2.324	N/A	1.873	V40 - 20XT
4	6.00	6146	2490.57	1043.68	N/A	2.468	N/A	1.973	V40 - 20XT
5	8.00	6146	2336.94	1023.26	N/A	2.630	N/A	2.084	V40 - 20XT
6	10.00	6146	2183.31	1002.85	N/A	2.815	N/A	2.208	V40 - 20XT
7	12.00	6146	2029.68	982.43	N/A	3.028	N/A	2.348	V40 - 20XT
8	14.00	6146	1876.05	962.02	N/A	3.276	N/A	2.507	V40 - 20XT
9	16.00	6146	1245.28	941.60	N/A	4.936	N/A	3.397	V40 - 20XT
10	18.00	6146	614.51	921.18	N/A	10.002	N/A	5.271	V40 - 20XT
11	20.00	6146	460.89	900.77	N/A	13.336	N/A	6.145	V40 - 20XT
12	22.00	6146	266.50	880.35	N/A	23.063	N/A	7.744	V40 - 20XT
13	23.33	6146	2473.55	866.78	N/A	2.485	N/A	2.054	V40 - 20XT
14	26.67	6146	1775.17	729.78	N/A	3.462	N/A	2.778	V40 - 20XT
15	28.00	6146	2117.99	716.20	N/A	2.902	N/A	2.413	V40 - 20XT
16	30.00	6146	2403.37	695.78	N/A	2.557	N/A	2.180	V40 - 20XT
17	32.00	6146	2249.74	675.37	N/A	2.732	N/A	2.316	V40 - 20XT
18	34.00	4107	2096.11	654.95	N/A	1.960	N/A	1.651	V40 - 10XT
19	36.00	4107	1942.48	634.54	N/A	2.115	N/A	1.769	V40 - 10XT
20	38.00	4107	1788.86	614.12	N/A	2.296	N/A	1.905	V40 - 10XT
21	40.00	4107	1635.23	593.71	N/A	2.512	N/A	2.063	V40 - 10XT
22	42.00	4107	1481.60	573.29	N/A	2.772	N/A	2.251	V40 - 10XT
23	44.00	4107	1327.97	552.88	N/A	3.093	N/A	2.476	V40 - 10XT
24	46.00	4107	1174.34	532.46	N/A	3.498	N/A	2.751	V40 - 10XT
25	48.00	4107	1020.71	512.04	N/A	4.024	N/A	3.095	V40 - 10XT
26	50.00	4107	867.08	491.63	N/A	4.737	N/A	3.536	V40 - 10XT
27	52.00	4107	604.66	471.21	N/A	6.793	N/A	4.632	V40 - 10XT
28	53.33	6146	942.61	549.71	N/A	6.521	N/A	4.833	V40 - 20XT

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RESULTS for PULLOUT Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic Fs	Actual Seismic Fs
1	0.67	1.000	1935.9	1098.1	59.63	0.37	434958.2	N/A	224.684	347966.6	N/A	114.691
2	2.00	1.000	2318.5	1084.5	58.89	1.11	421561.4	N/A	181.827	337249.1	N/A	99.104
3	4.00	1.000	2644.2	1064.1	57.78	2.22	401982.3	N/A	152.024	321585.8	N/A	86.721
4	6.00	1.000	2490.6	1043.7	56.67	3.33	382759.7	N/A	153.684	306207.7	N/A	86.640
5	8.00	1.000	2336.9	1023.3	55.57	4.43	364029.1	N/A	155.772	291223.3	N/A	86.668
6	10.00	1.000	2183.3	1002.8	54.46	5.54	346553.0	N/A	158.728	277242.4	N/A	87.015
7	12.00	1.000	2029.7	982.4	53.35	6.65	328816.0	N/A	162.004	263052.8	N/A	87.332
8	14.00	1.000	1876.0	962.0	52.24	7.76	311569.7	N/A	166.078	249255.8	N/A	87.826
9	16.00	1.000	1245.3	941.6	51.13	8.87	294813.4	N/A	236.744	235850.7	N/A	107.848
10	18.00	1.000	614.5	921.2	50.02	9.98	278655.6	N/A	453.457	222924.5	N/A	145.162
11	20.00	1.000	460.9	900.8	48.91	11.09	263595.1	N/A	571.932	210876.1	N/A	154.868
12	22.00	1.000	266.5	880.4	47.81	12.19	248319.0	N/A	931.772	198655.2	N/A	173.217
13	23.33	1.000	2473.6	866.8	47.07	12.93	238519.5	N/A	96.428	190815.6	N/A	57.125
14	26.67	1.000	1775.2	729.8	39.63	0.37	121798.8	N/A	68.613	97439.0	N/A	38.899
15	28.00	1.000	2118.0	716.2	38.89	1.11	113700.2	N/A	53.683	90960.1	N/A	32.094
16	30.00	1.000	2403.4	695.8	37.78	2.22	101947.5	N/A	42.419	81558.0	N/A	26.316
17	32.00	1.000	2249.7	675.4	36.67	3.33	90737.7	N/A	40.332	72590.1	N/A	24.816
18	34.00	1.000	2096.1	655.0	35.57	4.43	79983.4	N/A	38.158	63986.7	N/A	23.259
19	36.00	1.000	1942.5	634.5	34.46	5.54	69730.2	N/A	35.897	55784.1	N/A	21.647
20	38.00	1.000	1788.9	614.1	33.35	6.65	60008.4	N/A	33.546	48006.7	N/A	19.978
21	40.00	1.000	1635.2	593.7	32.24	7.76	50753.6	N/A	31.038	40602.9	N/A	18.216
22	42.00	1.000	1481.6	573.3	31.13	8.87	41999.8	N/A	28.348	33599.9	N/A	16.351
23	44.00	1.000	1328.0	552.9	30.02	9.98	33766.1	N/A	25.427	27012.9	N/A	14.362
24	46.00	1.000	1174.3	532.5	28.91	11.09	26010.7	N/A	22.149	20808.6	N/A	12.192
25	48.00	1.000	1020.7	512.0	27.81	12.19	18756.4	N/A	18.376	15005.1	N/A	9.790
26	50.00	1.000	867.1	491.6	26.70	13.30	12010.8	N/A	13.852	9608.6	N/A	7.072
27	52.00	1.000	604.7	471.2	25.59	14.41	5754.9	N/A	9.518	4603.9	N/A	4.279
28	53.33	1.000	942.6	549.7	29.85	15.15	2248.3	N/A	2.385	1798.7	N/A	1.205

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	1936	0.63	0.63	7113	6146	N/A	3.67	N/A	3.17	V40 - 20XT
2	2.00	2318	0.63	0.63	7113	6146	N/A	3.07	N/A	2.65	V40 - 20XT
3	4.00	2644	0.63	0.63	7113	6146	N/A	2.69	N/A	2.32	V40 - 20XT
4	6.00	2491	0.63	0.63	7113	6146	N/A	2.86	N/A	2.47	V40 - 20XT
5	8.00	2337	0.62	0.62	7041	6146	N/A	3.01	N/A	2.63	V40 - 20XT
6	10.00	2183	0.59	0.59	6641	6146	N/A	3.04	N/A	2.82	V40 - 20XT
7	12.00	2030	0.55	0.55	6241	6146	N/A	3.07	N/A	3.03	V40 - 20XT
8	14.00	1876	0.52	0.52	5840	6146	N/A	3.11	N/A	3.28	V40 - 20XT
9	16.00	1245	0.48	0.48	5440	6146	N/A	4.37	N/A	4.94	V40 - 20XT
10	18.00	615	0.45	0.45	5040	6146	N/A	8.20	N/A	10.00	V40 - 20XT
11	20.00	461	0.41	0.41	4640	6146	N/A	10.07	N/A	13.34	V40 - 20XT
12	22.00	267	0.38	0.38	4239	6146	N/A	15.91	N/A	23.06	V40 - 20XT
13	23.33	2474	0.35	0.35	3973	6146	N/A	1.61	N/A	2.48	V40 - 20XT
14	26.67	1775	0.63	0.63	7113	6146	N/A	4.01	N/A	3.46	V40 - 20XT
15	28.00	2118	0.63	0.63	7113	6146	N/A	3.36	N/A	2.90	V40 - 20XT
16	30.00	2403	0.63	0.63	7113	6146	N/A	2.96	N/A	2.56	V40 - 20XT
17	32.00	2250	0.63	0.63	7113	6146	N/A	3.16	N/A	2.73	V40 - 20XT
18	34.00	2096	0.72	0.72	5433	4107	N/A	2.59	N/A	1.96	V40 - 10XT
19	36.00	1942	0.72	0.72	5433	4107	N/A	2.80	N/A	2.11	V40 - 10XT
20	38.00	1789	0.72	0.72	5433	4107	N/A	3.04	N/A	2.30	V40 - 10XT
21	40.00	1635	0.67	0.67	5059	4107	N/A	3.09	N/A	2.51	V40 - 10XT
22	42.00	1482	0.61	0.61	4606	4107	N/A	3.11	N/A	2.77	V40 - 10XT
23	44.00	1328	0.55	0.55	4152	4107	N/A	3.13	N/A	3.09	V40 - 10XT
24	46.00	1174	0.49	0.49	3699	4107	N/A	3.15	N/A	3.50	V40 - 10XT
25	48.00	1021	0.43	0.43	3246	4107	N/A	3.18	N/A	4.02	V40 - 10XT
26	50.00	867	0.37	0.37	2793	4107	N/A	3.22	N/A	4.74	V40 - 10XT
27	52.00	605	0.31	0.31	2340	4107	N/A	3.87	N/A	6.79	V40 - 10XT
28	53.33	943	0.35	0.35	3973	6146	N/A	4.21	N/A	6.52	V40 - 20XT

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RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	3034	0.63	0.63	7113	6146	N/A	2.34	N/A	2.37	V40 - 20XT
2	2.00	3403	0.63	0.63	7113	6146	N/A	2.09	N/A	2.07	V40 - 20XT
3	4.00	3708	0.63	0.63	7113	6146	N/A	1.92	N/A	1.87	V40 - 20XT
4	6.00	3534	0.63	0.63	7113	6146	N/A	2.01	N/A	1.97	V40 - 20XT
5	8.00	3360	0.62	0.62	7041	6146	N/A	2.10	N/A	2.08	V40 - 20XT
6	10.00	3186	0.59	0.59	6641	6146	N/A	2.08	N/A	2.21	V40 - 20XT
7	12.00	3012	0.55	0.55	6241	6146	N/A	2.07	N/A	2.35	V40 - 20XT
8	14.00	2838	0.52	0.52	5840	6146	N/A	2.06	N/A	2.51	V40 - 20XT
9	16.00	2187	0.48	0.48	5440	6146	N/A	2.49	N/A	3.40	V40 - 20XT
10	18.00	1536	0.45	0.45	5040	6146	N/A	3.28	N/A	5.27	V40 - 20XT
11	20.00	1362	0.41	0.41	4640	6146	N/A	3.41	N/A	6.14	V40 - 20XT
12	22.00	1147	0.38	0.38	4239	6146	N/A	3.70	N/A	7.74	V40 - 20XT
13	23.33	3340	0.35	0.35	3973	6146	N/A	1.19	N/A	2.05	V40 - 20XT
14	26.67	2505	0.63	0.63	7113	6146	N/A	2.84	N/A	2.78	V40 - 20XT
15	28.00	2834	0.63	0.63	7113	6146	N/A	2.51	N/A	2.41	V40 - 20XT
16	30.00	3099	0.63	0.63	7113	6146	N/A	2.30	N/A	2.18	V40 - 20XT
17	32.00	2925	0.63	0.63	7113	6146	N/A	2.43	N/A	2.32	V40 - 20XT
18	34.00	2751	0.72	0.72	5433	4107	N/A	1.97	N/A	1.65	V40 - 10XT
19	36.00	2577	0.72	0.72	5433	4107	N/A	2.11	N/A	1.77	V40 - 10XT
20	38.00	2403	0.72	0.72	5433	4107	N/A	2.26	N/A	1.90	V40 - 10XT
21	40.00	2229	0.67	0.67	5059	4107	N/A	2.27	N/A	2.06	V40 - 10XT
22	42.00	2055	0.61	0.61	4606	4107	N/A	2.24	N/A	2.25	V40 - 10XT
23	44.00	1881	0.55	0.55	4152	4107	N/A	2.21	N/A	2.48	V40 - 10XT
24	46.00	1707	0.49	0.49	3699	4107	N/A	2.17	N/A	2.75	V40 - 10XT
25	48.00	1533	0.43	0.43	3246	4107	N/A	2.12	N/A	3.09	V40 - 10XT
26	50.00	1359	0.37	0.37	2793	4107	N/A	2.06	N/A	3.54	V40 - 10XT
27	52.00	1076	0.31	0.31	2340	4107	N/A	2.17	N/A	4.63	V40 - 10XT
28	53.33	1492	0.35	0.35	3973	6146	N/A	2.66	N/A	4.83	V40 - 20XT

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GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.180 has been applied.
The seismic force is applied at the center of the sliding mass.

STATIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.616
(it corresponds to a critical circle at Xc = -8.00, Yc = 112.00 and R = 112.29 [ft] where (x=0, y=0) is taken at the TOE or Xc = 92.00, Yc = 1112.00 and R = 112.29 [ft] when the terrain coordinate system is used as shown in the table below.)

SEISMIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.196
(it corresponds to a critical circle at Xc = -8.00, Yc = 112.00 and R = 112.29 [ft] where (x=0, y=0) is taken at the TOE or Xc = 92.00, Yc = 1112.00 and R = 112.29 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Soil layer #1:	γ = 120.00 [lb/ft ³]			ϕ = 28.0°		c = 500.00 [lb/ft ²]					
x [ft]	0.0	15.0	20.0	50.0	180.0	200.0	250.0	300.0	350.0	375.0	400.0
y [ft]	1004.0	1004.0	1004.0	1004.0	1000.0	1000.0	1000.0	1000.0	1000.0	1065.0	1070.0

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AASHTO 2002 ASD DESIGN METHOD
Portola Center - TTM 17300

MSEW(3.0): Update # 14.3

PROJECT IDENTIFICATION

Title: Portola Center - TTM 17300
Project Number: 0704 034A
Client: USA Portola Properties, LLC
Designer: DAO
Station Number: DESIGN 7

Description:

Middle 2 Walls of 4-Tier - Tiered 11 ft over 20 ft Wall - 2:1 Separation Slope - Offset of 25 ft - Level Crest of Upper Wall for Trail - Upper 4th Wall and Slope Above Modeled as Surcharge

Company's information:

Name: Soil Retention Designs, Inc.
Street: 2501 State Street

Carlsbad, CA 92008
Telephone #: 760-966-6090
Fax #: 760-966-6099
E-Mail: dosborne@soilretention.com

Original file path and name: C:\Users\dosborne\Desktop\Portola North Rev Design\Upda..... ..... Walls of 4-Tier.BEN

Original date and time of creating this file: Mon Nov 29 16:13:17 2010

PROGRAM MODE: ANALYSIS of SUPERIMPOSED WALL using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	28.0 °
Equivalent cohesion, $c_{equiv.}$	500.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3610 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 25.80 N γ= 16.72

SEISMICITY

Maximum ground acceleration coefficient, A = 0.360
Design acceleration coefficient in Internal Stability: Kh = Am = 0.392
Design acceleration coefficient in External Stability: Kh_d = 0.175 => Kh = Am = 0.175
(Kh in External Stability is based on allowable displacement, d = 75 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.4861 Kae (Kh = 0) = 0.3610 Δ Kae = 0.1250
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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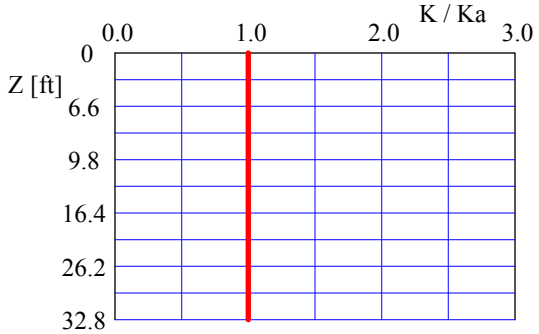
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3590.0	6230.0	8300.0	12420.0	
Durability reduction factor, RFd	1.10	1.10	1.10	1.10	
Installation-damage reduction factor, RFid	1.11	1.10	1.10	1.10	
Creep reduction factor, RFc	1.67	1.67	1.67	1.67	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	1.000	
Friction angle along geogrid-soil interface, ρ	29.40	29.40	29.40	29.40	
Pullout resistance factor, F*	$0.90 \cdot \tan\phi$	$0.90 \cdot \tan\phi$	$0.90 \cdot \tan\phi$	$0.90 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Note: Z for calculating K/Ka and F* is measured from top of the wall at the face (AASHTO).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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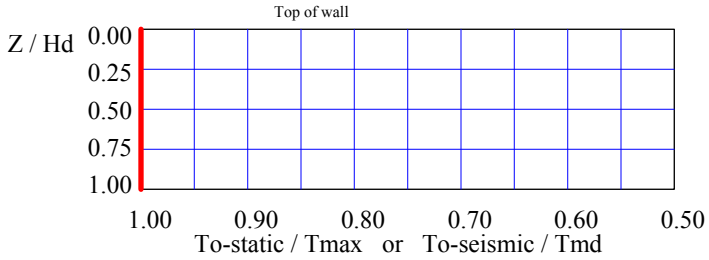
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.00/0.67 ft. Horizontal distance to Center of Gravity of block is 0.42 ft.
Average unit weight of block is γ_f = 117.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	V40 - 5XT	V40 - 8XT	V40 - 10XT	V40 - 20XT	N/A
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

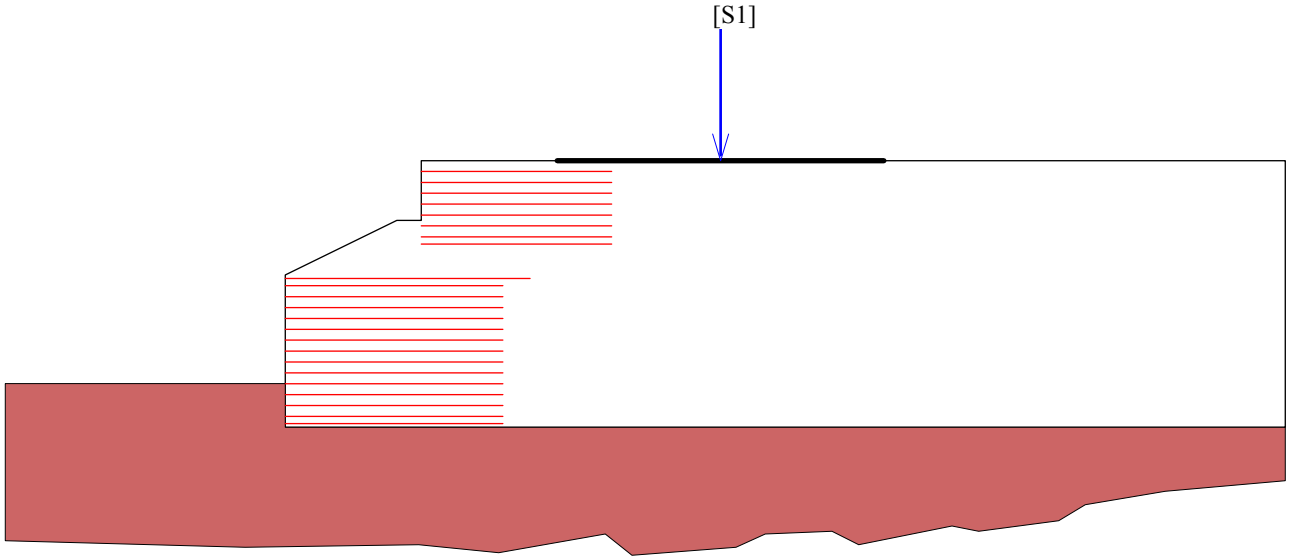
Design height, Hd	49.00	[ft]	{ Embedded depth is E = 8.00 ft, and height above top of finished bottom grade is H = 41.00 ft, where H1 = 11.00 and H2 = 20.00 }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 25.0 ft, Blackslope2 = 26.0 deg. and Backslope rise, S2 = 10.0 ft.

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 1800.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=60.0 [ft]. Distance of center of footing from wall face, d = 55.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 10 15 20 25 30 [ft]

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ANALYSIS: CALCULATED FACTORS (Static condition Bearing capacity, Fs = 7.92, Meyerhof stress = 5785 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.822, Eccentricity, e/L = 0.0897, Fs-overturning = 3.93

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	40.00	4	3.46	2.99	2.990	106.726	1.659	0.0853	V40 - 20XT
2	2.00	40.00	4	2.88	2.49	2.487	84.744	1.690	0.0767	V40 - 20XT
3	4.00	40.00	4	2.51	2.17	2.169	68.782	1.740	0.0638	V40 - 20XT
4	6.00	40.00	4	2.65	2.29	2.288	67.311	1.794	0.0508	V40 - 20XT
5	8.00	40.00	3	2.14	1.62	1.618	65.812	1.852	0.0378	V40 - 10XT
6	10.00	40.00	3	2.27	1.72	1.717	64.549	1.915	0.0245	V40 - 10XT
7	12.00	40.00	3	2.42	1.83	1.830	63.072	1.984	0.0110	V40 - 10XT
8	14.00	40.00	3	2.41	1.96	1.959	61.634	2.060	-0.0029	V40 - 10XT
9	16.00	40.00	3	2.36	2.11	2.107	60.201	2.145	-0.0174	V40 - 10XT
10	18.00	40.00	3	2.30	2.28	2.280	58.737	2.241	-0.0328	V40 - 10XT
11	20.00	40.00	3	2.24	2.48	2.483	57.637	2.352	-0.0493	V40 - 10XT
12	22.00	40.00	3	2.15	2.73	2.726	56.217	2.482	-0.0675	V40 - 10XT
13	24.00	40.00	3	2.05	3.02	3.022	54.848	2.640	-0.0880	V40 - 10XT
14	26.00	40.00	3	3.21	5.63	5.630	88.849	2.841	-0.1122	V40 - 10XT
15	27.33	45.00	4	1.52	2.36	2.356	29.209	2.458	-0.1182	V40 - 20XT
16	33.67	35.00	3	7.10	5.44	5.442	75.933	3.218	-0.0411	V40 - 10XT
17	35.00	35.00	3	5.96	4.84	4.837	60.324	3.376	-0.0513	V40 - 10XT
18	37.00	35.00	3	5.20	4.64	4.642	47.982	3.662	-0.0680	V40 - 10XT
19	39.00	35.00	3	5.63	5.57	5.570	46.368	4.030	-0.0872	V40 - 10XT
20	41.00	35.00	2	6.02	5.23	5.226	44.753	4.538	-0.1102	V40 - 8XT
21	43.00	35.00	2	7.62	6.97	6.968	43.116	5.318	-0.1394	V40 - 8XT
22	45.00	35.00	2	10.82	10.45	10.452	41.502	6.761	-0.1797	V40 - 8XT
23	47.00	35.00	2	18.15	18.58	18.582	35.436	10.820	-0.2419	V40 - 8XT

ANALYSIS: CALCULATED FACTORS (Seismic conditi Bearing capacity, Fs = 6.54, Meyerhof stress = 6470 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.463, Eccentricity, e/L = 0.1279, Fs-overturning = 3.09

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	40.00	4	2.29	2.29	2.287	56.409	1.335	0.1221	V40 - 20XT
2	2.00	40.00	4	2.03	1.99	1.988	47.770	1.368	0.1106	V40 - 20XT
3	4.00	40.00	4	1.85	1.79	1.788	40.603	1.420	0.0937	V40 - 20XT
4	6.00	40.00	4	1.94	1.88	1.879	39.487	1.477	0.0770	V40 - 20XT
5	8.00	40.00	3	1.56	1.32	1.322	38.341	1.539	0.0606	V40 - 10XT
6	10.00	40.00	3	1.64	1.40	1.396	37.315	1.607	0.0443	V40 - 10XT
7	12.00	40.00	3	1.73	1.48	1.480	36.146	1.682	0.0281	V40 - 10XT
8	14.00	40.00	3	1.71	1.57	1.573	34.977	1.765	0.0119	V40 - 10XT
9	16.00	40.00	3	1.66	1.68	1.679	33.784	1.858	-0.0046	V40 - 10XT
10	18.00	40.00	3	1.60	1.80	1.801	32.542	1.963	-0.0216	V40 - 10XT
11	20.00	40.00	3	1.53	1.94	1.942	31.459	2.085	-0.0393	V40 - 10XT
12	22.00	40.00	3	1.44	2.11	2.106	30.150	2.226	-0.0583	V40 - 10XT
13	24.00	40.00	3	1.35	2.30	2.301	28.805	2.396	-0.0792	V40 - 10XT
14	26.00	40.00	3	1.66	3.61	3.610	36.743	2.605	-0.1032	V40 - 10XT
15	27.33	45.00	4	1.17	1.99	1.993	17.907	2.326	-0.1113	V40 - 20XT
16	33.67	35.00	3	3.20	3.14	3.142	27.333	2.611	-0.0317	V40 - 10XT
17	35.00	35.00	3	2.89	2.96	2.955	23.389	2.772	-0.0436	V40 - 10XT
18	37.00	35.00	3	2.62	2.92	2.917	19.318	3.064	-0.0626	V40 - 10XT
19	39.00	35.00	3	2.63	3.31	3.305	17.298	3.444	-0.0836	V40 - 10XT
20	41.00	35.00	2	2.53	2.86	2.861	15.040	3.972	-0.1080	V40 - 8XT
21	43.00	35.00	2	2.75	3.38	3.379	12.435	4.781	-0.1383	V40 - 8XT
22	45.00	35.00	2	3.04	4.13	4.126	9.325	6.268	-0.1793	V40 - 8XT
23	47.00	35.00	2	3.38	5.13	5.134	5.275	10.389	-0.2418	V40 - 8XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.654
(it corresponds to a critical circle at Xc = -32.00, Yc = 160.00 and R = 163.17 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.148
(it corresponds to a critical circle at Xc = -56.00, Yc = 176.00 and R = 184.69 [ft]).

