MSE Retaining Wall Design Services

Chick-fil-A #04723
O'Fallon, Missouri
January 4, 2022
Terracon Project No. 15215199

Prepared for:
Chick-fil-A Corporation
Atlanta, GA

APPROVED
Jeannie Greenlee 02/01/2022

Prepared by:
Terracon Consultants, Inc.
Tempe, AZ

January 4, 2022

Chick-fil-A Corporation
5200 Buffington Road
Atlanta, GA 30349-2945

Attn: Mr. Justin Lurk
P: (404) 765 7822
E: justin.lurk@cfacorp.com

Re: MSE Retaining Wall Report
Chick-fil-A #04723
Old Highway N
O'Fallon, Missouri
Terracon Project No. 15215199

Dear Mr. Lurk:

At your request, Terracon Consultants. Inc. (Terracon) has completed engineering design of the proposed MSE retaining wall for the Chick-fil-A #04723, to be located at Old Highway N, O'Fallon, Missouri. Our design services have been completed subject to the Terracon Task Order, P15215199 dated October 15, 2021. Engineering calculations used in the design of the MSE wall are attached. Sheet RW-2 of the project plans provides the Technical Scope of Work, along with material requirements and specifications for construction of the wall.

The engineering design has been completed on the basis of information provided to Terracon as outlined in Section 1.03 of the Technical Scope of Work as shown on Sheet RW-2 of the project plans. Terracon has prepared the following calculation package for the above referenced project. We are available to discuss the engineering design with you. Please call should further consultation be required.

Sincerely,

Terracon Consultants, Inc.

Aria Fathi, Ph.D., E.I.T.
GeoDesign Engineer

Sara J. Somsky, P.E.
Senior Engineer

APR: Tom Mando Kapita, P.E. (AZ, TX, OK)
Principal/Manager Regional Services

Attachments

REPORT TOPICS

INTRODUCTION 1
WALL ELEMENT PARAMETERS 1
INTERNAL STABILITY ANALYSIS 3
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Note: This report was delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Attachment 1 – MSEW (3.0) Input and Output for Static and Seismic Load Cases

Attachment 2 – Global Stability Graphical Output

Attachment 3 – Block to Block and Geogrid to Block Shear Strength Capacity Technical Data Sheets

MSE Retaining Wall Report

Chick-fil-A #04723
Old Highway N
O'Fallon, Missouri

Terracon Project No. 15215199
January 4, 2022

INTRODUCTION

This calculation package is a design brief for the proposed MSE retaining wall planned as part of the site development for the Chick-fil-A #04723 in O'Fallon, Missouri. The retaining wall has been designed in general accordance with the following guidelines:

- National Concrete Masonry Association (NCMA), Design Manual for Segmental Retaining Walls, 3rd Edition, 5th Printing, January 2012

Considerations in the design of the retaining wall included the following elements:

- Internal and local external stability analyses
- Compound and global stability analyses

Internal, local external, compound, and global stability analyses were performed using the MSEW (3.0) Software developed by Adama Engineering. Global stability was also checked using the limit equilibrium software Slope/W. This set of calculations was performed to assess internal and external stability of the wall. These calculations represent the maximum section within a particular segment of the wall considered.

WALL ELEMENT PARAMETERS

Soil Parameters

Geotechnical parameters for design of the project MSE retaining wall were provided by Terracon Consultants Inc. (Terracon). Other geotechnical design considerations are contained in the Geotechnical Engineering Report by Terracon, Project No. 15215199, dated August 19, 2021. The following recommended geotechnical design parameters were provided and used in the design of the proposed MSE retaining wall:

Materials	Unit Weight (pcf)	Angle of Internal Friction (degrees)	Cohesion (psf)
Reinforced Backfill	120	30	0
Retained Backfill	120	24	0
Foundation Soils	120	24	0

Seismic Design Parameters

Seismic design parameters were derived from seismicmaps.org, where inputs such as the project coordinates, reference methodology, risk category, and site class are selected. The Peak Ground Acceleration (PGA) used in the analysis consists of using a PGA of 0.237g (% gravity).

The following parameters were developed based on the recommended PGA value.

- Normalized Horizontal Acceleration, Am = (1.45 – A)A From FHWA Circular No. 7
  Where A = 0.237g
  - Am = (1.45 - 0.237) x 0.237 = 0.2875
- For Internal and External Stability, Kh = Am = 0.2875
- For Global Stability per FHWA Circular No. 7, it is acceptable to select Kh between 0.5A and 0.67A,
  - Kh = 0.5A = 0.5 x 0.237 = 0.119

Foundation and Uniform Surcharge Loading

Terracon considered a uniform surcharge of 150 psf for portions of wall subjected to traffic loading which for this project and application is in general agreement with Section 5.6.3.2 of the NCMA Design Manual for Segmental Retaining Walls suggests using the following uniform surcharge magnitudes:

- Cars and Light Truck Traffic – 100 psf
- Tractor Trailer Traffic or Fire Lane, Highway Loading – 250 psf

Segmental Block Design Parameters

- Block Type: Anchor Diamond Pro
- Block Dimensions: Width x Depth x Height = 18 inches x 12 inches x 8 inches
- Unit Weight = 120 pcf

Block to block shear is based on the TRI Environmental for Anchor Diamond Pro Block units. For this design, block to block interface shear was taken as follows:

- Inter-unit Shear Data: N tan (45°) + 1181 lb./ft.
  Where N = Normal Load

The details of the block to block shear results obtained from the laboratory tests can be found in Attachment 3.

Geogrid to block shear is based on information contained in the report entitled "Results of Diamond Pro Block Units with Miragrid 3XT Geogrid Connection Capacity Testing" prepared by

Bathurst, Clarabut Geotechnical Testing, Inc. The connection capacity results extracted from the reports for Anchor Diamond Pro modular block facing units in combination with Miragrid 3XT were used for the design of the MSE wall.

The details of the connection capacity results obtained from the laboratory tests can be found in Attachment 3.

Geogrid Reinforcement Design Parameters

- Geogrid Type – Miragrid 3XT at 100% coverage along length of MSE Wall
  - Minimum Average Roll Value (MARV): 3XT = 3500 lb/ft
  - Creep Reduction Factor, RFCR = 1.44
  - Installation Damage Reduction Factor, RFID = 1.25
  - Durability Reduction Factor, RFD = 1.1
  - Long Term Design Strength (LTDS) = MARV/(RFCRxRFIDxRFD); 3XT = 1767 lb/ft

- Soil Geogrid Interaction Coefficient used:
  Ci = tan ρ /Tan ϕ'
  Where C_i = soil/geogrid interaction coefficient (0.8 provided for backfill used)
  ρ = Interface friction angle between soil and geogrid (24.80 degrees for static and seismic conditions)
  ϕ' = Reinforced backfill internal of friction.

INTERNAL STABILITY ANALYSIS

Internal and local external stability were analyzed to determine minimum reinforcement length requirements for various failure modes using MSEW (3.0) software. We understand the high-water level (HWL) during a 100-year storm event to be at elevation 582 ft. The majority of the wall is proposed to be constructed above elevation 582 ft, and therefore, a temporary condition was analyzed with water at the base of the wall. However, at STA 2+50, the bottom of the wall is proposed to be constructed at elevation 581 ft which will likely create a partially submerged condition for this portion of wall. Accordingly, our analyses include consideration for this potential condition. In this case water was analyzed behind the wall. For completeness, the attached calculations (Attachment 1) includes the static and seismic analyses at the selected wall stations under a permanent dry condition. The failure criteria were also checked under a temporary 100-year flood event. The summary excerpts presented in this section reflects the maximum section of wall at Station 2+50 for static and seismic.

Wall 1 Station 2+50 Static and Seismic Output-Permanent Dry Condition

The analysis performed for the 8.33-foot high wall section represented by Station 2+50 indicates that minimum safety factor requirements under the referenced design methodologies have been satisfied under a permanent dry condition.

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 6.81, Meyerhof stress = 1198 lb/ft².

Foundation Interface: Direct sliding, Fs = 3.177, Eccentricity, e/L = 0.0334, Fs-overturning = 14.97

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	13.00	1	3.39	3.39	3.61	3.609	20.026	4.846	0.0290	Miragrid 3XT
2	2.67	13.00	1	3.09	3.09	3.81	3.813	13.811	6.364	0.0177	Miragrid 3XT
3	4.67	13.00	1	3.67	3.67	5.37	5.366	10.904	9.344	0.0090	Miragrid 3XT
4	6.67	13.00	1	4.28	4.28	7.67	7.668	5.997	18.447	0.0030	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 6.40, Meyerhof stress = 1239 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.305, Eccentricity, e/L = 0.0514, Fs-overturning = 9.73

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	13.00	1	2.56	2.56	3.93	3.930	15.145	3.439	0.0457	Miragrid 3XT
2	2.67	13.00	1	1.99	1.99	3.52	3.524	8.864	4.160	0.0303	Miragrid 3XT
3	4.67	13.00	1	1.84	1.84	3.87	3.869	5.461	5.405	0.0174	Miragrid 3XT
4	6.67	13.00	1	1.30	1.30	3.35	3.347	1.818	8.704	0.0069	Miragrid 3XT

Wall 1 Station 2+50 Static & Seismic Output-Temporary 100-Year Flood Event Condition

The analysis performed for the 8.33-foot high wall section represented by Station 2+50 indicates that minimum safety factor requirements under the referenced design methodologies have been satisfied under a permanent dry condition.