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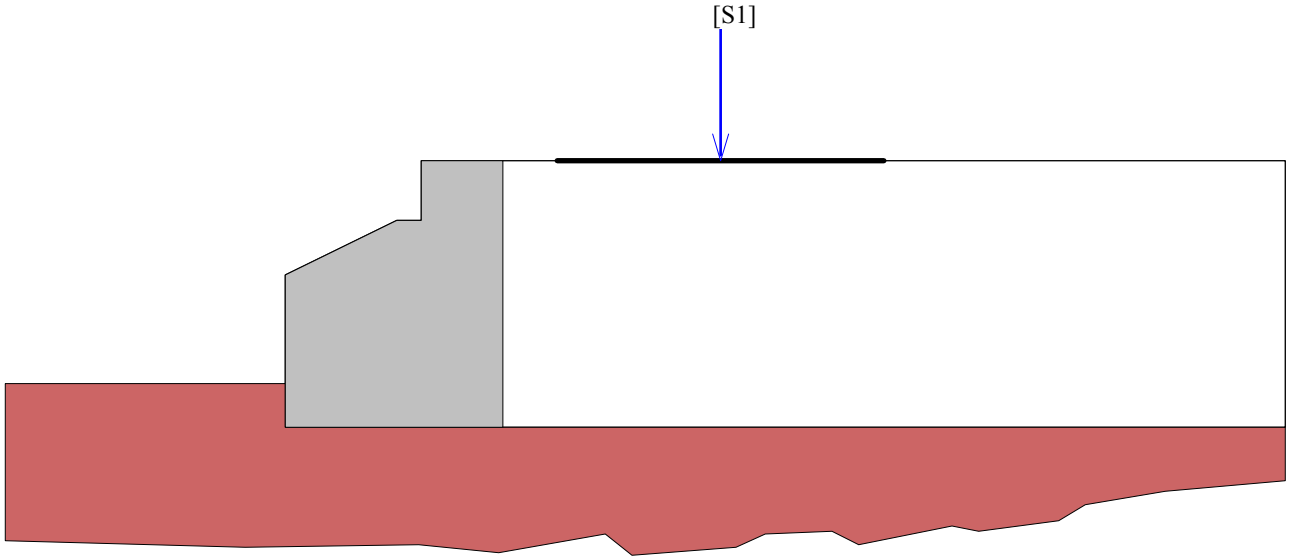
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	45827	42342	[lb/ft ²]
Meyerhof stress, σ_V	5785.0	6470	[lb/ft ²]
Eccentricity, e	3.59	5.32	[ft]
Eccentricity, e/L	0.090	0.133	
Fs calculated	7.92	6.54	
Base length	40.00	40.00	[ft]



SCALE:

0 5 10 15 20 25 30 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 1.822 and Fs-seismic = 1.463

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	40.00	1.659	1.335	4	V40 - 20XT
2	2.00	40.00	1.690	1.368	4	V40 - 20XT
3	4.00	40.00	1.740	1.420	4	V40 - 20XT
4	6.00	40.00	1.794	1.477	4	V40 - 20XT
5	8.00	40.00	1.852	1.539	3	V40 - 10XT
6	10.00	40.00	1.915	1.607	3	V40 - 10XT
7	12.00	40.00	1.984	1.682	3	V40 - 10XT
8	14.00	40.00	2.060	1.765	3	V40 - 10XT
9	16.00	40.00	2.145	1.858	3	V40 - 10XT
10	18.00	40.00	2.241	1.963	3	V40 - 10XT
11	20.00	40.00	2.352	2.085	3	V40 - 10XT
12	22.00	40.00	2.482	2.226	3	V40 - 10XT
13	24.00	40.00	2.640	2.396	3	V40 - 10XT
14	26.00	40.00	2.841	2.605	3	V40 - 10XT
15	27.33	45.00	2.458	2.326	4	V40 - 20XT
16	33.67	35.00	3.218	2.611	3	V40 - 10XT
17	35.00	35.00	3.376	2.772	3	V40 - 10XT
18	37.00	35.00	3.662	3.064	3	V40 - 10XT
19	39.00	35.00	4.030	3.444	3	V40 - 10XT
20	41.00	35.00	4.538	3.972	2	V40 - 8XT
21	43.00	35.00	5.318	4.781	2	V40 - 8XT
22	45.00	35.00	6.761	6.268	2	V40 - 8XT
23	47.00	35.00	10.820	10.389	2	V40 - 8XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0897, e/L seismic = 0.1279; Overturning: Fs-static = 3.93, Fs-seismic = 3.09

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	40.00	0.0853	0.1221	4	V40 - 20XT
2	2.00	40.00	0.0767	0.1106	4	V40 - 20XT
3	4.00	40.00	0.0638	0.0937	4	V40 - 20XT
4	6.00	40.00	0.0508	0.0770	4	V40 - 20XT
5	8.00	40.00	0.0378	0.0606	3	V40 - 10XT
6	10.00	40.00	0.0245	0.0443	3	V40 - 10XT
7	12.00	40.00	0.0110	0.0281	3	V40 - 10XT
8	14.00	40.00	-0.0029	0.0119	3	V40 - 10XT
9	16.00	40.00	-0.0174	-0.0046	3	V40 - 10XT
10	18.00	40.00	-0.0328	-0.0216	3	V40 - 10XT
11	20.00	40.00	-0.0493	-0.0393	3	V40 - 10XT
12	22.00	40.00	-0.0675	-0.0583	3	V40 - 10XT
13	24.00	40.00	-0.0880	-0.0792	3	V40 - 10XT
14	26.00	40.00	-0.1122	-0.1032	3	V40 - 10XT
15	27.33	45.00	-0.1182	-0.1113	4	V40 - 20XT
16	33.67	35.00	-0.0411	-0.0317	3	V40 - 10XT
17	35.00	35.00	-0.0513	-0.0436	3	V40 - 10XT
18	37.00	35.00	-0.0680	-0.0626	3	V40 - 10XT
19	39.00	35.00	-0.0872	-0.0836	3	V40 - 10XT
20	41.00	35.00	-0.1102	-0.1080	2	V40 - 8XT
21	43.00	35.00	-0.1394	-0.1383	2	V40 - 8XT
22	45.00	35.00	-0.1797	-0.1793	2	V40 - 8XT
23	47.00	35.00	-0.2419	-0.2418	2	V40 - 8XT

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Tavailable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.67	6146	2055.77	1055.85	N/A	2.990	N/A	2.287	V40 - 20XT
2	2.00	6146	2471.85	1036.21	N/A	2.487	N/A	1.988	V40 - 20XT
3	4.00	6146	2834.06	1006.67	N/A	2.169	N/A	1.788	V40 - 20XT
4	6.00	6146	2686.57	977.13	N/A	2.288	N/A	1.879	V40 - 20XT
5	8.00	4107	2539.09	947.59	N/A	1.618	N/A	1.322	V40 - 10XT
6	10.00	4107	2391.60	918.06	N/A	1.717	N/A	1.396	V40 - 10XT
7	12.00	4107	2244.12	888.52	N/A	1.830	N/A	1.480	V40 - 10XT
8	14.00	4107	2096.64	858.98	N/A	1.959	N/A	1.573	V40 - 10XT
9	16.00	4107	1949.15	829.44	N/A	2.107	N/A	1.679	V40 - 10XT
10	18.00	4107	1801.67	799.91	N/A	2.280	N/A	1.801	V40 - 10XT
11	20.00	4107	1654.18	770.37	N/A	2.483	N/A	1.942	V40 - 10XT
12	22.00	4107	1506.70	740.83	N/A	2.726	N/A	2.106	V40 - 10XT
13	24.00	4107	1359.22	711.29	N/A	3.022	N/A	2.301	V40 - 10XT
14	26.00	4107	729.53	681.76	N/A	5.630	N/A	3.610	V40 - 10XT
15	27.33	6146	2608.47	795.33	N/A	2.356	N/A	1.993	V40 - 20XT
16	33.67	4107	754.73	922.63	N/A	5.442	N/A	3.142	V40 - 10XT
17	35.00	4107	849.18	902.99	N/A	4.837	N/A	2.955	V40 - 10XT
18	37.00	4107	884.90	873.45	N/A	4.642	N/A	2.917	V40 - 10XT
19	39.00	4107	737.42	843.91	N/A	5.570	N/A	3.305	V40 - 10XT
20	41.00	3083	589.94	814.37	N/A	5.226	N/A	2.861	V40 - 8XT
21	43.00	3083	442.45	784.84	N/A	6.968	N/A	3.379	V40 - 8XT
22	45.00	3083	294.97	755.30	N/A	10.452	N/A	4.126	V40 - 8XT
23	47.00	3083	165.92	725.76	N/A	18.582	N/A	5.134	V40 - 8XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic Fs	Actual Seismic Fs
1	0.67	1.000	2055.8	1055.8	39.63	0.37	219403.3	N/A	106.726	175522.6	N/A	56.409
2	2.00	1.000	2471.8	1036.2	38.89	1.11	209474.3	N/A	84.744	167579.5	N/A	47.770
3	4.00	1.000	2834.1	1006.7	37.78	2.22	194932.7	N/A	68.782	155946.2	N/A	40.603
4	6.00	1.000	2686.6	977.1	36.67	3.33	180836.7	N/A	67.311	144669.3	N/A	39.487
5	8.00	1.000	2539.1	947.6	35.57	4.43	167101.8	N/A	65.812	133681.5	N/A	38.341
6	10.00	1.000	2391.6	918.1	34.46	5.54	154375.3	N/A	64.549	123500.2	N/A	37.315
7	12.00	1.000	2244.1	888.5	33.35	6.65	141540.8	N/A	63.072	113232.6	N/A	36.146
8	14.00	1.000	2096.6	859.0	32.24	7.76	129223.5	N/A	61.634	103378.8	N/A	34.977
9	16.00	1.000	1949.2	829.4	31.13	8.87	117341.5	N/A	60.201	93873.2	N/A	33.784
10	18.00	1.000	1801.7	799.9	30.02	9.98	105824.4	N/A	58.737	84659.5	N/A	32.542
11	20.00	1.000	1654.2	770.4	28.91	11.09	95342.5	N/A	57.637	76274.0	N/A	31.459
12	22.00	1.000	1506.7	740.8	27.81	12.19	84702.4	N/A	56.217	67762.0	N/A	30.150
13	24.00	1.000	1359.2	711.3	26.70	13.30	74550.5	N/A	54.848	59640.4	N/A	28.805
14	26.00	1.000	729.5	681.8	25.59	14.41	64818.2	N/A	88.849	51854.5	N/A	36.743
15	27.33	1.000	2608.5	795.3	29.85	15.15	76190.2	N/A	29.209	60952.1	N/A	17.907
16	33.67	1.000	754.7	922.6	34.63	0.37	57308.8	N/A	75.933	45847.1	N/A	27.333
17	35.00	1.000	849.2	903.0	33.89	1.11	51225.7	N/A	60.324	40980.6	N/A	23.389
18	37.00	1.000	884.9	873.4	32.78	2.22	42459.4	N/A	47.982	33967.5	N/A	19.318
19	39.00	1.000	737.4	843.9	31.67	3.33	34192.4	N/A	46.368	27353.9	N/A	17.298
20	41.00	1.000	589.9	814.4	30.57	4.43	26401.5	N/A	44.753	21121.2	N/A	15.040
21	43.00	1.000	442.5	784.8	29.46	5.54	19077.0	N/A	43.116	15261.6	N/A	12.435
22	45.00	1.000	295.0	755.3	28.35	6.65	12241.8	N/A	41.502	9793.4	N/A	9.325
23	47.00	1.000	165.9	725.8	27.24	7.76	5879.5	N/A	35.436	4703.6	N/A	5.275

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	2056	0.63	0.63	7113	6146	N/A	3.46	N/A	2.99	V40 - 20XT
2	2.00	2472	0.63	0.63	7113	6146	N/A	2.88	N/A	2.49	V40 - 20XT
3	4.00	2834	0.63	0.63	7113	6146	N/A	2.51	N/A	2.17	V40 - 20XT
4	6.00	2687	0.63	0.63	7113	6146	N/A	2.65	N/A	2.29	V40 - 20XT
5	8.00	2539	0.72	0.72	5433	4107	N/A	2.14	N/A	1.62	V40 - 10XT
6	10.00	2392	0.72	0.72	5433	4107	N/A	2.27	N/A	1.72	V40 - 10XT
7	12.00	2244	0.72	0.72	5433	4107	N/A	2.42	N/A	1.83	V40 - 10XT
8	14.00	2097	0.67	0.67	5059	4107	N/A	2.41	N/A	1.96	V40 - 10XT
9	16.00	1949	0.61	0.61	4606	4107	N/A	2.36	N/A	2.11	V40 - 10XT
10	18.00	1802	0.55	0.55	4152	4107	N/A	2.30	N/A	2.28	V40 - 10XT
11	20.00	1654	0.49	0.49	3699	4107	N/A	2.24	N/A	2.48	V40 - 10XT
12	22.00	1507	0.43	0.43	3246	4107	N/A	2.15	N/A	2.73	V40 - 10XT
13	24.00	1359	0.37	0.37	2793	4107	N/A	2.05	N/A	3.02	V40 - 10XT
14	26.00	730	0.31	0.31	2340	4107	N/A	3.21	N/A	5.63	V40 - 10XT
15	27.33	2608	0.35	0.35	3973	6146	N/A	1.52	N/A	2.36	V40 - 20XT
16	33.67	755	0.71	0.71	5360	4107	N/A	7.10	N/A	5.44	V40 - 10XT
17	35.00	849	0.67	0.67	5059	4107	N/A	5.96	N/A	4.84	V40 - 10XT
18	37.00	885	0.61	0.61	4606	4107	N/A	5.20	N/A	4.64	V40 - 10XT
19	39.00	737	0.55	0.55	4152	4107	N/A	5.63	N/A	5.57	V40 - 10XT
20	41.00	590	0.63	0.63	3552	3083	N/A	6.02	N/A	5.23	V40 - 8XT
21	43.00	442	0.60	0.60	3372	3083	N/A	7.62	N/A	6.97	V40 - 8XT
22	45.00	295	0.56	0.56	3192	3083	N/A	10.82	N/A	10.45	V40 - 8XT
23	47.00	166	0.53	0.53	3012	3083	N/A	18.15	N/A	18.58	V40 - 8XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	3112	0.63	0.63	7113	6146	N/A	2.29	N/A	2.29	V40 - 20XT
2	2.00	3508	0.63	0.63	7113	6146	N/A	2.03	N/A	1.99	V40 - 20XT
3	4.00	3841	0.63	0.63	7113	6146	N/A	1.85	N/A	1.79	V40 - 20XT
4	6.00	3664	0.63	0.63	7113	6146	N/A	1.94	N/A	1.88	V40 - 20XT
5	8.00	3487	0.72	0.72	5433	4107	N/A	1.56	N/A	1.32	V40 - 10XT
6	10.00	3310	0.72	0.72	5433	4107	N/A	1.64	N/A	1.40	V40 - 10XT
7	12.00	3133	0.72	0.72	5433	4107	N/A	1.73	N/A	1.48	V40 - 10XT
8	14.00	2956	0.67	0.67	5059	4107	N/A	1.71	N/A	1.57	V40 - 10XT
9	16.00	2779	0.61	0.61	4606	4107	N/A	1.66	N/A	1.68	V40 - 10XT
10	18.00	2602	0.55	0.55	4152	4107	N/A	1.60	N/A	1.80	V40 - 10XT
11	20.00	2425	0.49	0.49	3699	4107	N/A	1.53	N/A	1.94	V40 - 10XT
12	22.00	2248	0.43	0.43	3246	4107	N/A	1.44	N/A	2.11	V40 - 10XT
13	24.00	2071	0.37	0.37	2793	4107	N/A	1.35	N/A	2.30	V40 - 10XT
14	26.00	1411	0.31	0.31	2340	4107	N/A	1.66	N/A	3.61	V40 - 10XT
15	27.33	3404	0.35	0.35	3973	6146	N/A	1.17	N/A	1.99	V40 - 20XT
16	33.67	1677	0.71	0.71	5360	4107	N/A	3.20	N/A	3.14	V40 - 10XT
17	35.00	1752	0.67	0.67	5059	4107	N/A	2.89	N/A	2.96	V40 - 10XT
18	37.00	1758	0.61	0.61	4606	4107	N/A	2.62	N/A	2.92	V40 - 10XT
19	39.00	1581	0.55	0.55	4152	4107	N/A	2.63	N/A	3.31	V40 - 10XT
20	41.00	1404	0.63	0.63	3552	3083	N/A	2.53	N/A	2.86	V40 - 8XT
21	43.00	1227	0.60	0.60	3372	3083	N/A	2.75	N/A	3.38	V40 - 8XT
22	45.00	1050	0.56	0.56	3192	3083	N/A	3.04	N/A	4.13	V40 - 8XT
23	47.00	892	0.53	0.53	3012	3083	N/A	3.38	N/A	5.13	V40 - 8XT

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GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.180 has been applied.
The seismic force is applied at the center of the sliding mass.

STATIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.654
(it corresponds to a critical circle at Xc = -32.00, Yc = 160.00 and R = 163.17 [ft] where (x=0, y=0) is taken at the TOE or Xc = 68.00, Yc = 1160.00 and R = 163.17 [ft] when the terrain coordinate system is used as shown in the table below.)

SEISMIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.148
(it corresponds to a critical circle at Xc = -56.00, Yc = 176.00 and R = 184.69 [ft] where (x=0, y=0) is taken at the TOE or Xc = 44.00, Yc = 1176.00 and R = 184.69 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Soil layer #1:	γ = 120.00 [lb/ft ³]		ϕ = 28.0°		c = 500.00 [lb/ft ²]						
x [ft]	0.0	15.0	20.0	50.0	150.0	180.0	250.0	275.0	300.0	350.0	400.0
y [ft]	1008.0	1008.0	1008.0	1008.0	1000.0	1000.0	1000.0	1000.0	1000.0	1045.0	1050.0

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AASHTO 2002 ASD DESIGN METHOD
Portola Center - TTM 17300

MSEW(3.0): Update # 14.3

PROJECT IDENTIFICATION

Title: Portola Center - TTM 17300
Project Number: 0704 034A
Client: USA Portola Properties, LLC
Designer: DAO
Station Number: DESIGN 8

Description:

Upper 2 Walls of 4-Tier - Tiered 15 ft over 11 ft Wall -
Level Separation - Offset of 20 ft - Ascending 15 ft 2:1 above Crest
of Upper Wall

Company's information:

Name: Soil Retention Designs, Inc.
Street: 2501 State Street

Carlsbad, CA 92008
Telephone #: 760-966-6090
Fax #: 760-966-6099
E-Mail: dosborne@soilretention.com

Original file path and name: C:\Users\dosborne\Desktop\Portola North Rev Design\Upda.....
..... Walls of 4-Tier.BEN
Original date and time of creating this file: Mon Nov 29 16:13:17 2010

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	125.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft ³
Design value of internal angle of friction, ϕ	28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	28.0 °
Equivalent cohesion, $c_{equiv.}$	500.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3989 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 25.80 N γ= 16.72

SEISMICITY

Maximum ground acceleration coefficient, A = 0.360
Design acceleration coefficient in Internal Stability: Kh = Am = 0.392
Design acceleration coefficient in External Stability: Kh_d = 0.175 => Kh = Am = 0.175
(Kh in External Stability is based on allowable displacement, d = 75 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.6501 Kae (Kh = 0) = 0.3989 Δ Kae = 0.2513
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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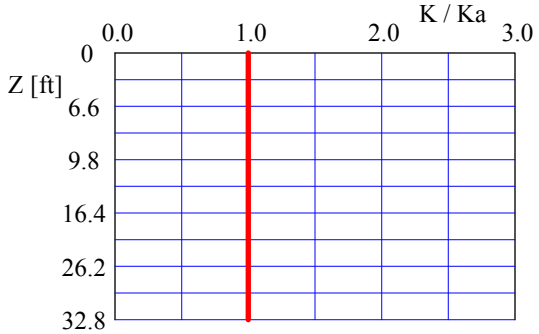
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3590.0	6230.0	8300.0	12420.0	
Durability reduction factor, RFd	1.10	1.10	1.10	1.10	
Installation-damage reduction factor, RFid	1.11	1.10	1.10	1.10	
Creep reduction factor, RFc	1.67	1.67	1.67	1.67	N/A
Fs-overall for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	1.000	
Friction angle along geogrid-soil interface, ρ	29.40	29.40	29.40	29.40	
Pullout resistance factor, F*	0.90·tarϕ	0.90·tan$\flat$	0.90·tan$\flat$	0.90·tan$\flat$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Note: Z for calculating K/Ka and F* is measured from top of the wall at the face (AASHTO).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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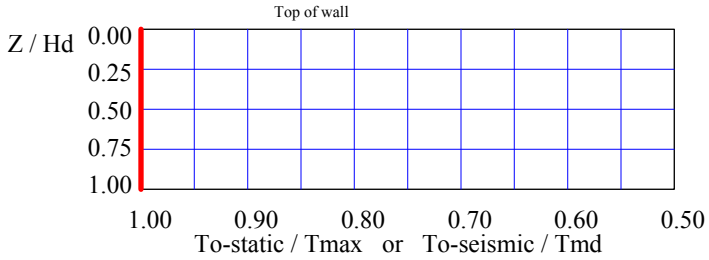
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.00/0.67 ft. Horizontal distance to Center of Gravity of block is 0.42 ft.
Average unit weight of block is γ_f = 117.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.98	0.0	0.50	0.0	0.25	0.0	0.34		
4000.0	0.98	1545.0	0.71	1831.0	0.72	1914.0	0.63	N/A	
		4000.0	0.71	4000.0	0.72	4000.0	0.63		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	V40 - 5XT	V40 - 8XT	V40 - 10XT	V40 - 20XT	N/A
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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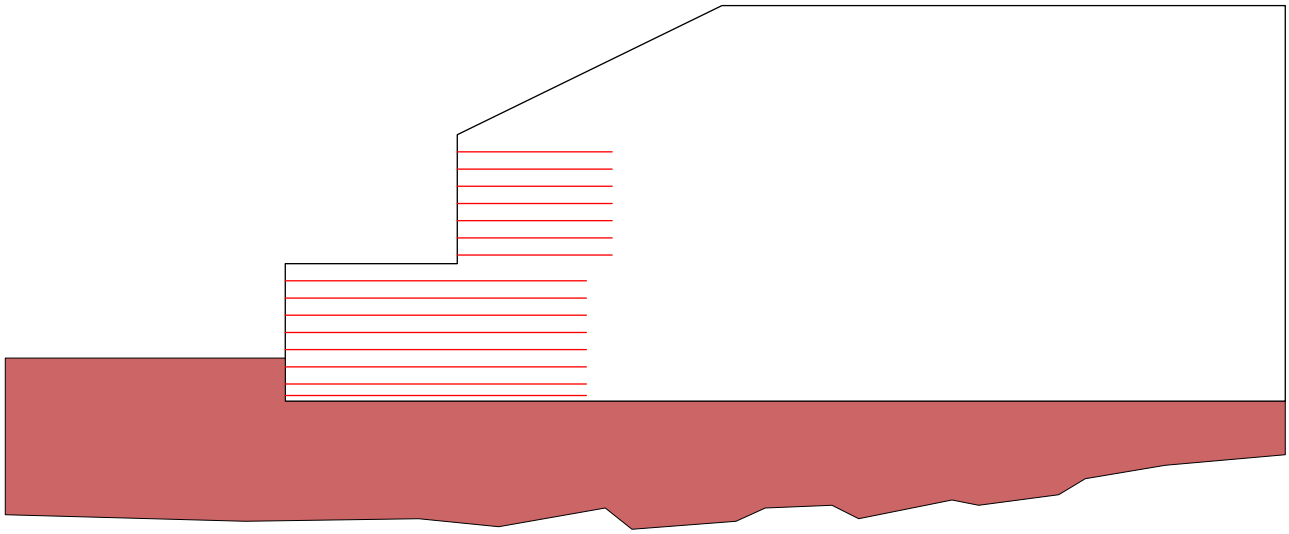
INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

Design height, Hd	31.00	[ft]	{ Embedded depth is E = 5.00 ft, and height above top of finished bottom grade is H = 26.00 ft, where H1 = 15.00 and H2 = 11.00 }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	15.0	[ft]	Broken back equivalent angle, I = 13.60° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 20.0 ft, Blackslope2 = 0.0 deg. and Backslope rise, S2 = 0.0 ft.