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 2.77, Meyerhof stress = 1178 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.389, Eccentricity, e/L = 0.0446, Fs-overturning = 11.19

	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	13.00	1	2.95	3.12	3.118	14.777	2.967	0.0372	Miragrid 3XT
2	2.67	13.00	1	2.62	3.20	3.196	10.405	3.775	0.0222	Miragrid 3XT
3	4.67	13.00	1	3.10	4.50	4.497	8.515	5.000	0.0113	Miragrid 3XT
4	6.67	13.00	1	3.61	6.43	6.427	4.906	7.402	0.0037	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 2.28, Meyerhof stress = 1297 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.348, Eccentricity, e/L = 0.0937, Fs-overturning = 5.34

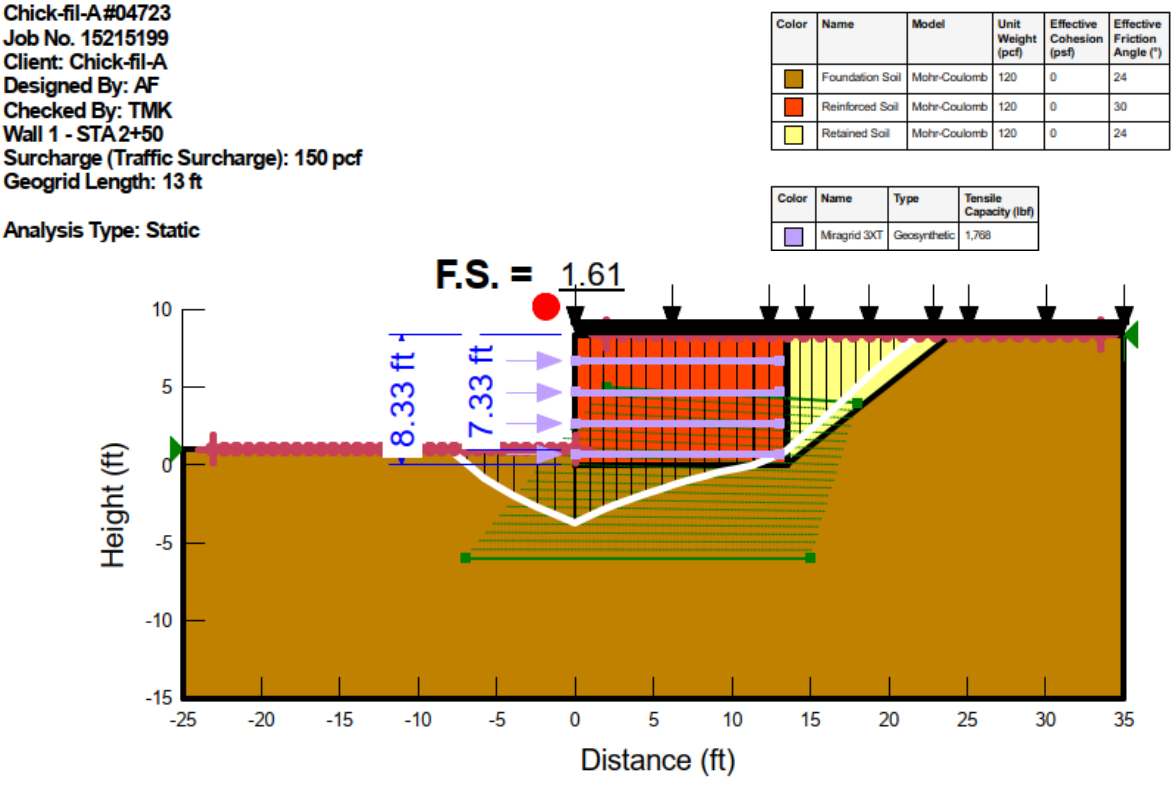
GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	13.00	1	1.75	2.50	2.503	10.918	1.692	0.0770	Miragrid 3XT
2	2.67	13.00	1	1.57	2.60	2.601	7.828	2.231	0.0434	Miragrid 3XT
3	4.67	13.00	1	1.75	3.49	3.488	6.011	3.139	0.0202	Miragrid 3XT
4	6.67	13.00	1	1.89	4.70	4.701	3.210	5.293	0.0056	Miragrid 3XT

GLOBAL AND COMPOUND STABILITY ANALYSIS

Global and compound stability were analyzed to meet a minimum global stability safety factor of 1.50, 1.30, and 1.13 under permanent static, temporary 100-year flood event, and temporary seismic conditions, respectively. The summary excerpts presented in this section reflects the maximum section of Wall at Station 2+50 under permanent and temporary conditions mentioned above.

Wall 1 Station 2+50 Global/Compound Stability Analysis-Permanent Static Condition

This analysis represents the global stability for the wall during the permanent static condition. A safety factor of 1.61 was obtained for this analysis which exceeds the minimum required safety factor of 1.50 and hence is considered acceptable.



Wall 1 Station 2+50 Global/Compound Stability Analysis-Temporary 100-Year Flood Event Condition

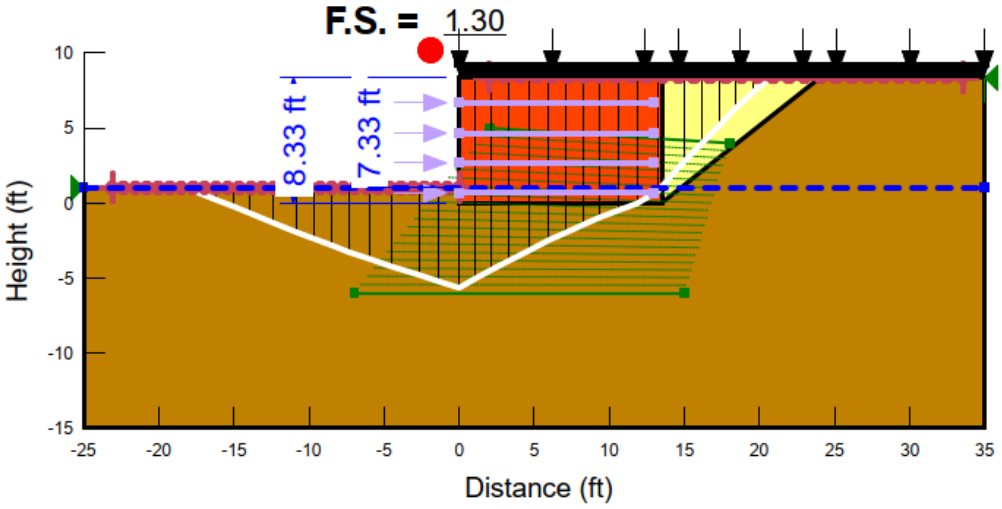
This analysis represents the global stability for the wall during the temporary high-water condition. A safety factor of 1.30 was obtained for this analysis which satisfies the minimum required safety factor of 1.30 and hence is considered acceptable.

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+50
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 13 ft

Analysis Type: 100 yr Flood Event (Elv. 582 ft)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Line
	Foundation Soil	Mohr-Coulomb	120	0	24	1
	Reinforced Soil	Mohr-Coulomb	120	0	30	1
	Retained Soil	Mohr-Coulomb	120	0	24	1

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



Wall 1 Station 2+50 Global/Compound Stability Analysis-Temporary Seismic Condition

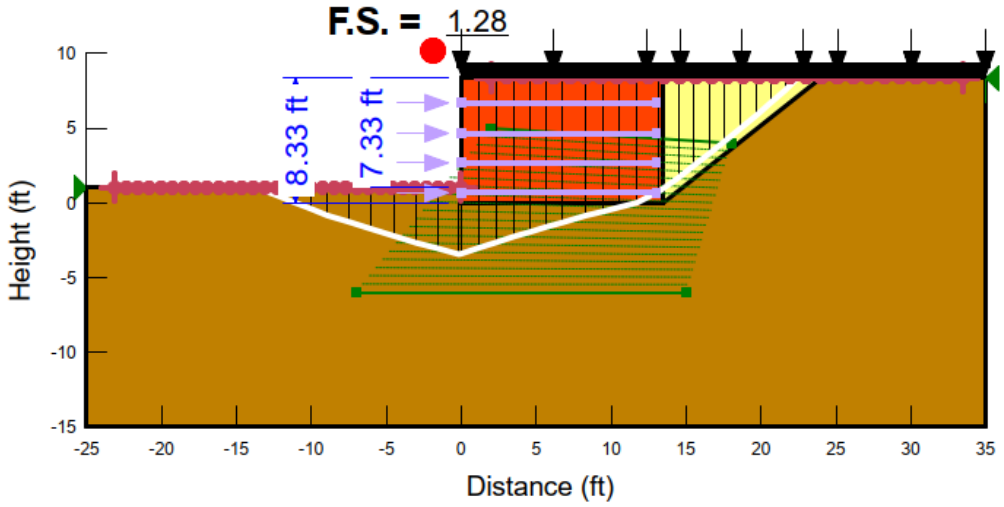
This analysis represents the global stability for the wall during the temporary seismic condition. A safety factor of 1.28 was obtained for this analysis which exceeds the minimum required safety factor of 1.13 and hence is considered acceptable.

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+50
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 13 ft

Analysis Type: Seismic (kh = 0.119)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



CLOSURE

With this submittal, our engineering design services for the project are complete. The Technical Scope of Work also calls for certain testing, inspection, and post design engineering services. Terracon is available to discuss the supplemental scope of services that you may require of us for post design services on this project.

ATTACHMENTS

ATTACHMENT 1

MSEW (3.0) Input and Output for Static and Seismic Load Cases

NCMA DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 0+70

Description:

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

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Original date and time of creating this file: 12/06/2021

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	30.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	24.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Water table does not affect bearing capacity
Note: A separate analysis has been performed for temporary 100-year flood event.

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2973
Inclination of internal slip plane, ψ = 55.98°.
Ka (external stability) = 0.3682

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 19.32 N γ = 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237

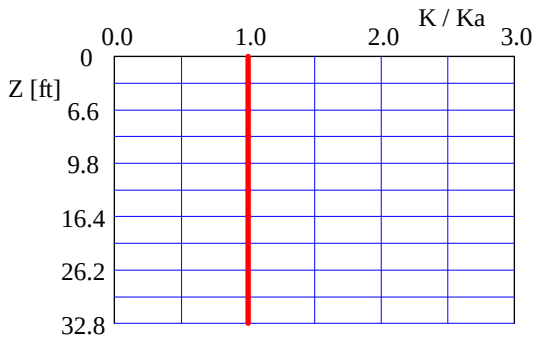
Kae (Kh > 0) = 0.4711 Kae (Kh = 0) = 0.3682 Δ Kae = 0.1029
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Cds = tan(ro) / tan(Phi.reinforced)	0.87				
Ci	0.80	N/A	N/A	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

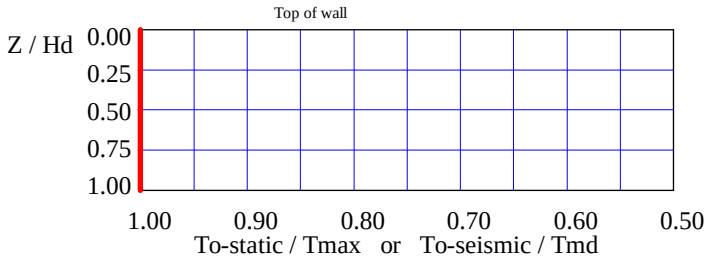
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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



Peak Strength Criterion

Geogrid Type #1 Weight of blocks	(1) (2) Tultconn	Geogrid Type #2 Weight of blocks	Tultconn	Geogrid Type #3 Weight of blocks	Tultconn	Geogrid Type #4 Weight of blocks	Tultconn	Geogrid Type #5 Weight of blocks	Tultconn
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Service Strength Criterion @ 3/4"

Geogrid Type #1 Weight of blocks	(3) Tconn @ 3/4"	Geogrid Type #2 Weight of blocks	Tconn @ 3/4"	Geogrid Type #3 Weight of blocks	Tconn @ 3/4"	Geogrid Type #4 Weight of blocks	Tconn @ 3/4"	Geogrid Type #5 Weight of blocks	Tconn @ 3/4"
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Ultimate Strength Criterion

Weight of blocks	Vu (4)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

Service Strength Criterion

Weight of blocks	Vu' (5)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

(1) (2) (3) (4) (5) Weight of blocks, Tultconn., Tconn@3/4", Vu and Vu' are in [lb/ft]

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	1.00	N/A	N/A	N/A	N/A

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

Design height, Hd	4.33	[ft]	{ Embedded depth is E = 0.67 ft, and height above top of finished bottom grade is H = 3.67 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00°

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], and live load is 150.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:

SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 6.33, Meyerhof stress = 677 lb/ft².
Foundation Interface: Direct sliding, Fs = 2.518, Eccentricity, e/L = 0.0465, Fs-overturning = 10.76

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	6.50	1	7.10	7.10	10.37	10.372	12.026	6.209	0.0360	Miragrid 3XT
2	1.33	6.50	1	8.30	8.30	12.91	12.912	11.190	7.592	0.0269	Miragrid 3XT
3	2.67	6.50	1	5.22	5.22	9.35	9.350	3.606	13.806	0.0119	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 5.96, Meyerhof stress = 700 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.919, Eccentricity, e/L = 0.0659, Fs-overturning = 7.59

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	6.50	1	5.01	5.01	10.53	10.530	8.478	4.582	0.0527	Miragrid 3XT
2	1.33	6.50	1	5.17	5.17	11.59	11.585	6.973	5.393	0.0408	Miragrid 3XT
3	2.67	6.50	1	2.26	2.26	5.83	5.828	1.561	8.816	0.0199	Miragrid 3XT

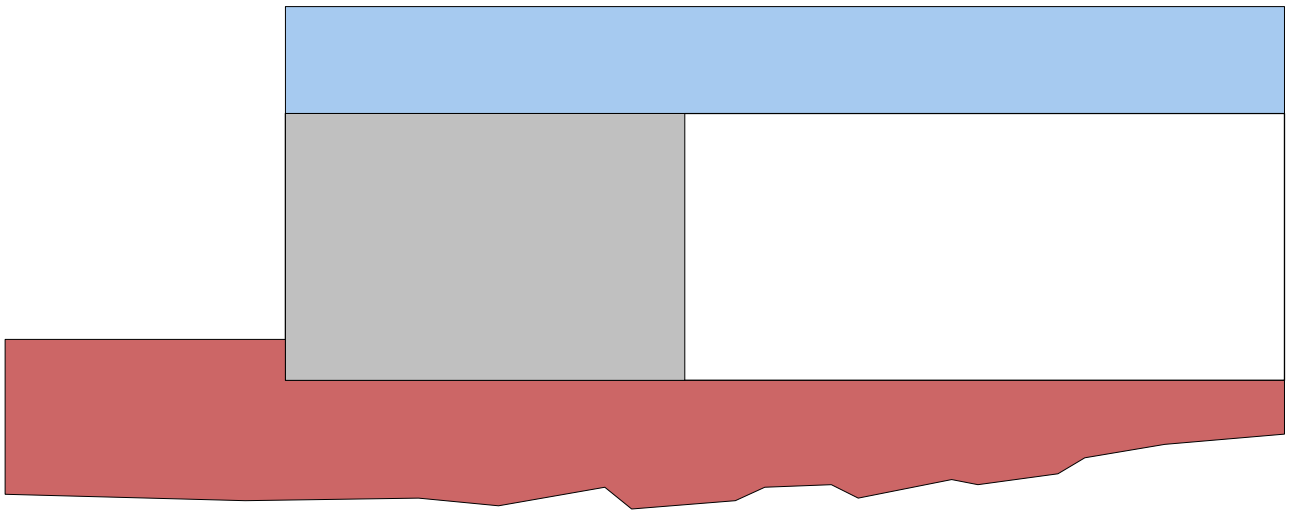
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 2.379
(it corresponds to a critical circle at Xc = -3.45, Yc = 41.03 and R = 41.58 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.644
(it corresponds to a critical circle at Xc = -3.45, Yc = 41.03 and R = 41.58 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	4287	4172	[lb/ft ²]
Meyerhof stress, σ_V	677.1	700	[lb/ft ²]
Eccentricity, e	0.14	0.25	[ft]
Eccentricity, e/L	0.022	0.038	
Fs calculated	6.33	5.96	
Base length	6.50	6.50	[ft]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.518 and Fs-seismic = 1.919

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	6.50	6.209	4.582	1	Miragrid 3XT
2	1.33	6.50	7.592	5.393	1	Miragrid 3XT
3	2.67	6.50	13.806	8.816	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0465, e/L seismic = 0.0659; Overturning: Fs-static = 10.76, Fs-seismic = 7.59

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	6.50	0.0360	0.0527	1	Miragrid 3XT
2	1.33	6.50	0.0269	0.0408	1	Miragrid 3XT
3	2.67	6.50	0.0119	0.0199	1	Miragrid 3XT

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	1768	170.42	71.32	N/A	10.372	N/A	10.530	Miragrid 3XT
2	1.33	1768	136.90	82.81	N/A	12.912	N/A	11.585	Miragrid 3XT
3	2.67	1768	189.05	247.68	N/A	9.350	N/A	5.828	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	170.4	71.3	5.05	0.45	2049.5	N/A	12.026	2049.5	N/A	8.478
2	1.33	1.000	136.9	82.8	4.60	0.90	1531.9	N/A	11.190	1531.9	N/A	6.973
3	2.67	1.000	189.1	247.7	3.70	1.80	681.6	N/A	3.606	681.6	N/A	1.561

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection peak		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	170	30.85	30.85	1211	1211	1768	N/A	7.10	N/A	7.10	N/A	10.37	Miragrid 3XT
2	1.33	137	17.51	17.51	1137	1137	1768	N/A	8.30	N/A	8.30	N/A	12.91	Miragrid 3XT
3	2.67	189	11.89	11.89	987	987	1768	N/A	5.22	N/A	5.22	N/A	9.35	Miragrid 3XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection break		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	242	16.18	16.18	1211	1211	1768	N/A	5.01	N/A	5.01	N/A	10.53	Miragrid 3XT
2	1.33	220	9.20	9.20	1137	1137	1768	N/A	5.17	N/A	5.17	N/A	11.59	Miragrid 3XT
3	2.67	437	4.36	4.36	987	987	1768	N/A	2.26	N/A	2.26	N/A	5.83	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 2.379
(it corresponds to a critical circle at Xc = -3.45, Yc = 41.03 and R = 41.58 [ft] where (x=0, y=0) is taken at the TOE or Xc = 105.91, Yc = 1041.03 and R = 41.58 [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 1.644
(it corresponds to a critical circle at Xc = -3.45, Yc = 41.03 and R = 41.58 [ft] where (x=0, y=0) is taken at the TOE or Xc = 105.91, Yc = 1041.03 and R = 41.58 [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 = 24.0° c = 0.00 [lb/ft ²]											
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0

AASHTO 2002 ASD DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 0+70

Description:

Temporary Condition: Water level at 585 ft (ground level in front of wall)

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

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Original date and time of creating this file: 12/06/2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	24.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3333 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 60.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.4217 (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 = 19.32 N γ= 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237
Design acceleration coefficient in Internal Stability: Kh = Am = 0.287
Design acceleration coefficient in External Stability: Kh_d = 0.287 => Kh = Am = 0.287

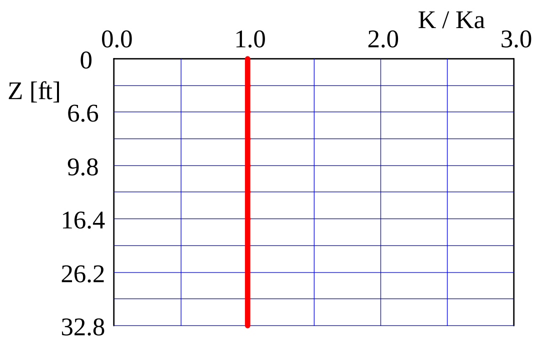
Kae (Kh > 0) = 0.6883 Kae (Kh = 0) = 0.4217 Δ Kae = 0.2665
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Friction angle along geogrid-soil interface, ρ	26.56				
Pullout resistance factor, F*	$0.80 \cdot \tan\phi$	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	0.8				

Variation of Lateral Earth Pressure Coefficient With Depth

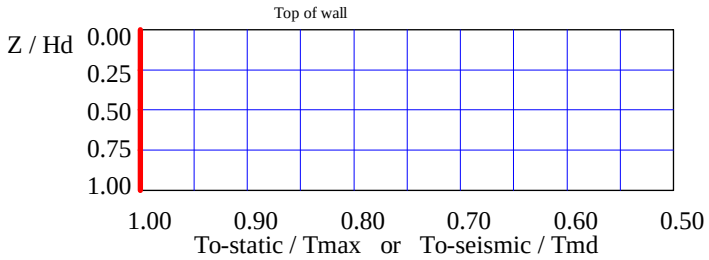
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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 σ (1)	CRult (2)	Geogrid Type #2 σ	CRult	Geogrid Type #3 σ	CRult	Geogrid Type #4 σ	CRult	Geogrid Type #5 σ	CRult
0.0	0.29								
500.0	0.34	N/A		N/A		N/A		N/A	
1000.0	0.39								
2000.0	0.49								

Geogrid Type #1 3) σ	CRcr	Geogrid Type #2 σ	CRcr	Geogrid Type #3 σ	CRcr	Geogrid Type #4 σ	CRcr	Geogrid Type #5 σ	CRcr
0.0	0.29								
500.0	0.34	N/A		N/A		N/A		N/A	
1000.0	0.39								
2000.0	0.49								

(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 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

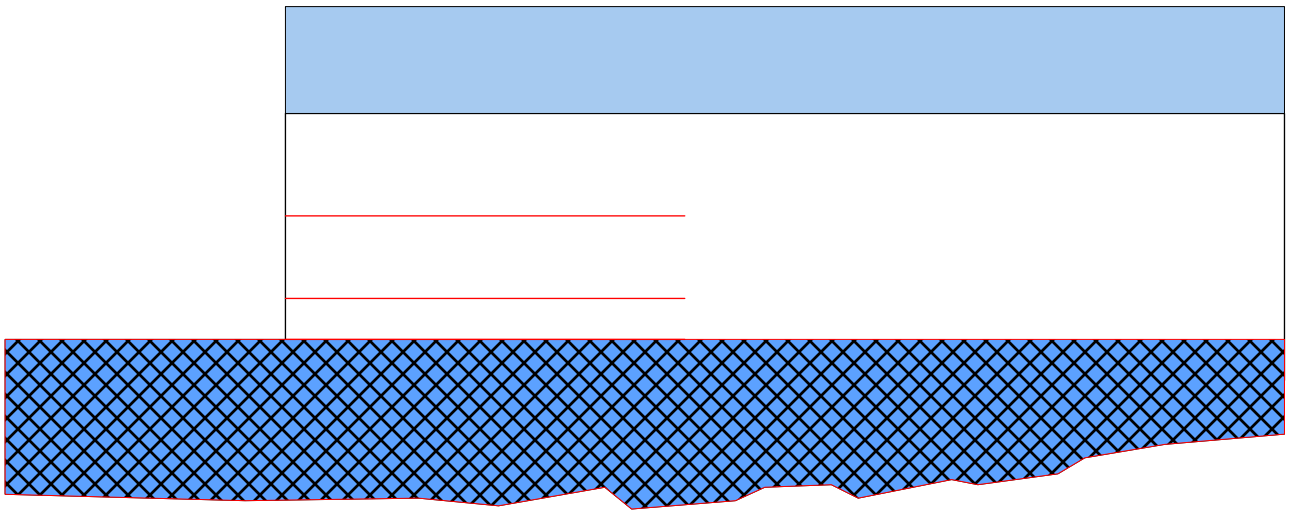
Design height, Hd	4.33	[ft]	{ Embedded depth is E = 0.67 ft, and height above top of finished bottom grade is H = 3.67 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