U N I F O R M S U R C H A R G E
Uniformly distributed dead load is 0.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 14.41, Meyerhof stress = 3352 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.995, Eccentricity, e/L = -0.0159, Fs-overturning = 5.51

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	35.00	3	5.70	4.37	4.367	132.118	1.811	-0.0211	V40 - 10XT
2	2.00	35.00	3	4.70	3.81	3.813	108.329	1.833	-0.0317	V40 - 10XT
3	4.00	35.00	3	3.99	3.56	3.562	91.676	1.864	-0.0489	V40 - 10XT
4	6.00	35.00	3	4.70	4.65	4.647	107.723	1.890	-0.0679	V40 - 10XT
5	8.00	35.00	2	5.78	5.02	5.017	138.708	1.907	-0.0895	V40 - 8XT
6	10.00	35.00	2	7.32	6.69	6.689	164.307	1.912	-0.1152	V40 - 8XT
7	12.00	35.00	2	10.39	10.03	10.034	217.231	1.899	-0.1470	V40 - 8XT
8	14.00	35.00	2	2.24	2.30	2.298	43.398	1.856	-0.1886	V40 - 8XT
9	17.00	18.00	2	2.71	2.08	2.080	18.529	1.991	0.0481	V40 - 8XT
10	19.00	18.00	2	2.95	2.32	2.321	16.597	2.122	0.0283	V40 - 8XT
11	21.00	18.00	2	3.18	2.62	2.625	14.573	2.271	0.0085	V40 - 8XT
12	23.00	18.00	1	3.13	1.72	1.724	12.439	2.439	-0.0119	V40 - 5XT
13	25.00	18.00	1	3.69	2.03	2.030	10.123	2.625	-0.0340	V40 - 5XT
14	27.00	18.00	1	4.48	2.47	2.467	7.499	2.824	-0.0599	V40 - 5XT
15	29.00	18.00	1	4.09	2.25	2.250	3.102	3.014	-0.0946	V40 - 5XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 15.14, Meyerhof stress = 3264 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.767, Eccentricity, e/L = -0.0051, Fs-overturning = 5.07

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	35.00	3	3.34	3.07	3.068	61.932	1.613	-0.0112	V40 - 10XT
2	2.00	35.00	3	2.93	2.80	2.800	54.033	1.651	-0.0236	V40 - 10XT
3	4.00	35.00	3	2.58	2.68	2.684	47.450	1.709	-0.0430	V40 - 10XT
4	6.00	35.00	3	2.78	3.29	3.291	51.058	1.764	-0.0639	V40 - 10XT
5	8.00	35.00	2	2.96	3.19	3.192	56.767	1.813	-0.0871	V40 - 8XT
6	10.00	35.00	2	3.29	3.86	3.856	59.028	1.851	-0.1139	V40 - 8XT
7	12.00	35.00	2	3.75	4.87	4.870	62.715	1.867	-0.1464	V40 - 8XT
8	14.00	35.00	2	1.62	1.86	1.863	24.983	1.847	-0.1884	V40 - 8XT
9	17.00	18.00	2	2.21	1.83	1.833	12.091	1.373	0.1163	V40 - 8XT
10	19.00	18.00	2	2.38	2.03	2.034	10.741	1.517	0.0778	V40 - 8XT
11	21.00	18.00	2	2.54	2.28	2.284	9.335	1.694	0.0423	V40 - 8XT
12	23.00	18.00	1	2.48	1.49	1.488	7.864	1.914	0.0091	V40 - 5XT
13	25.00	18.00	1	2.86	1.73	1.731	6.288	2.188	-0.0226	V40 - 5XT
14	27.00	18.00	1	3.39	2.07	2.070	4.544	2.524	-0.0552	V40 - 5XT
15	29.00	18.00	1	3.23	1.94	1.942	1.962	2.892	-0.0936	V40 - 5XT

GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.687
(it corresponds to a critical circle at Xc = -8.00, Yc = 116.00 and R = 116.28 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.109
(it corresponds to a critical circle at Xc = -22.00, Yc = 144.00 and R = 145.67 [ft]).

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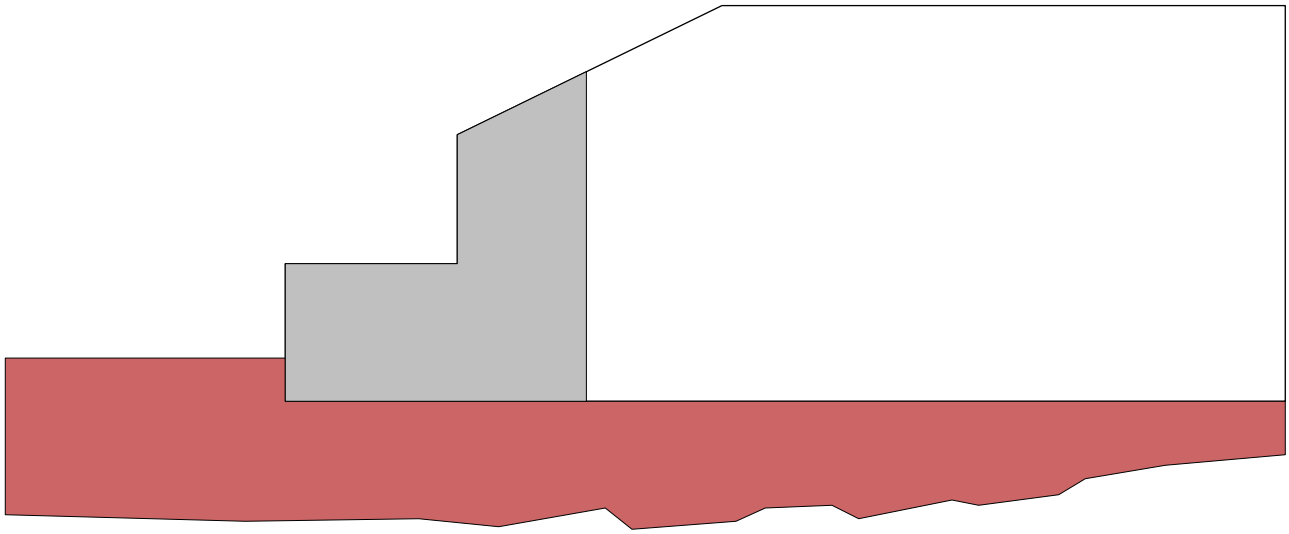
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	48306	49409	[lb/ft ²]
Meyerhof stress, σ_V	3352.1	3264	[lb/ft ²]
Eccentricity, e	-0.56	0.03	[ft]
Eccentricity, e/L	-0.016	0.001	
Fs calculated	14.41	15.14	
Base length	35.00	35.00	[ft]



SCALE:

0 2 4 6 8 10[ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 1.995 and Fs-seismic = 1.767

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	35.00	1.811	1.613	3	V40 - 10XT
2	2.00	35.00	1.833	1.651	3	V40 - 10XT
3	4.00	35.00	1.864	1.709	3	V40 - 10XT
4	6.00	35.00	1.890	1.764	3	V40 - 10XT
5	8.00	35.00	1.907	1.813	2	V40 - 8XT
6	10.00	35.00	1.912	1.851	2	V40 - 8XT
7	12.00	35.00	1.899	1.867	2	V40 - 8XT
8	14.00	35.00	1.856	1.847	2	V40 - 8XT
9	17.00	18.00	1.991	1.373	2	V40 - 8XT
10	19.00	18.00	2.122	1.517	2	V40 - 8XT
11	21.00	18.00	2.271	1.694	2	V40 - 8XT
12	23.00	18.00	2.439	1.914	1	V40 - 5XT
13	25.00	18.00	2.625	2.188	1	V40 - 5XT
14	27.00	18.00	2.824	2.524	1	V40 - 5XT
15	29.00	18.00	3.014	2.892	1	V40 - 5XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = -0.0159, e/L seismic = -0.0051; Overturning: Fs-static = 5.51, Fs-seismic = 5.07

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	35.00	-0.0211	-0.0112	3	V40 - 10XT
2	2.00	35.00	-0.0317	-0.0236	3	V40 - 10XT
3	4.00	35.00	-0.0489	-0.0430	3	V40 - 10XT
4	6.00	35.00	-0.0679	-0.0639	3	V40 - 10XT
5	8.00	35.00	-0.0895	-0.0871	2	V40 - 8XT
6	10.00	35.00	-0.1152	-0.1139	2	V40 - 8XT
7	12.00	35.00	-0.1470	-0.1464	2	V40 - 8XT
8	14.00	35.00	-0.1886	-0.1884	2	V40 - 8XT
9	17.00	18.00	0.0481	0.1163	2	V40 - 8XT
10	19.00	18.00	0.0283	0.0778	2	V40 - 8XT
11	21.00	18.00	0.0085	0.0423	2	V40 - 8XT
12	23.00	18.00	-0.0119	0.0091	1	V40 - 5XT
13	25.00	18.00	-0.0340	-0.0226	1	V40 - 5XT
14	27.00	18.00	-0.0599	-0.0552	1	V40 - 5XT
15	29.00	18.00	-0.0946	-0.0936	1	V40 - 5XT

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Tavailable [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.67	4107	940.68	664.71	N/A	4.367	N/A	3.068	V40 - 10XT
2	2.00	4107	1077.28	650.55	N/A	3.813	N/A	2.800	V40 - 10XT
3	4.00	4107	1153.27	629.27	N/A	3.562	N/A	2.684	V40 - 10XT
4	6.00	4107	883.89	607.99	N/A	4.647	N/A	3.291	V40 - 10XT
5	8.00	3083	614.51	586.71	N/A	5.017	N/A	3.192	V40 - 8XT
6	10.00	3083	460.89	565.43	N/A	6.689	N/A	3.856	V40 - 8XT
7	12.00	3083	307.26	544.15	N/A	10.034	N/A	4.870	V40 - 8XT
8	14.00	3083	1341.85	522.87	N/A	2.298	N/A	1.863	V40 - 8XT
9	17.00	3083	1481.93	334.87	N/A	2.080	N/A	1.833	V40 - 8XT
10	19.00	3083	1328.27	313.59	N/A	2.321	N/A	2.034	V40 - 8XT
11	21.00	3083	1174.64	292.31	N/A	2.625	N/A	2.284	V40 - 8XT
12	23.00	1761	1021.01	271.03	N/A	1.724	N/A	1.488	V40 - 5XT
13	25.00	1761	867.38	249.75	N/A	2.030	N/A	1.731	V40 - 5XT
14	27.00	1761	713.75	228.47	N/A	2.467	N/A	2.070	V40 - 5XT
15	29.00	1761	782.58	207.19	N/A	2.250	N/A	1.942	V40 - 5XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic Fs	Actual Seismic Fs
1	0.67	1.000	940.7	664.7	34.63	0.37	124280.5	N/A	132.118	99424.4	N/A	61.932
2	2.00	1.000	1077.3	650.6	33.89	1.11	116700.6	N/A	108.329	93360.5	N/A	54.033
3	4.00	1.000	1153.3	629.3	32.78	2.22	105727.0	N/A	91.676	84581.6	N/A	47.450
4	6.00	1.000	883.9	608.0	31.67	3.33	95215.6	N/A	107.723	76172.5	N/A	51.058
5	8.00	1.000	614.5	586.7	30.57	4.43	85238.2	N/A	138.708	68190.6	N/A	56.767
6	10.00	1.000	460.9	565.4	29.46	5.54	75726.6	N/A	164.307	60581.3	N/A	59.028
7	12.00	1.000	307.3	544.2	28.35	6.65	66745.4	N/A	217.231	53396.4	N/A	62.715
8	14.00	1.000	1341.9	522.9	27.24	7.76	58233.7	N/A	43.398	46587.0	N/A	24.983
9	17.00	1.000	1481.9	334.9	17.45	0.55	27458.3	N/A	18.529	21966.6	N/A	12.091
10	19.00	1.000	1328.3	313.6	16.34	1.66	22045.1	N/A	16.597	17636.1	N/A	10.741
11	21.00	1.000	1174.6	292.3	15.23	2.77	17117.9	N/A	14.573	13694.3	N/A	9.335
12	23.00	1.000	1021.0	271.0	14.12	3.88	12700.6	N/A	12.439	10160.4	N/A	7.864
13	25.00	1.000	867.4	249.8	13.01	4.99	8780.1	N/A	10.123	7024.1	N/A	6.288
14	27.00	1.000	713.8	228.5	11.90	6.10	5352.2	N/A	7.499	4281.8	N/A	4.544
15	29.00	1.000	782.6	207.2	10.79	7.21	2427.7	N/A	3.102	1942.1	N/A	1.962

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	941	0.71	0.71	5360	4107	N/A	5.70	N/A	4.37	V40 - 10XT
2	2.00	1077	0.67	0.67	5059	4107	N/A	4.70	N/A	3.81	V40 - 10XT
3	4.00	1153	0.61	0.61	4606	4107	N/A	3.99	N/A	3.56	V40 - 10XT
4	6.00	884	0.55	0.55	4152	4107	N/A	4.70	N/A	4.65	V40 - 10XT
5	8.00	615	0.63	0.63	3552	3083	N/A	5.78	N/A	5.02	V40 - 8XT
6	10.00	461	0.60	0.60	3372	3083	N/A	7.32	N/A	6.69	V40 - 8XT
7	12.00	307	0.56	0.56	3192	3083	N/A	10.39	N/A	10.03	V40 - 8XT
8	14.00	1342	0.53	0.53	3012	3083	N/A	2.24	N/A	2.30	V40 - 8XT
9	17.00	1482	0.71	0.71	4021	3083	N/A	2.71	N/A	2.08	V40 - 8XT
10	19.00	1328	0.69	0.69	3913	3083	N/A	2.95	N/A	2.32	V40 - 8XT
11	21.00	1175	0.66	0.66	3733	3083	N/A	3.18	N/A	2.62	V40 - 8XT
12	23.00	1021	0.98	0.98	3198	1761	N/A	3.13	N/A	1.72	V40 - 5XT
13	25.00	867	0.98	0.98	3198	1761	N/A	3.69	N/A	2.03	V40 - 5XT
14	27.00	714	0.98	0.98	3198	1761	N/A	4.48	N/A	2.47	V40 - 5XT
15	29.00	783	0.98	0.98	3198	1761	N/A	4.09	N/A	2.25	V40 - 5XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	Reduction factor for connection (short-term strength) CRult	Reduction factor for connection (long-term strength) CRcr	Available connection strength [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection strength Specified	Fs-overall connection strength Actual	Fs-overall Geogrid strength Specified	Fs-overall Geogrid strength Actual	Product name
1	0.67	1605	0.71	0.71	5360	4107	N/A	3.34	N/A	3.07	V40 - 10XT
2	2.00	1728	0.67	0.67	5059	4107	N/A	2.93	N/A	2.80	V40 - 10XT
3	4.00	1783	0.61	0.61	4606	4107	N/A	2.58	N/A	2.68	V40 - 10XT
4	6.00	1492	0.55	0.55	4152	4107	N/A	2.78	N/A	3.29	V40 - 10XT
5	8.00	1201	0.63	0.63	3552	3083	N/A	2.96	N/A	3.19	V40 - 8XT
6	10.00	1026	0.60	0.60	3372	3083	N/A	3.29	N/A	3.86	V40 - 8XT
7	12.00	851	0.56	0.56	3192	3083	N/A	3.75	N/A	4.87	V40 - 8XT
8	14.00	1865	0.53	0.53	3012	3083	N/A	1.62	N/A	1.86	V40 - 8XT
9	17.00	1817	0.71	0.71	4021	3083	N/A	2.21	N/A	1.83	V40 - 8XT
10	19.00	1642	0.69	0.69	3913	3083	N/A	2.38	N/A	2.03	V40 - 8XT
11	21.00	1467	0.66	0.66	3733	3083	N/A	2.54	N/A	2.28	V40 - 8XT
12	23.00	1292	0.98	0.98	3198	1761	N/A	2.48	N/A	1.49	V40 - 5XT
13	25.00	1117	0.98	0.98	3198	1761	N/A	2.86	N/A	1.73	V40 - 5XT
14	27.00	942	0.98	0.98	3198	1761	N/A	3.39	N/A	2.07	V40 - 5XT
15	29.00	990	0.98	0.98	3198	1761	N/A	3.23	N/A	1.94	V40 - 5XT

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GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.180 has been applied.
The seismic force is applied at the center of the sliding mass.

STATIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.687
(it corresponds to a critical circle at Xc = -8.00, Yc = 116.00 and R = 116.28 [ft] where (x=0, y=0) is taken at the TOE or Xc = 67.00, Yc = 1116.00 and R = 116.28 [ft] when the terrain coordinate system is used as shown in the table below.)

SEISMIC CONDITIONS:
For the specified search grid, the calculated minimum Fs is 1.109
(it corresponds to a critical circle at Xc = -22.00, Yc = 144.00 and R = 145.67 [ft] where (x=0, y=0) is taken at the TOE or Xc = 53.00, Yc = 1144.00 and R = 145.67 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Soil layer #1:	γ = 120.00 [lb/ft ³]		ϕ = 28.0°		c = 500.00 [lb/ft ²]						
x [ft]	0.0	15.0	50.0	70.0	110.0	140.0	200.0	250.0	300.0	350.0	400.0
y [ft]	1005.0	1005.0	1005.0	1005.0	1000.0	1000.0	1000.0	1000.0	1000.0	1040.0	1050.0

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SINGLE FAMILY 60' x 100' LOT AREA SUMMARY (LOTS 109-304)

Lot No.	S.F	Lot No.	S.F	Lot No.	S.F	Lot No.	S.F	Lot No.	S.F
109	6818	150	6136	191	9374	232	6497	273	7153
110	9055	151	6309	192	7587	233	9961	274	6508
111	6668	152	6741	193	5999	234	7379	275	6600
112	6512	153	6862	194	7104	235	6400	276	6400
113	6272	154	6623	195	9114	236	6400	277	6000
114	6200	155	6556	196	6439	237	7463	278	6000
115	6386	156	6720	197	10040	238	8423	279	5800
116	6957	157	6951	198	6637	239	7029	280	6128
117	6437	158	7026	199	7293	240	6720	281	6000
118	6328	159	8208	200	7405	241	6405	282	6000
119	6281	160	12208	201	7220	242	6398	283	7025
120	6306	161	8166	202	10,769	243	7491	284	6231
121	6331	162	12422	203	8.279	244	7350	285	6265
122	6443	163	7778	204	6701	245	8798	286	7149
123	7794	164	6801	205	7376	246	7345	287	6334
124	8728	165	6575	206	10515	247	8093	288	9965
125	8309	166	6325	207	6778	248	6917	289	10587
126	8421	167	6398	208	6883	249	7439	290	6321
127	8435	168	6345	209	7629	250	8016	291	6525
128	7761	169	6233	210	7186	251	8016	292	7179
129	8724	170	6137	211	7041	252	7678	293	7684
130	7642	171	6170	212	7203	253	7804	294	7627
131	7182	172	6216	213	6521	254	7435	295	7830
132	8129	173	6160	214	6561	255	6952	296	6568
133	7657	174	6123	215	8689	256	7334	297	6171
134	6943	175	6770	216	7762	257	7648	298	6032
135	8736	176	7912	217	6642	258	7763	299	6274
136	11071	177	9348	218	6833	259	7674	300	6328
137	10915	178	11398	219	9829	260	8082	301	6376
138	7614	179	7321	220	11528	261	7647	302	6494
139	7344	180	6742	221	6943	262	7525	303	6279
140	7187	181	7621	222	7649	263	7609	304	6275
141	7324	182	9260	223	7827	264	7665		
142	6950	183	13203	224	9553	265	7810		
143	6648	184	11606	225	8423	266	7628		
144	6720	185	11953	226	7870	267	8121		
145	6897	186	7863	227	6768	268	8595		
146	7226	187	7104	228	6154	269	8865		
147	8089	188	6711	229	6060	270	6461		
148	6400	189	6817	230	6053	271	7210		
149	6244	190	8030	231	6175	272	8133		

TOTAL GROSS 1,462,631 S.F.
33.5 Acres
AVERAGE GROSS 7,462 S.F.

SINGLE FAMILY 55' x 100' LOT AREA SUMMARY (LOTS 1-108)

Lot No.	S.F	Lot No.	S.F	Lot No.	S.F
1	6822	42	6437	83	6476
2	6360	43	6212	84	6940
3	6507	44	5905	85	6526
4	6434	45	6253	86	9652
5	8609	46	6570	87	5885
6	6314	47	7227	88	6150
7	6112	48	7092	89	6538
8	6035	49	6392	90	6759
9	6011	50	5911	91	8433
10	6071	51	6283	92	8713
11	5987	52	6051	93	5701
12	5997	53	5681	94	10326
13	5954	54	5900	95	6989
14	5871	55	5900	96	6631
15	6819	56	5500	97	9584
15	6501	57	6125	98	6091
17	7209	58	7105	99	6532
18	5815	59	6356	100	6076
19	6127	60	5566	101	6076
20	6335	61	5651	102	6122
21	6994	62	5711	103	6174
22	6042	63	5711	104	6228
23	8099	64	5711	105	6210
24	5442	65	5711	106	6475
25	6058	66	5720	107	5981
26	7693	67	5735	108	5786
27	8588	68	5728		
28	5914	69	5732		
29	5526	70	5732		
30	7242	71	5548		
31	7474	72	5500		
32	6843	73	5500		
33	7373	74	5500		
34	8198	75	5500		
35	8016	76	5900		
36	7898	77	8034		
37	6870	78	7621		
38	6825	79	5896		
39	8258	80	5987		
40	9585	81	5659		
41	8450	82	6296		

TOTAL GROSS 709,181 S.F.
16.3 Acres
AVERAGE GROSS 6,566 S.F.

PARK SUMMARY

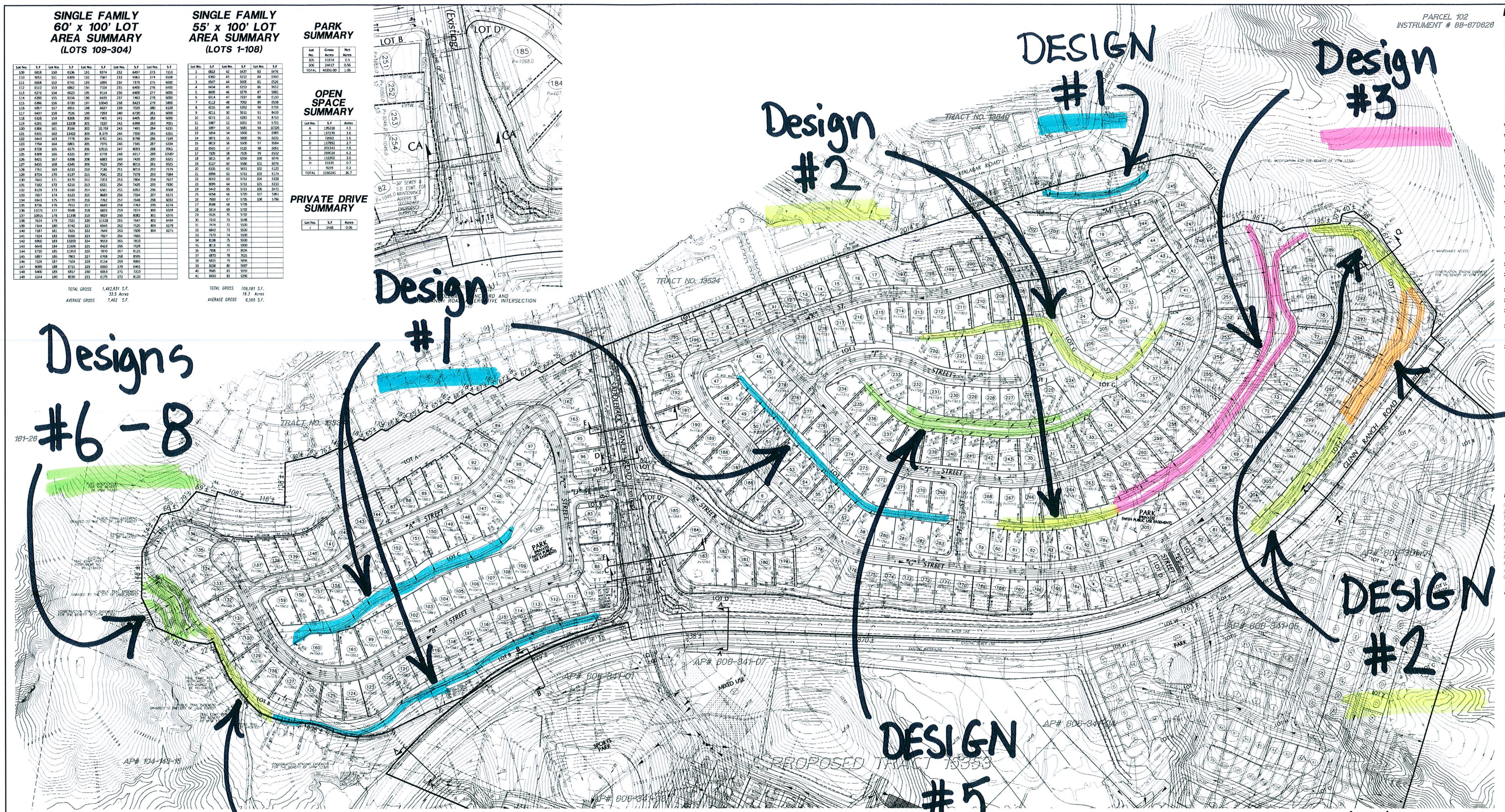
Lot No.	Gross Acres	Net Acres
305	21974	0.5
306	24417	0.56
TOTAL	46391.00	1.06

OPEN SPACE SUMMARY

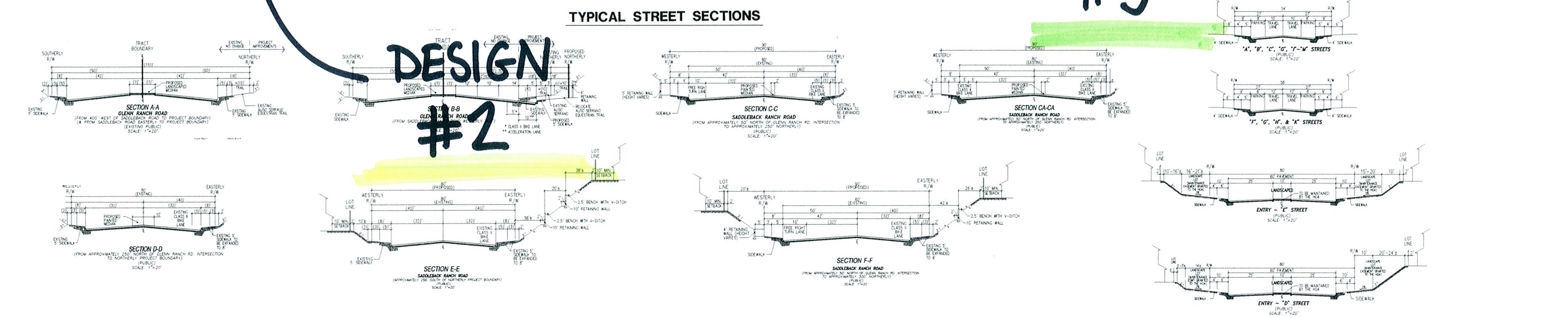
Lot No.	S.F	Acres
A	195218	4.5
B	157270	3.6
C	72692	1.6
D	117892	2.7
E	201343	4.6
F	269024	6.2
G	111902	2.6
H	31635	0.7
I	9269	0.2
TOTAL	1166245	26.7