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], and live load is 150.0 [lb/ft ²]

Hydrostatic water pressure exist in analysis. hw1 = 0.67 and hw2 = 0.67 ft.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 2.30, Meyerhof stress = 695 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.862, Eccentricity, e/L = 0.0633, Fs-overturning = 7.88

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	6.50	1	5.95	9.00	9.002	10.113	2.500	0.0452	Miragrid 3XT
2	1.33	6.50	1	6.99	10.82	10.822	9.345	2.800	0.0337	Miragrid 3XT
3	2.67	6.50	1	4.81	7.84	7.837	3.242	3.701	0.0150	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 1.90, Meyerhof stress = 765 lb/ft².
Foundation Interface: Direct sliding, Fs = 1.137, Eccentricity, e/L = 0.1174, Fs-overturning = 4.26

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	6.50	1	3.54	7.26	7.256	7.511	1.569	0.0807	Miragrid 3XT
2	1.33	6.50	1	4.02	8.51	8.514	6.720	1.813	0.0576	Miragrid 3XT
3	2.67	6.50	1	3.09	6.70	6.699	2.605	2.646	0.0223	Miragrid 3XT

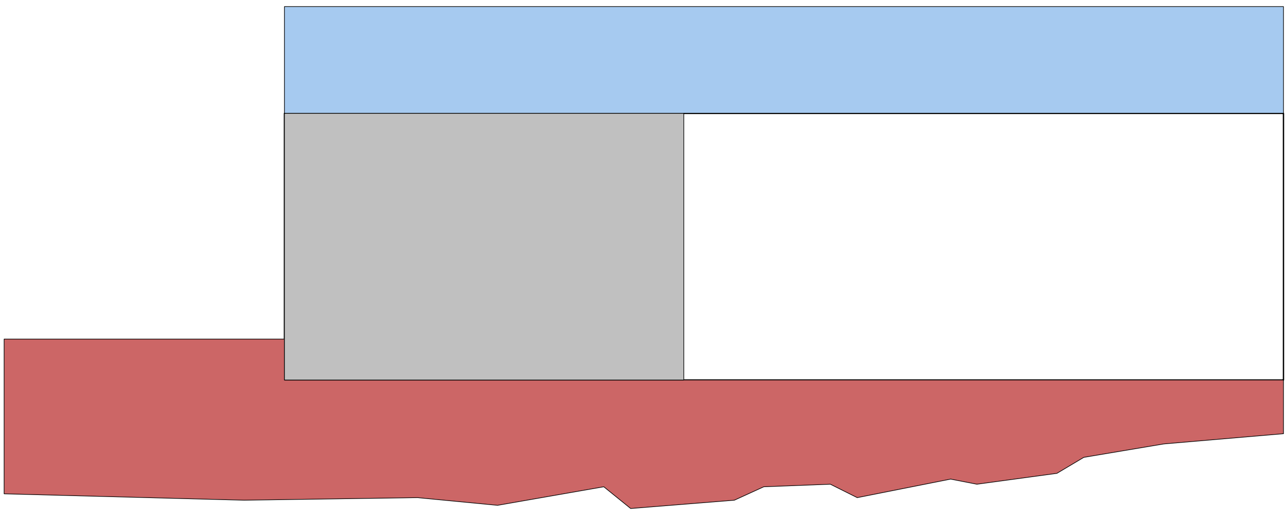
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.778
(it corresponds to a critical circle at Xc = -3.45, Yc = 18.10 and R = 22.46 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.166
(it corresponds to a critical circle at Xc = -3.45, Yc = 18.10 and R = 22.46 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Ultimate bearing capacity, q-ult	1596	1451	[lb/ft ²]
Meyerhof stress, σ_V	695.2	765	[lb/ft ²]
Eccentricity, e	0.31	0.58	[ft]
Eccentricity, e/L	0.048	0.089	
Fs calculated	2.30	1.90	
Base length	6.50	6.50	[ft]



SCALE:

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 1.862 and Fs-seismic = 1.137

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	6.50	2.500	1.569	1	Miragrid 3XT
2	1.33	6.50	2.800	1.813	1	Miragrid 3XT
3	2.67	6.50	3.701	2.646	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0633, e/L seismic = 0.1174; Overturning: Fs-static = 7.88, Fs-seismic = 4.26

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	6.50	0.0452	0.0807	1	Miragrid 3XT
2	1.33	6.50	0.0337	0.0576	1	Miragrid 3XT
3	2.67	6.50	0.0150	0.0223	1	Miragrid 3XT

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	1768	196.36	68.03	N/A	9.002	N/A	7.256	Miragrid 3XT
2	1.33	1768	163.33	63.79	N/A	10.822	N/A	8.514	Miragrid 3XT
3	2.67	1768	225.56	55.18	N/A	7.837	N/A	6.699	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	196.4	68.0	6.11	0.39	1985.8	N/A	10.113	1985.8	N/A	7.511
2	1.33	1.000	163.3	63.8	5.73	0.77	1526.3	N/A	9.345	1526.3	N/A	6.720
3	2.67	1.000	225.6	55.2	4.96	1.54	731.3	N/A	3.242	731.3	N/A	2.605

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	196	0.33	0.33	1169	1768	N/A	5.95	N/A	9.00	Miragrid 3XT
2	1.33	163	0.33	0.33	1141	1768	N/A	6.99	N/A	10.82	Miragrid 3XT
3	2.67	226	0.31	0.31	1085	1768	N/A	4.81	N/A	7.84	Miragrid 3XT

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	264	0.33	0.27	935	1768	N/A	3.54	N/A	7.26	Miragrid 3XT
2	1.33	227	0.33	0.26	913	1768	N/A	4.02	N/A	8.51	Miragrid 3XT
3	2.67	281	0.31	0.25	868	1768	N/A	3.09	N/A	6.70	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 1.778
(it corresponds to a critical circle at Xc = -3.45, Yc = 18.10 and R = 22.46 [ft] where (x=0, y=0) is taken at the TOE or Xc = 105.91, Yc = 1018.10 and R = 22.46 [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 1.166
(it corresponds to a critical circle at Xc = -3.45, Yc = 18.10 and R = 22.46 [ft] where (x=0, y=0) is taken at the TOE or Xc = 105.91, Yc = 1018.10 and R = 22.46 [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 = 24.0° c = 0.00 [lb/ft ²]											
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0
Water table:											
x [ft]	0.0	32.8	65.6	98.4	131.2	164.0	196.9	229.7	262.5	295.3	328.1
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7

NCMA DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 1+20

Description:

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

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Original date and time of creating this file: 12/06/2021

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	30.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	24.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Water table does not affect bearing capacity
Note: A separate analysis has been performed for temporary 100-year flood event.

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2973
Inclination of internal slip plane, ψ = 55.98°.
Ka (external stability) = 0.3682

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 19.32 N γ = 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237

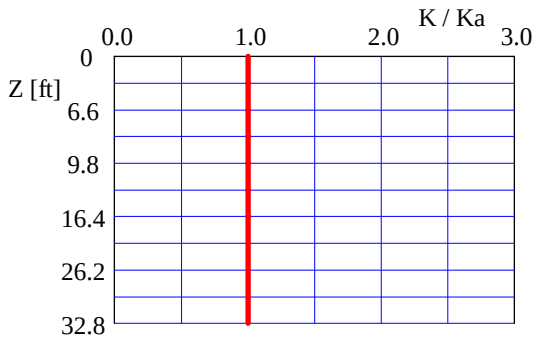
Kae (Kh > 0) = 0.4711 Kae (Kh = 0) = 0.3682 Δ Kae = 0.1029
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Cds = tan(ro) / tan(Phi.reinforced)	0.87				
Ci	0.80	N/A	N/A	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

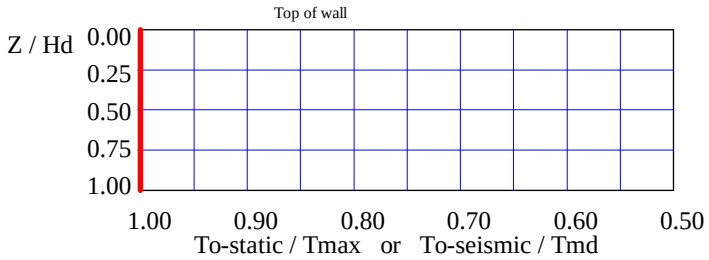
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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



Peak Strength Criterion

Geogrid Type #1 Weight of blocks	(1) (2) Tultconn	Geogrid Type #2 Weight of blocks	Tultconn	Geogrid Type #3 Weight of blocks	Tultconn	Geogrid Type #4 Weight of blocks	Tultconn	Geogrid Type #5 Weight of blocks	Tultconn
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Service Strength Criterion @ 3/4"

Geogrid Type #1 Weight of blocks	(3) Tconn @ 3/4"	Geogrid Type #2 Weight of blocks	Tconn @ 3/4"	Geogrid Type #3 Weight of blocks	Tconn @ 3/4"	Geogrid Type #4 Weight of blocks	Tconn @ 3/4"	Geogrid Type #5 Weight of blocks	Tconn @ 3/4"
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Ultimate Strength Criterion

Weight of blocks	Vu (4)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

Service Strength Criterion

Weight of blocks	Vu' (5)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

(1) (2) (3) (4) (5) Weight of blocks, Tultconn., Tconn@3/4", Vu and Vu' are in [lb/ft]

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	1.00	N/A	N/A	N/A	N/A

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

Design height, Hd	5.67	[ft]	{ Embedded depth is E = 0.67 ft, and height above top of finished bottom grade is H = 5.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00°

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], and live load is 150.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:

SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 6.25, Meyerhof stress = 855 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.756, Eccentricity, e/L = 0.0414, Fs-overturning = 12.08

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	8.50	1	4.86	4.86	6.32	6.320	13.954	5.329	0.0339	Miragrid 3XT
2	2.00	8.50	1	4.57	4.57	6.67	6.668	9.429	7.168	0.0211	Miragrid 3XT
3	4.00	8.50	1	4.28	4.28	7.65	7.654	3.839	15.205	0.0070	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 5.86, Meyerhof stress = 886 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.054, Eccentricity, e/L = 0.0608, Fs-overturning = 8.22

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	8.50	1	3.53	3.53	6.61	6.607	10.131	3.863	0.0513	Miragrid 3XT
2	2.00	8.50	1	2.78	2.78	5.85	5.848	5.743	4.845	0.0342	Miragrid 3XT
3	4.00	8.50	1	1.66	1.66	4.27	4.268	1.487	8.690	0.0132	Miragrid 3XT

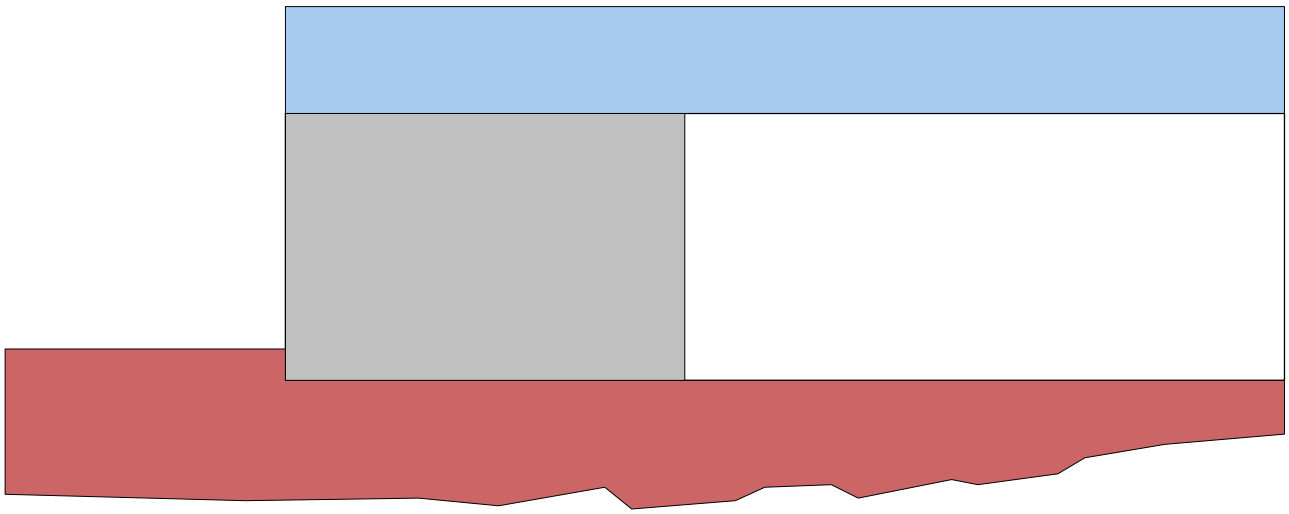
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 2.480
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.617
(it corresponds to a critical circle at Xc = -6.90, Yc = 41.93 and R = 45.15 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	5342	5185	[lb/ft ²]
Meyerhof stress, σ_V	855.2	886	[lb/ft ²]
Eccentricity, e	0.21	0.35	[ft]
Eccentricity, e/L	0.025	0.041	
Fs calculated	6.25	5.86	
Base length	8.50	8.50	[ft]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.756 and Fs-seismic = 2.054

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	8.50	5.329	3.863	1	Miragrid 3XT
2	2.00	8.50	7.168	4.845	1	Miragrid 3XT
3	4.00	8.50	15.205	8.690	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0414, e/L seismic = 0.0608; Overturning: Fs-static = 12.08, Fs-seismic = 8.22

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	8.50	0.0339	0.0513	1	Miragrid 3XT
2	2.00	8.50	0.0211	0.0342	1	Miragrid 3XT
3	4.00	8.50	0.0070	0.0132	1	Miragrid 3XT

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	1768	279.70	105.54	N/A	6.320	N/A	6.607	Miragrid 3XT
2	2.00	1768	265.10	170.20	N/A	6.668	N/A	5.848	Miragrid 3XT
3	4.00	1768	230.96	365.46	N/A	7.654	N/A	4.268	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	279.7	105.5	7.05	0.45	3902.8	N/A	13.954	3902.8	N/A	10.131
2	2.00	1.000	265.1	170.2	6.15	1.35	2499.7	N/A	9.429	2499.7	N/A	5.743
3	4.00	1.000	231.0	365.5	4.80	2.70	886.6	N/A	3.839	886.6	N/A	1.487

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection peak		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	280	13.50	13.50	1360	1360	1768	N/A	4.86	N/A	4.86	N/A	6.32	Miragrid 3XT
2	2.00	265	10.95	10.95	1211	1211	1768	N/A	4.57	N/A	4.57	N/A	6.67	Miragrid 3XT
3	4.00	231	11.86	11.86	987	987	1768	N/A	4.28	N/A	4.28	N/A	7.65	Miragrid 3XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection break		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	385	8.54	8.54	1360	1360	1768	N/A	3.53	N/A	3.53	N/A	6.61	Miragrid 3XT
2	2.00	435	5.91	5.91	1211	1211	1768	N/A	2.78	N/A	2.78	N/A	5.85	Miragrid 3XT
3	4.00	596	3.74	3.74	987	987	1768	N/A	1.66	N/A	1.66	N/A	4.27	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 2.480
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1035.34 and R = 39.11 [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 1.617
(it corresponds to a critical circle at Xc = -6.90, Yc = 41.93 and R = 45.15 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1041.93 and R = 45.15 [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 = 24.0°		c = 0.00 [lb/ft ^{2}]					
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0

AASHTO 2002 ASD DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 1+20

Description:

Temporary Condition: Water Level at 583.67 ft (ground level in front of wall)

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

Original file path and name: C:\Users\afathi2\OneDrive - Terracon Consultants Inc\De.....
.....0-Temp Condition.BEN

Original date and time of creating this file: 12/06/2021

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	24.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3333 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 60.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.4217 (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 = 19.32 N γ= 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237
Design acceleration coefficient in Internal Stability: Kh = Am = 0.287
Design acceleration coefficient in External Stability: Kh_d = 0.287 => Kh = Am = 0.287

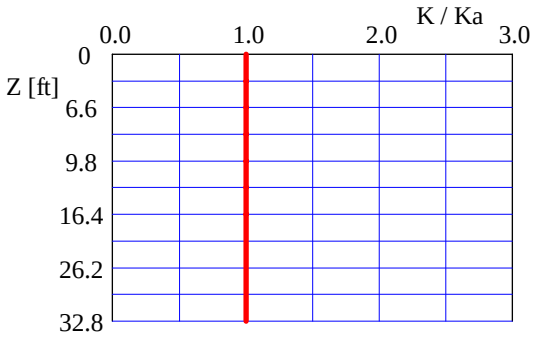
Kae (Kh > 0) = 0.6883 Kae (Kh = 0) = 0.4217 Δ Kae = 0.2665
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Friction angle along geogrid-soil interface, ρ	26.56				
Pullout resistance factor, F*	0.80·tanϕ	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	0.8				

Variation of Lateral Earth Pressure Coefficient With Depth

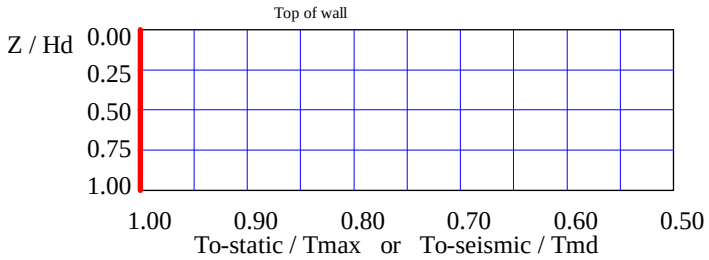
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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 σ (1)	CRult (2)	Geogrid Type #2 σ	CRult	Geogrid Type #3 σ	CRult	Geogrid Type #4 σ	CRult	Geogrid Type #5 σ	CRult
0.0	0.29								
500.0	0.34	N/A		N/A		N/A		N/A	
1000.0	0.39								
2000.0	0.49								

Geogrid Type #1 3) σ	CRcr	Geogrid Type #2 σ	CRcr	Geogrid Type #3 σ	CRcr	Geogrid Type #4 σ	CRcr	Geogrid Type #5 σ	CRcr
0.0	0.29								
500.0	0.34	N/A		N/A		N/A		N/A	
1000.0	0.39								
2000.0	0.49								

(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 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

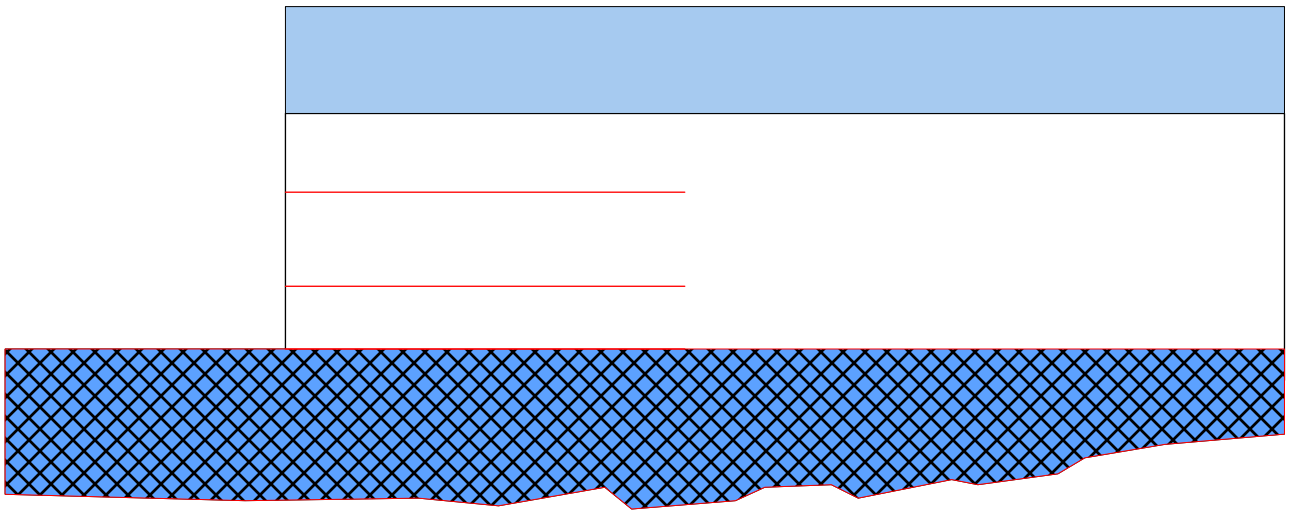
Design height, Hd	5.67	[ft]	{ Embedded depth is E = 0.67 ft, and height above top of finished bottom grade is H = 5.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

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], and live load is 150.0 [lb/ft ²]

Hydrostatic water pressure exist in analysis. hw1 = 0.67 and hw2 = 0.67 ft.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 2.43, Meyerhof stress = 866 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.073, Eccentricity, e/L = 0.0553, Fs-overturning = 9.03

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	8.50	1	3.78	5.45	5.449	11.081	2.688	0.0425	Miragrid 3XT
2	2.00	8.50	1	3.70	5.59	5.589	7.550	3.268	0.0265	Miragrid 3XT
3	4.00	8.50	1	3.94	6.41	6.415	3.320	4.836	0.0088	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 1.99, Meyerhof stress = 956 lb/ft².