PRIVATE DRIVE SUMMARY

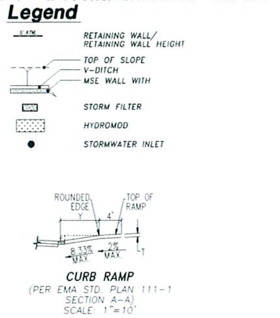
Lot No.	S.F	Acres
J	2468	0.06



TYPICAL STREET SECTIONS



Legend



NOTES

1. **EXISTING LAND USE:** VACANT.
2. **PROPOSED LAND USE:** RESIDENTIAL, AND PARK.
3. **EXISTING ZONING:** CITY OF LAKE FOREST - PORTOLA HILLS PLANNED COMMUNITY, SINGLE FAMILY, AND OPEN SPACE.
4. **PROPOSED ZONING:** CITY OF LAKE FOREST - PORTOLA HILLS PLANNED COMMUNITY, SINGLE FAMILY, AND OPEN SPACE.
5. **WATER SERVICE PROVIDED BY:** IRVINE RANCH WATER DISTRICT.
6. **SANITARY SEWER SERVICE PROVIDED BY:** IRVINE RANCH WATER DISTRICT.
7. **ELECTRIC SERVICE PROVIDED BY:** SOUTHERN CALIFORNIA EDISON COMPANY.
8. **GAS SERVICE PROVIDED BY:** SOUTHERN CALIFORNIA GAS COMPANY.
9. **TELEPHONE SERVICE PROVIDED BY:** PACIFIC BELL.
10. **CABLE SERVICE PROVIDED BY:** COX TELECOMMUNICATION.
11. **SOLID WASTE MANAGEMENT IS UNDER THE JURISDICTION OF:** COUNTY ENVIRONMENTAL MANAGEMENT AGENCY WASTE MANAGEMENT DEPARTMENT.
12. PROJECT IS LOCATED WITHIN THE JURISDICTION OF THE SADDLEBACK VALLEY UNIFIED SCHOOL DISTRICT.
13. NO BUILDINGS EXIST ON THIS SITE.
14. ALL PROPOSED UTILITIES TO BE UNDERGROUND.
15. DRAINAGE FACILITIES TO BE DESIGNED IN ACCORDANCE WITH THE MASTER PLAN OF DRAINAGE, AND COUNTY OF ORANGE GRADING AND EXCAVATION CODE.
16. ALL GRADING, SLOPE TERRACE DRAINS AND DOWN DRAINS SHALL CONFORM TO THE COUNTY OF ORANGE GRADING AND EXCAVATION CODE.
17. ALL SLOPES SHALL BE 2:1 UNLESS OTHERWISE NOTED.
18. THE LOCAL PARK CODE REQUIREMENT FOR THIS PROJECT IS 2.43 AC. (304 UNITS x .008) AND SHALL BE SATISFIED BY A COMBINATION OF PARK LAND AND IMPROVEMENTS ON AND OFF SITE. PER AGREEMENT THE THE SURPLUS OPEN SPACE OF THE ADJOINING TRACT (15353) WILL BE JOINTLY UTILIZED TO MEET THE REMAINING PARK CODE REQUIREMENT OF THIS TRACT.
19. WE RESERVE THE RIGHT TO FILE MULTIPLE FINAL MAPS ON SUBJECT TENTATIVE.
20. THIS IS AN APPLICATION FOR A DEVELOPMENT PERMIT.
21. ALL SLOPES WITHIN LETTERED LOTS TO BE MAINTAINED BY THE HOME OWNERS ASSOCIATION OR (LMD) LIGHTING MAINTENANCE DISTRICT (CITY).
22. AP#'s 606-321-(01,02,03,04,05,07,08,09), 606-331-(01,02,03,), 606-322-01, 606-161-(28,30,31)
23. ALL STREETS ARE PUBLIC.
24. PER FIRM MAPS 06059C0317H AND 06059C0336H, THE PROJECT GRADING DOES NOT RESIDE WITHIN FLOOD HAZARD ZONE LIMITS.
25. THE PROJECT C.C.&R.'S SHALL INCLUDE PROVISIONS FOR PARKING RESTRICTION OF COMMERCIAL VEHICLES AND PERMITTING ENCROACHMENT FOR LANDSCAPE MAINTENANCE VEHICLES PER MUNICIPAL CODE, SECTION 12.12.020-PERMIT.
26. EARTHWORK - CUT = 1,685,445 FILL = 1,685,445; SELECT MATERIAL = 504,780 CYS

LOT SUMMARY

Lot No.	Land Use	Maintenance Responsibility	Acres
1-304	SINGLE FAMILY RESIDENTIAL	HOMEOWNER	52.3
305	PARK SITE	H[illegible]A	0.5
306	[illegible]	[illegible]A	0.6
A-I	[illegible]	[illegible]A	26.7
[illegible]	[illegible]VATE DRIV[illegible]	[illegible]A	0.06
[illegible]	[illegible]	[illegible]	15.7
	EXISTING GLENN RANCH ROAD & SADDLEBACK RANCH ROAD	CITY	6.9
			100.2

LEGAL DESCRIPTION

IN THE CITY OF LAKE FOREST, COUNTY OF ORANGE, STATE OF CALIFORNIA, BEING ALL OF LOT 11, OF TRACT NO. 13849 AS SHOWN ON A MAP FILED IN BOOK 639, PAGES 16 THROUGH 22, INCLUSIVE, AND PORTIONS OF SADDLEBACK RANCH ROAD AND GLENN RANCH ROAD, OF TRACT NO. 13524 AS SHOWN ON A MAP FILED IN BOOK 639, PAGES 11 THROUGH 15, INCLUSIVE, BOTH OF MISCELLANEOUS MAPS, IN THE OFFICE OF THE COUNTY RECORDER OF SAID COUNTY, TOGETHER WITH A PORTION OF PARCEL 1 OF LOT LINE ADJUSTMENT NO. LLA 2010-01, RECORDED SEPTEMBER 16, 2010, AS INSTRUMENT NO. 2010000460178, ALL OF PARCEL 12 OF LOT LINE ADJUSTMENT NO. LLA 2009-02, RECORDED SEPTEMBER 16, 2010, AS INSTRUMENT NO. 2010000460179, AND ALL OF PARCEL 2 OF LOT LINE ADJUSTMENT NO. LLA 2009-03 RECORDED SEPTEMBER 16, 2010, AS INSTRUMENT NO. 2010000460180, ALL OF OFFICIAL RECORDS, IN THE OFFICE OF THE COUNTY RECORDER OF SAID COUNTY.

STATEMENT OF OWNERSHIP

WE, USA PORTOLA LLC, DO HEREBY STATE THAT WE ARE OWNERS OF THE PROPERTY COMPRISING THIS TENTATIVE TRACT MAP, AND WE HAVE CONSENTED TO THE SUBMISSION OF SAID MAP.

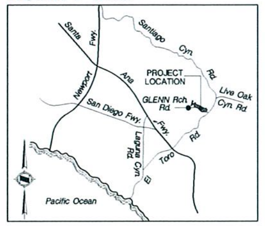
DATE

I HEREBY STATE THAT THIS MAP WAS PREPARED UNDER MY SUPERVISION AND THAT THE OWNER OF RECORD HAS KNOWLEDGE OF AND CONSENTS TO THE FILING OF THIS MAP.

DATE
EDWARD A. MANDICH

REGISTERED PROFESSIONAL ENGINEER EDWARD A. MANDICH No. 59089 CIVIL STATE OF CALIFORNIA

VICINITY MAP



MAP DATE IDENTIFIER
DATE OF LATEST CHANGE TO THIS MAP: 4/27/12 BY: kb
DATE OF THIS PLOT: 05/29/12

DATE	REVISION	BY
4/27/12	NEW ACCESS TO SADDLEBACK RANCH RD.	KB
7/12/11	RESPONSE TO CITY COMMENTS DATED MAY 20, 2011	JAM
12/17/09	RESPONSE TO CITY COMMENTS DATED MAY 26, 2009	JAM

DATE 4/27/12
W.O. 3645-2
GROSS AREA 100.2 AC.±
CONTOUR INTERVAL 2'
TOTAL LOTS 306 NUMBERED
10 LETTERED

FEET 0 50 100 200
INCHES 0 1/2 1 2

PREPARED FOR:

USA PORTOLA LLC
280 NEWPORT CENTER DRIVE
SUITE 240
NEWPORT BEACH, CA 92660

PREPARED BY:

H&A
HUNSAKER & ASSOCIATES IRVINE, INC.
PLANNING • ENGINEERING • SURVEYING
Three Hughes • Irvine, CA 92618
FX: (949) 583-0759 • PH: (949) 583-1010

TENTATIVE TRACT NO. 17300

SHEET 1 OF 2

WO: 3645-2 TTM 17300 PORTOLA CENTER BIN: 152B RM: 269 DOC.: 67799

F:\0334\Planning\0A_Project\TTM\334P-TT17300.dwg

RECEIVED
JAN 10 2012
City of Lake Forest
Planning

Memorandum

To: Ron Santos, Senior Planner

Cc: Dennis Jue, Deputy City Engineer

Prepared Under Direction of: Tim D'Zmura, Interwest Consulting Group

From: Steven Palmer, Interwest Consulting Group
Roger Peterson, Interwest Consulting Group

Date: December 16, 2011

Subject: **Portola Center Segmental Retaining Walls for the North and South Parcels – Preliminary Structural Plan Review**

Interwest Consulting Group has performed a preliminary review of the above referenced Portola Center Segmental Retaining Walls at the north and south parcels and our comments are noted below:

S1. Please provide a current ICC ES report that is in conformance with the 2009 IBC. Please note that ER-5515 is in compliance with the 1997 Uniform Building Code.

S2. Please submit a letter from the geotechnical engineer confirming that the design and detailing of the segmental retaining walls have been reviewed and that it has been determined that the recommendations in the Geotechnical Report have been properly incorporated into the calculations and drawings.

S3. Specify on plans that the geotechnical engineer shall be retained to provide observation and testing services during the grading and construction phase of retaining walls per the recommendations of the geotechnical report and that inspection and testing reports shall be submitted to the Building Department.

S4. Please provide a plan to clarify the locations of the various segmental retaining walls shown on the drawings prepared by Soil Retention Designs Inc.

S5. Section 9.13.13 of the Geotechnical Report recommends that a soldier pile wall should be used at the location adjacent to Glenn Ranch Road on the northeast side of the site, from Saddleback Road to Alley B-B', rather than the proposed segmental retaining wall. Please provide calculations and details for this soldier pile wall if used.

S6. Section 9.2.3 and Appendix B of the Geotechnical Report show that the on site materials possess a severe sulfate exposure to concrete structures. Please verify that the Verdura segmental concrete blocks will be acceptable for use in

soil with severe sulfate exposure. Please note per ACI Section 4.3 that concrete used in severe sulfate exposure is to be made with type V cement, have a maximum water / cement ratio of 0.45 and have a minimum compressive strength of 4500 psi.

S6. Section 9.13.12 of the Geotechnical Report specifies that MSE walls in excess of 60' high should be constructed using metallic reinforcement in the reinforced zone to prevent significant deformations that would be expected in similar height walls reinforced with geosynthetic reinforcement. Please verify if metallic reinforcement should be used at walls over 60' in height.

S7. On sheet 1, (at both sets of drawings), please reference the Geotechnical Report prepared by Geocon Inc.

S8. Please verify if a surcharge at the top of the retaining walls due to future structures or roads should be included in the design of the retaining walls.

S9. At sheet 1, (at both sets of drawings), please amend Table 3 to correspond with the Geotechnical Report and the values used in the design of the walls.

S10. Please clarify how the seismic coefficient was determined. Please justify using 0.5 x 0.63g for the seismic coefficient.

S11. Please provide calculations for the vertical and horizontal deformations of the MSE walls as required per section 9.13.10 of the Geotechnical Report.

S12. Please provide calculations for the 76' tall wall, the 116' tall wall and the 90' tall wall shown on sheets 2/5, 3/5 and 4/5 respectively for the North Parcel.

S13. Please provide drawings and calculation that bear the wet stamp and signature of the engineer of record.

UNIFORM BUILDING CODE STANDARD 21-4
HOLLOW AND SOLID LOAD-BEARING CONCRETE MASONRY UNITS

Based on Standard Specification C 90-95 of the American Society for Testing and Materials. Extracted, with permission, from the *Annual Book of ASTM Standards*, copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428

SECTION 21.401 — SCOPE

This standard covers solid (units with 75 percent or more net area) and hollow load-bearing concrete masonry units made from portland cement, water and mineral aggregates with or without the inclusion of other materials.

SECTION 21.402 — CLASSIFICATION

21.402.1 Types. Two types of concrete masonry units in each of two grades are covered as follows:

21.402.1.1 Type I, moisture-controlled units. Units designated as Type I shall conform to all requirements of this standard including the moisture content requirements of Table 21-4-A.

21.402.1.2 Type II, nonmoisture-controlled units. Units designated as Type II shall conform to all requirements of this standard except the moisture content requirements of Table 21-4-A.