Foundation Interface: Direct sliding, Fs = 1.222, Eccentricity, e/L = 0.1083, Fs-overturning = 4.62

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	8.50	1	2.21	4.34	4.337	8.092	1.614	0.0812	Miragrid 3XT
2	2.00	8.50	1	2.20	4.51	4.514	5.621	2.051	0.0473	Miragrid 3XT
3	4.00	8.50	1	2.37	5.21	5.214	2.493	3.457	0.0131	Miragrid 3XT

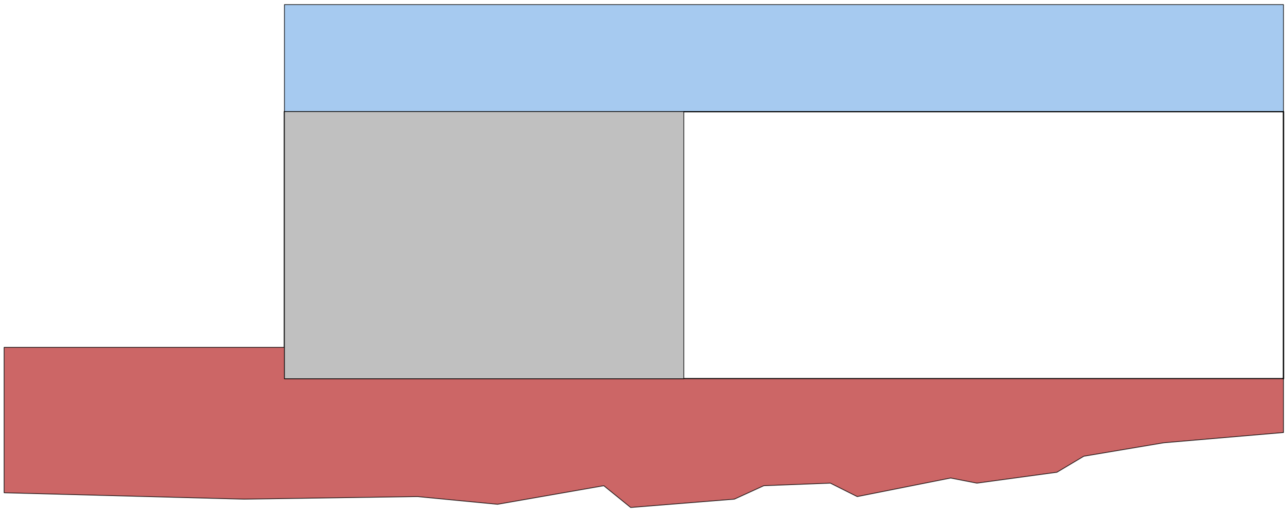
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.713
(it corresponds to a critical circle at Xc = -6.90, Yc = 22.17 and R = 27.78 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.111
(it corresponds to a critical circle at Xc = -6.90, Yc = 28.76 and R = 33.28 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Ultimate bearing capacity, q-ult	2103	1905	[lb/ft ²]
Meyerhof stress, σ_V	865.7	956	[lb/ft ²]
Eccentricity, e	0.38	0.75	[ft]
Eccentricity, e/L	0.045	0.088	
Fs calculated	2.43	1.99	
Base length	8.50	8.50	[ft]



SCALE:

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.073 and Fs-seismic = 1.222

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	8.50	2.688	1.614	1	Miragrid 3XT
2	2.00	8.50	3.268	2.051	1	Miragrid 3XT
3	4.00	8.50	4.836	3.457	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0553, e/L seismic = 0.1083; Overturning: Fs-static = 9.03, Fs-seismic = 4.62

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	8.50	0.0425	0.0812	1	Miragrid 3XT
2	2.00	8.50	0.0265	0.0473	1	Miragrid 3XT
3	4.00	8.50	0.0088	0.0131	1	Miragrid 3XT

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	1768	324.40	119.84	N/A	5.449	N/A	4.337	Miragrid 3XT
2	2.00	1768	316.29	108.50	N/A	5.589	N/A	4.514	Miragrid 3XT
3	4.00	1768	275.56	91.44	N/A	6.415	N/A	5.214	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	324.4	119.8	8.11	0.39	3594.6	N/A	11.081	3594.6	N/A	8.092
2	2.00	1.000	316.3	108.5	7.35	1.15	2387.9	N/A	7.550	2387.9	N/A	5.621
3	4.00	1.000	275.6	91.4	6.19	2.31	914.8	N/A	3.320	914.8	N/A	2.493

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	324	0.35	0.35	1225	1768	N/A	3.78	N/A	5.45	Miragrid 3XT
2	2.00	316	0.33	0.33	1169	1768	N/A	3.70	N/A	5.59	Miragrid 3XT
3	4.00	276	0.31	0.31	1085	1768	N/A	3.94	N/A	6.41	Miragrid 3XT

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	444	0.35	0.28	980	1768	N/A	2.21	N/A	4.34	Miragrid 3XT
2	2.00	425	0.33	0.27	935	1768	N/A	2.20	N/A	4.51	Miragrid 3XT
3	4.00	367	0.31	0.25	868	1768	N/A	2.37	N/A	5.21	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 1.713

(it corresponds to a critical circle at Xc = -6.90, Yc = 22.17 and R = 27.78 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1022.17 and R = 27.78 [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 1.111

(it corresponds to a critical circle at Xc = -6.90, Yc = 28.76 and R = 33.28 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1028.76 and R = 33.28 [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 = 24.0° c = 0.00 [lb/ft ²]											
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0
Water table:											
x [ft]	0.0	32.8	65.6	98.4	131.2	164.0	196.9	229.7	262.5	295.3	328.1
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7

NCMA DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 2+18

Description:

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

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Original date and time of creating this file: 12/06/2021

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	30.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	24.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Water table does not affect bearing capacity
Note: A separate analysis has been performed for temporary 100-year flood event.

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2973
Inclination of internal slip plane, ψ = 55.98°.
Ka (external stability) = 0.3682

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 19.32 N γ = 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237

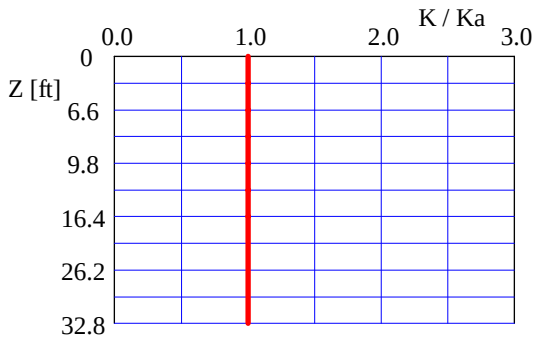
Kae (Kh > 0) = 0.4711 Kae (Kh = 0) = 0.3682 Δ Kae = 0.1029
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Cds = tan(ro) / tan(Phi.reinforced)	0.87				
Ci	0.80	N/A	N/A	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

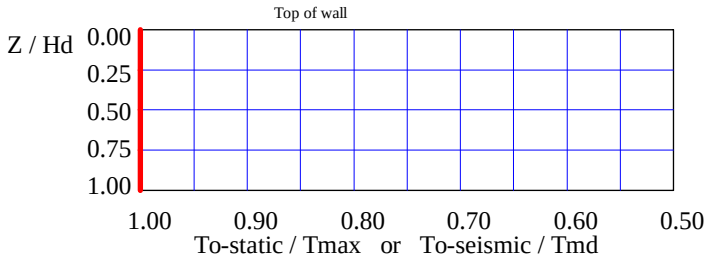
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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



Peak Strength Criterion

Geogrid Type #1 Weight of blocks	(1) (2) Tultconn	Geogrid Type #2 Weight of blocks	Tultconn	Geogrid Type #3 Weight of blocks	Tultconn	Geogrid Type #4 Weight of blocks	Tultconn	Geogrid Type #5 Weight of blocks	Tultconn
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Service Strength Criterion @ 3/4"

Geogrid Type #1 Weight of blocks	(3) Tconn @ 3/4"	Geogrid Type #2 Weight of blocks	Tconn @ 3/4"	Geogrid Type #3 Weight of blocks	Tconn @ 3/4"	Geogrid Type #4 Weight of blocks	Tconn @ 3/4"	Geogrid Type #5 Weight of blocks	Tconn @ 3/4"
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Ultimate Strength Criterion

Weight of blocks	Vu (4)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

Service Strength Criterion

Weight of blocks	Vu' (5)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

(1) (2) (3) (4) (5) Weight of blocks, Tultconn., Tconn@3/4", Vu and Vu' are in [lb/ft]

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	1.00	N/A	N/A	N/A	N/A

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

Design height, Hd	7.00	[ft]	{ Embedded depth is E = 0.67 ft, and height above top of finished bottom grade is H = 6.33 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00°

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], and live load is 150.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:

SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 6.54, Meyerhof stress = 1025 lb/ft².
Foundation Interface: Direct sliding, Fs = 3.064, Eccentricity, e/L = 0.0349, Fs-overturning = 14.33

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	11.00	1	4.45	4.45	5.21	5.206	19.740	5.084	0.0296	Miragrid 3XT
2	2.00	11.00	1	4.01	4.01	5.20	5.203	14.121	6.313	0.0203	Miragrid 3XT
3	4.00	11.00	1	4.61	4.61	7.16	7.163	9.847	10.023	0.0094	Miragrid 3XT
4	5.33	11.00	1	5.21	5.21	9.32	9.321	6.261	16.928	0.0042	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 6.15, Meyerhof stress = 1059 lb/ft².
Foundation Interface: Direct sliding, Fs = 2.249, Eccentricity, e/L = 0.0526, Fs-overturning = 9.50

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	11.00	1	3.31	3.31	5.59	5.589	14.716	3.641	0.0458	Miragrid 3XT
2	2.00	11.00	1	2.60	2.60	4.87	4.869	9.175	4.261	0.0333	Miragrid 3XT
3	4.00	11.00	1	2.33	2.33	5.22	5.217	4.981	5.940	0.0175	Miragrid 3XT
4	5.33	11.00	1	1.70	1.70	4.37	4.371	2.039	8.758	0.0088	Miragrid 3XT

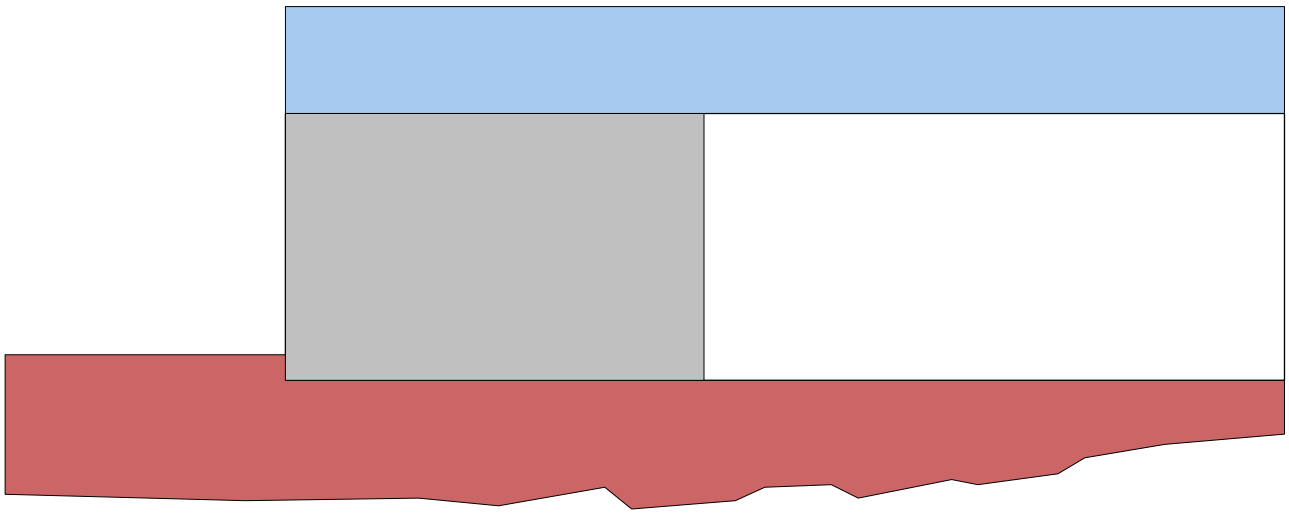
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 2.144
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.470
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	6709	6519	[lb/ft ²]
Meyerhof stress, σ_V	1025.3	1059	[lb/ft ²]
Eccentricity, e	0.26	0.43	[ft]
Eccentricity, e/L	0.024	0.039	
Fs calculated	6.54	6.15	
Base length	11.00	11.00	[ft]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 3.064 and Fs-seismic = 2.249

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	11.00	5.084	3.641	1	Miragrid 3XT
2	2.00	11.00	6.313	4.261	1	Miragrid 3XT
3	4.00	11.00	10.023	5.940	1	Miragrid 3XT
4	5.33	11.00	16.928	8.758	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0349, e/L seismic = 0.0526; Overturning: Fs-static = 14.33, Fs-seismic = 9.50

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	11.00	0.0296	0.0458	1	Miragrid 3XT
2	2.00	11.00	0.0203	0.0333	1	Miragrid 3XT
3	4.00	11.00	0.0094	0.0175	1	Miragrid 3XT
4	5.33	11.00	0.0042	0.0088	1	Miragrid 3XT

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	1768	339.52	115.90	N/A	5.206	N/A	5.589	Miragrid 3XT
2	2.00	1768	339.71	183.11	N/A	5.203	N/A	4.869	Miragrid 3XT
3	4.00	1768	246.77	241.10	N/A	7.163	N/A	5.217	Miragrid 3XT
4	5.33	1768	189.65	392.76	N/A	9.321	N/A	4.371	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	339.5	115.9	9.55	0.45	6702.1	N/A	19.740	6702.1	N/A	14.716
2	2.00	1.000	339.7	183.1	8.65	1.35	4797.0	N/A	14.121	4797.0	N/A	9.175
3	4.00	1.000	246.8	241.1	7.30	2.70	2429.9	N/A	9.847	2429.9	N/A	4.981
4	5.33	1.000	189.6	392.8	6.40	3.60	1187.4	N/A	6.261	1187.4	N/A	2.039

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection peak		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	340	12.01	12.01	1509	1509	1768	N/A	4.45	N/A	4.45	N/A	5.21	Miragrid 3XT
2	2.00	340	9.24	9.24	1361	1361	1768	N/A	4.01	N/A	4.01	N/A	5.20	Miragrid 3XT
3	4.00	247	17.63	17.63	1137	1137	1768	N/A	4.61	N/A	4.61	N/A	7.16	Miragrid 3XT
4	5.33	190	11.80	11.80	988	988	1768	N/A	5.21	N/A	5.21	N/A	9.32	Miragrid 3XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection break		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	455	7.96	7.96	1509	1509	1768	N/A	3.31	N/A	3.31	N/A	5.59	Miragrid 3XT
2	2.00	523	5.44	5.44	1361	1361	1768	N/A	2.60	N/A	2.60	N/A	4.87	Miragrid 3XT
3	4.00	488	7.41	7.41	1137	1137	1768	N/A	2.33	N/A	2.33	N/A	5.22	Miragrid 3XT
4	5.33	582	3.27	3.27	988	988	1768	N/A	1.70	N/A	1.70	N/A	4.37	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 2.144
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1035.34 and R = 39.11 [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 1.470
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1035.34 and R = 39.11 [ft] when the terrain coordinate system is used as shown in the table below.)

TERRAIN/WATER PROFILE

Soil layer #1: γ = 120.00 [lb/ft ^{3}] ϕ = 24.0° c = 0.00 [lb/ft ^{2}]

Point	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0

AASHTO 2002 ASD DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 2+18

Description:

Temporary Condition: Water level at 582.33 ft (Ground Level in front of Wall).

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

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Original date and time of creating this file: 12/06/2021

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	24.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3333 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 60.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.4217 (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 = 19.32 N γ= 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237
Design acceleration coefficient in Internal Stability: Kh = Am = 0.287
Design acceleration coefficient in External Stability: Kh_d = 0.287 => Kh = Am = 0.287

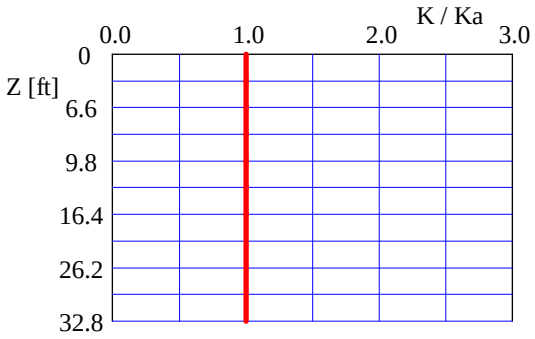
Kae (Kh > 0) = 0.6883 Kae (Kh = 0) = 0.4217 Δ Kae = 0.2665
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Friction angle along geogrid-soil interface, ρ	26.56				
Pullout resistance factor, F*	0.80·tanϕ	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	0.8				

Variation of Lateral Earth Pressure Coefficient With Depth

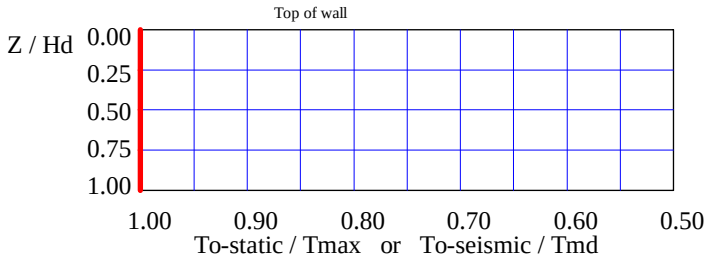
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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 σ (1)	CRult (2)	Geogrid Type #2 σ	CRult	Geogrid Type #3 σ	CRult	Geogrid Type #4 σ	CRult	Geogrid Type #5 σ	CRult
0.0	0.23								
1000.0	0.50	N/A		N/A		N/A		N/A	
2000.0	0.58								
2180.0	0.60								

Geogrid Type #1 3) σ	CRcr	Geogrid Type #2 σ	CRcr	Geogrid Type #3 σ	CRcr	Geogrid Type #4 σ	CRcr	Geogrid Type #5 σ	CRcr
0.0	0.23								
1000.0	0.50	N/A		N/A		N/A		N/A	
2000.0	0.58								
2180.0	0.60								

(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 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

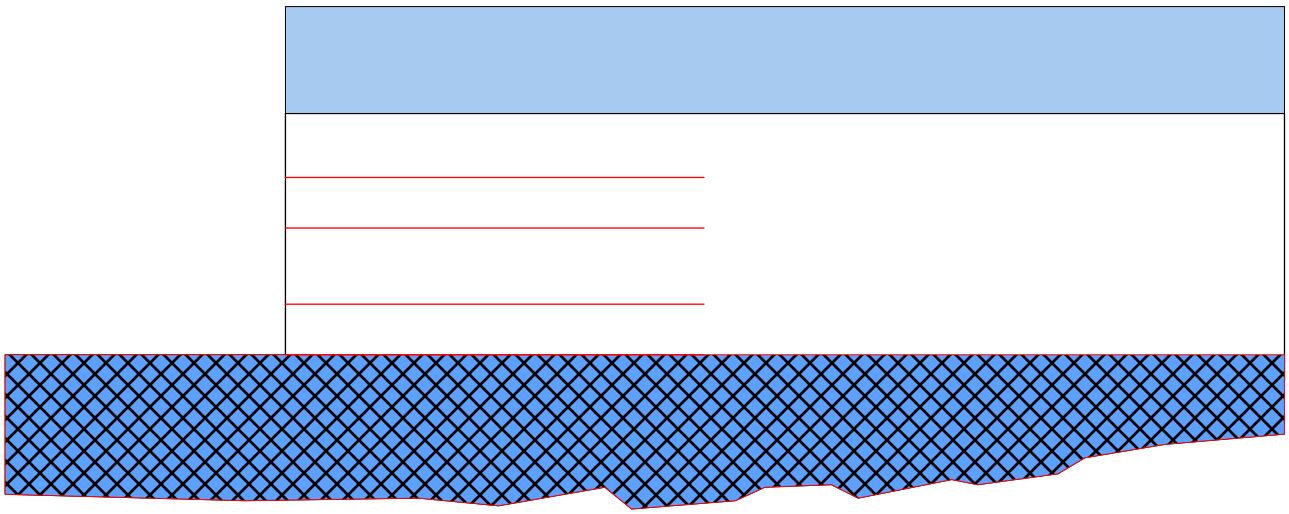
Design height, Hd	7.00	[ft]	{ Embedded depth is E = 0.67 ft, and height above top of finished bottom grade is H = 6.33 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

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], and live load is 150.0 [lb/ft ²]

Hydrostatic water pressure exist in analysis. hw1 = 0.67 and hw2 = 0.67 ft.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 2.68, Meyerhof stress = 1028 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.330, Eccentricity, e/L = 0.0460, Fs-overturning = 10.86

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	11.00	1	3.85	4.47	4.466	15.060	2.952	0.0371	Miragrid 3XT
2	2.00	11.00	1	3.39	4.36	4.361	10.776	3.475	0.0254	Miragrid 3XT
3	4.00	11.00	1	3.89	6.00	6.004	7.860	4.738	0.0118	Miragrid 3XT
4	5.33	11.00	1	4.40	7.81	7.812	5.196	6.249	0.0053	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 2.23, Meyerhof stress = 1126 lb/ft².