21.402.2 Grades. Concrete masonry units manufactured in accordance with this standard shall conform to two grades as follows:

21.402.2.1 Grade N. Units having a weight classification of 85 pcf (1360 kg/m^3) or greater, for general use such as in exterior walls below and above grade that may or may not be exposed to moisture penetration or the weather and for interior walls and backup.

21.402.2.2 Grade S. Units having a weight classification of less than 85 pcf (1360 kg/m^3), for uses limited to above-grade installation in exterior walls with weather-protective coatings and in walls not exposed to the weather.

SECTION 21.403 — MATERIALS

21.403.1 Cementitious Materials. Materials shall conform to the following applicable standards:

1. Portland Cement—ASTM C 150 modified as follows:

   Limitation on insoluble residue—1.5 percent maximum.
   Limitation on air content of mortar,
   Volume percent—22 percent maximum.
   Limitation on loss on ignition—7 percent maximum.
   Limestone with a minimum 85 percent calcium carbonate (C_aCO_3) content may be added to the cement, provided the requirements of ASTM C 150 as modified above are met.
2. Blended Cements—ASTM C 595.
3. Hydrated Lime, Type S—UBC Standard 21-13.

21.403.2 Other Constituents and Aggregates. Air-entraining agents, coloring pigments, integral water repellents, finely ground silica, aggregates, and other constituents, shall be previously established as suitable for use in concrete or shall be shown by test or experience to not be detrimental to the durability of the concrete.

SECTION 21.404 — PHYSICAL REQUIREMENTS

At the time of delivery to the work site, the units shall conform to the physical requirements prescribed in Table 21-4-B. The moisture content of Type I concrete masonry units at time of delivery shall conform to the requirements prescribed in Table 21-4-A.

At the time of delivery to the purchaser, the linear shrinkage of Type II units shall not exceed 0.065 percent.

SECTION 21.405 — MINIMUM FACE-SHELL AND WEB THICKNESSES

Face-shell (FST) and web (WT) thicknesses shall conform to the requirements listed in Table 21-4-C.

SECTION 21.406 — PERMISSIBLE VARIATIONS IN DIMENSIONS

21.406.1 Precision Units. For precision units, no overall dimension (width, height and length) shall differ by more than $^1/_8$ inch (3.2 mm) from the specified standard dimensions.

21.406.2 Particular Feature Units. For particular feature units, dimensions shall be in accordance with the following:

1. For molded face units, no overall dimension (width, height and length) shall differ by more than $^1/_8$ inch (3.2 mm) from the specified standard dimension. Dimensions of molded features (ribs, scores, hex-shapes, patterns, etc.) shall be within $^1/_{16}$ inch (1.6 mm) of the specified standard dimensions and shall be within $^1/_{16}$ inch (1.6 mm) of the specified placement of the unit.

2. For split-faced units, all non-split overall dimensions (width, height and length) shall differ by no more than $^1/_8$ inch (3.2 mm) from the specified standard dimensions. On faces that are split, overall dimensions will vary. Local suppliers should be consulted to determine dimensional tolerances achievable.

3. For slumped units, no overall height dimension shall differ by more than $^1/_8$ inch (3.2 mm) from the specified standard dimension. On faces that are slumped, overall dimensions will vary. Local suppliers should be consulted to determine dimension tolerances achievable.

NOTE: Standard dimensions of units are the manufacturer's designated dimensions. Nominal dimensions of modular size units, except slumped units, are equal to the standard dimensions plus $^3/_8$ inch (9.5 mm), the thickness of one standard mortar joint. Slumped units are equal to the standard dimensions plus $^1/_2$ inch (13 mm), the thickness of one standard mortar joint. Nominal dimensions of nonmodular size units usually exceed the standard dimensions by $^1/_8$ inch to $^1/_4$ inch (3.2 mm to 6.4 mm).

SECTION 21.407 — VISUAL INSPECTION

All units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or impair the strength or perm-anence of the construction. Units may have minor cracks incidental to the usual method of manufacture, or minor chipping resulting from customary methods of handling in shipment and delivery.

Aug 25 2009 5:10PM HP LASERJET FAX p.2

Units that are intended to serve as a base for plaster or stucco shall have a sufficiently rough surface to afford a good bond.

Where units are to be used in exposed wall construction, the face or faces that are to be exposed shall be free of chips, cracks or other imperfections when viewed from 20 feet (6100 mm), except that not more than 5 percent of a shipment may have slight cracks or small chips not larger than 1 inch (25.4 mm).

SECTION 21.408 — METHODS OF SAMPLING AND TESTING

The purchaser or authorized representative shall be accorded proper facilities to inspect and sample the units at the place of manufacture from the lots ready for delivery.

Sample and test units in accordance with ASTM C 140.

Total linear drying shrinkage shall be based on tests of concrete masonry units made with the same materials, concrete mix design, manufacturing process and curing method, conducted in accordance with ASTM C 426 and not more than 24 months prior to delivery.

SECTION 21.409 — REJECTION

If the samples tested from a shipment fail to conform to the specified requirements, the manufacturer may sort it, and new specimens shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. If the second set of specimens fails to conform to the specified requirements, the entire lot shall be rejected.

TABLE 21-4-A—MOISTURE CONTENT REQUIREMENTS FOR TYPE I UNITS

LINEAR SHRINKAGE, PERCENT	MOISTURE CONTENT, MAX. PERCENT OF TOTAL ABSORPTION (Average of 3 Units)		
	Humidity Conditions at Jobsite or Point of Use		
	Humid[1]	Intermediate[2]	Arid[3]
0.03 or less	45	40	35
From 0.03 to 0.045	40	35	30
0.045 to 0.065, max.	35	30	25

[1] Average annual relative humidity above 75 percent.

[2] Average annual relative humidity 50 to 75 percent.

[3] Average annual relative humidity less than 50 percent.

TABLE 21-4-B—STRENGTH AND ABSORPTION REQUIREMENTS

COMPRESSIVE STRENGTH, MIN, psi (MPa) Average Net Area		WATER ABSORPTION, MAX, lb./ft. (kg/m) (Average of 3 Units) Weight Classification—Oven-dry Weight of Concrete, lb./ft. (kg/m)		
Average of 3 Units	Individual Unit	Lightweight, Less than 105 (1680)	Medium Weight, 105 to less than 125 (1680-2000)	Normal Weight, 125 (2000) or more
1900 (13.1)	1700 (11.7)	18 (288)	15 (240)	13 (208)

TABLE 21-4-C—MINIMUM THICKNESS OF FACE-SHELLS AND WEBS

NOMINAL WIDTH (W) OF UNIT (Inches)	FACE-SHELL THICKNESS (FST) MIN., (Inches)[1, 4]	WEB THICKNESS (WT)	
		Webs[1] Min., (Inches)	Equivalent Web Thickness, Min., In./Lin. Ft.[2]
× 25.4 for mm			× 83 for mm/m. m
3 and 4	3/4	3/4	1 5/8
6	1	1	2 1/4
8	1 1/4	1	2 1/4
10	1 3/8	1 1/8	2 1/2
	1 1/4[3]		
12	1 1/2	1 1/8	2 1/2
	1 1/4[3]		

[1] Average of measurements on three units taken at the thinnest point.

[2] Sum of the measured thickness of all webs in the unit, multiplied by 12 (305 when using metric), and divided by the length of the unit. In the case of open-ended units where the open-ended portion is solid grouted, the length of that open-ended portion shall be deducted from the overall length of the unit.

[3] This face-shell thickness (FST) is applicable where allowable design load is reduced in proportion to the reduction in thicknesses shown, except that allowable design load on solid-grouted units shall not be reduced.

[4] For split-faced units, a maximum of 10 percent of a shipment may have face-shell thicknesses less than those shown, but in no case less than 3/4 inch (19 mm).

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5.2 SUPERIMPOSED WALLS

The design of superimposed MSE walls is made in two steps:

(1) A design using simplified design rules for calculating external stability and locating the internal failure plane for internal stability as shown in figure 48.

(2) A stability analysis, including both compound and global stability using a reinforced soil global stability computer program outlined in chapter 6. This is an essential computation.

For **preliminary design**, the following minimum values for reinforcement length, of L_1 and L_2, should be used for offsets (D) greater than [1/20 $(H_1 + H_2)$]:

Upper wall: $L'_1 \geq 0.7\ H_1$

Lower wall: $L'_2 \geq 0.6\ H$

where H = total height

Where the offset distance (D) is greater than $H_2 \tan(90\text{-}\varphi_r)$, walls are not considered superimposed and are independently designed.

For a small upper wall offset; $D \leq [\ 1/20\ (H_1 + H_2)\ ]$, it is assumed that the failure surface does not fundamentally change and it is simply adjusted laterally by the offset distance D. The walls should be designed as a single wall with a height H.

External stability calculations for the upper wall are conventionally performed as outlined in chapter 4. For the lower wall, consider the upper wall as a surcharge in computing bearing pressures. In lieu of a conventional external sliding stability computation, perform a slope stability analysis with failure circles exiting at the base. A minimum factor of safety of 1.5 is generally warranted.

For calculating the internal stability, the maximum tensile force lines are as indicated in figure 48a. These relationships are somewhat empirical and geometrically derived.

For intermediate offset distances, see figure 48a for the location of the failure surface and consider the vertical pressures in figure 48b for internal stress calculations.

For large setback distances, [$D \geq H_2 \tan(90\text{-}\varphi_r)$], the maximum tensile force lines are considered independently, without regard to the geometry of the two superimposed walls. For internal stability computations, the upper wall is neglected.

The balance of the computations remain identical as in chapter 4.

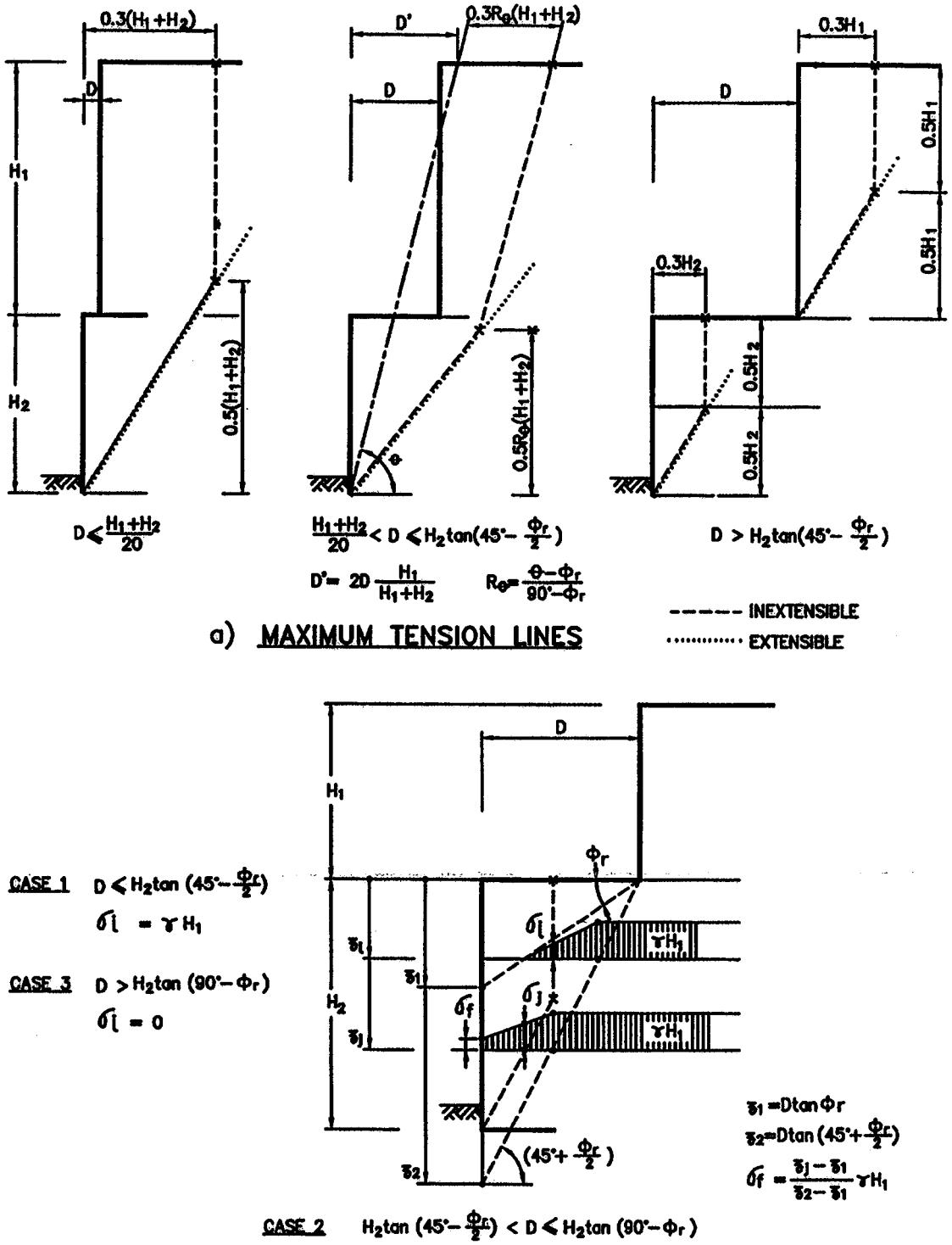

Figure 48. Design rules for superimposed walls.