Foundation Interface: Direct sliding, Fs = 1.341, Eccentricity, e/L = 0.0937, Fs-overturning = 5.33

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	11.00	1	2.28	3.59	3.586	11.128	1.721	0.0742	Miragrid 3XT
2	2.00	11.00	1	2.05	3.57	3.568	8.164	2.087	0.0486	Miragrid 3XT
3	4.00	11.00	1	2.24	4.73	4.727	5.659	3.068	0.0201	Miragrid 3XT
4	5.33	11.00	1	2.41	5.92	5.917	3.555	4.463	0.0079	Miragrid 3XT

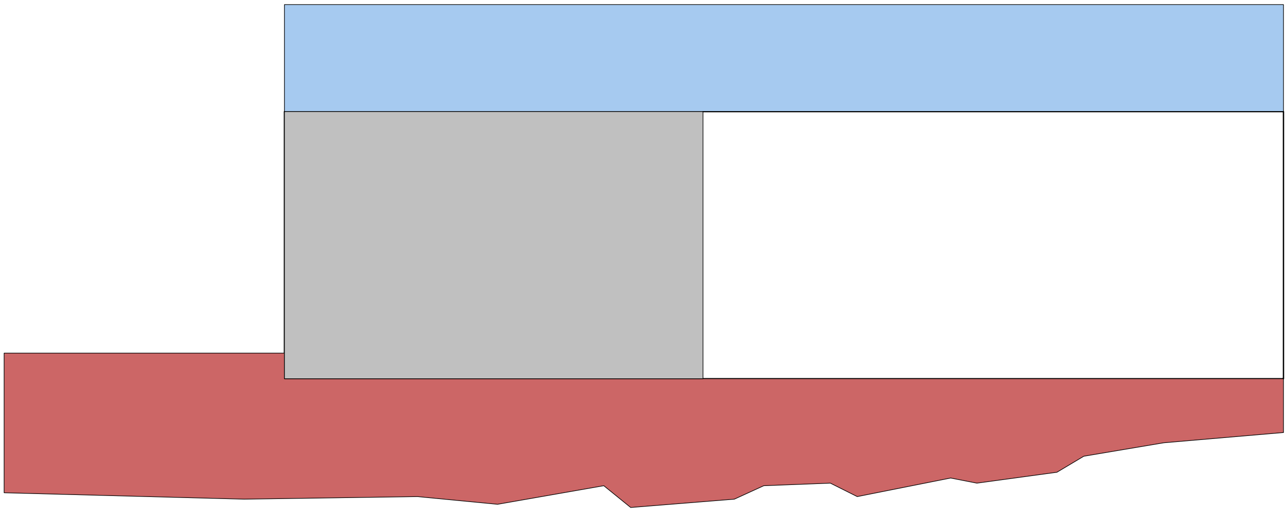
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 2.144
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.470
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Ultimate bearing capacity, q-ult	2757	2517	[lb/ft ²]
Meyerhof stress, σ_V	1028.2	1126	[lb/ft ²]
Eccentricity, e	0.43	0.87	[ft]
Eccentricity, e/L	0.039	0.079	
Fs calculated	2.68	2.23	
Base length	11.00	11.00	[ft]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.330 and Fs-seismic = 1.341

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	11.00	2.952	1.721	1	Miragrid 3XT
2	2.00	11.00	3.475	2.087	1	Miragrid 3XT
3	4.00	11.00	4.738	3.068	1	Miragrid 3XT
4	5.33	11.00	6.249	4.463	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0460, e/L seismic = 0.0937; Overturning: Fs-static = 10.86, Fs-seismic = 5.33

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	11.00	0.0371	0.0742	1	Miragrid 3XT
2	2.00	11.00	0.0254	0.0486	1	Miragrid 3XT
3	4.00	11.00	0.0118	0.0201	1	Miragrid 3XT
4	5.33	11.00	0.0053	0.0079	1	Miragrid 3XT

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	1768	395.77	139.83	N/A	4.466	N/A	3.586	Miragrid 3XT
2	2.00	1768	405.31	129.71	N/A	4.361	N/A	3.568	Miragrid 3XT
3	4.00	1768	294.43	114.50	N/A	6.004	N/A	4.727	Miragrid 3XT
4	5.33	1768	226.27	104.38	N/A	7.812	N/A	5.917	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	395.8	139.8	10.61	0.39	5960.3	N/A	15.060	5960.3	N/A	11.128
2	2.00	1.000	405.3	129.7	9.85	1.15	4367.8	N/A	10.776	4367.8	N/A	8.164
3	4.00	1.000	294.4	114.5	8.69	2.31	2314.0	N/A	7.860	2314.0	N/A	5.659
4	5.33	1.000	226.3	104.4	7.92	3.08	1175.6	N/A	5.196	1175.6	N/A	3.555

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	396	0.44	0.44	1523	1768	N/A	3.85	N/A	4.47	Miragrid 3XT
2	2.00	405	0.39	0.39	1372	1768	N/A	3.39	N/A	4.36	Miragrid 3XT
3	4.00	294	0.33	0.33	1146	1768	N/A	3.89	N/A	6.00	Miragrid 3XT
4	5.33	226	0.28	0.28	995	1768	N/A	4.40	N/A	7.81	Miragrid 3XT

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	536	0.44	0.35	1219	1768	N/A	2.28	N/A	3.59	Miragrid 3XT
2	2.00	535	0.39	0.31	1098	1768	N/A	2.05	N/A	3.57	Miragrid 3XT
3	4.00	409	0.33	0.26	916	1768	N/A	2.24	N/A	4.73	Miragrid 3XT
4	5.33	331	0.28	0.23	796	1768	N/A	2.41	N/A	5.92	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 2.144
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1035.34 and R = 39.11 [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 1.470
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1035.34 and R = 39.11 [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 = 24.0° c = 0.00 [lb/ft ²]											
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0

NCMA DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 2+50

Description:

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

Original file path and name: C:\Users\afathi2\OneDrive - Terracon Consultants Inc\De.....
.....all 1 - STA 2+50.BEN

Original date and time of creating this file: 12/06/2021

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

SOIL DATA

REINFORCED SOIL

Unit weight,	γ	120.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	30.0 °

RETAINED SOIL

Unit weight,	γ	120.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight,	$\gamma_{equiv.}$	120.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	24.0 °
Equivalent cohesion,	$c_{equiv.}$	0.0 lb/ft ^{2}

Water table does not affect bearing capacity
Note: A separate analysis has been performed for temporary 100-year flood event.

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2973
Inclination of internal slip plane, ψ = 55.98°.
Ka (external stability) = 0.3682

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 19.32 N γ = 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237

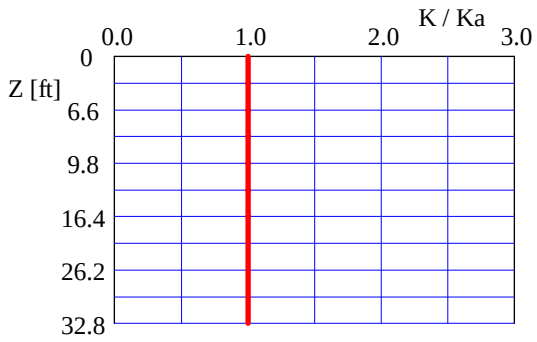
Kae (Kh > 0) = 0.4711 Kae (Kh = 0) = 0.3682 Δ Kae = 0.1029
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Cds = tan(ro) / tan(Phi.reinforced)	0.87				
Ci	0.80	N/A	N/A	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

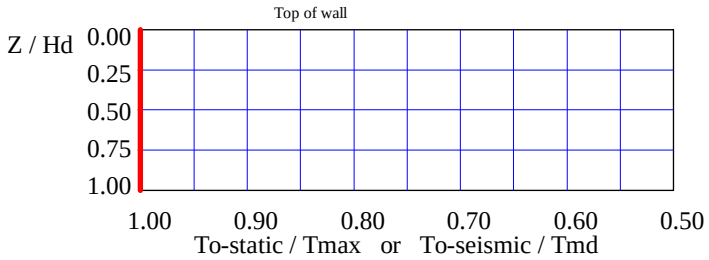
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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



Peak Strength Criterion

Geogrid Type #1 Weight of blocks	(1) (2) Tultconn	Geogrid Type #2 Weight of blocks	Tultconn	Geogrid Type #3 Weight of blocks	Tultconn	Geogrid Type #4 Weight of blocks	Tultconn	Geogrid Type #5 Weight of blocks	Tultconn
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Service Strength Criterion @ 3/4"

Geogrid Type #1 Weight of blocks	(3) Tconn @ 3/4"	Geogrid Type #2 Weight of blocks	Tconn @ 3/4"	Geogrid Type #3 Weight of blocks	Tconn @ 3/4"	Geogrid Type #4 Weight of blocks	Tconn @ 3/4"	Geogrid Type #5 Weight of blocks	Tconn @ 3/4"
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Ultimate Strength Criterion

Weight of blocks	Vu (4)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

Service Strength Criterion

Weight of blocks	Vu' (5)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

(1) (2) (3) (4) (5) Weight of blocks, Tultconn., Tconn@3/4", Vu and Vu' are in [lb/ft]

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	1.00	N/A	N/A	N/A	N/A

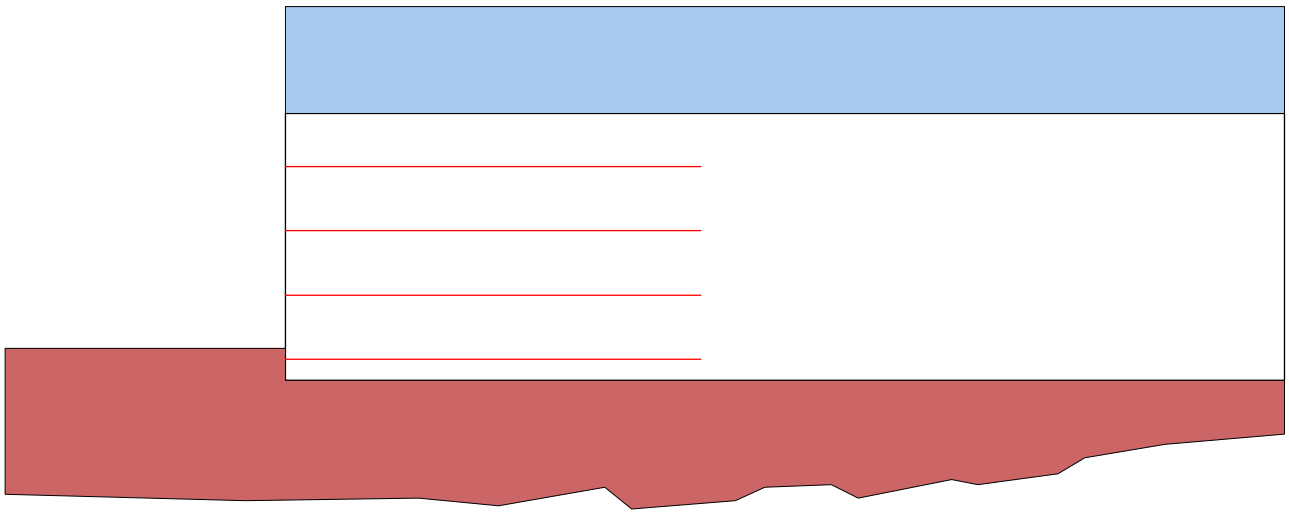
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	8.33	[ft]	{ Embedded depth is E = 1.00 ft, and height above top of finished bottom grade is H = 7.33 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00°

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], and live load is 150.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 6.81, Meyerhof stress = 1198 lb/ft².
Foundation Interface: Direct sliding, Fs = 3.177, Eccentricity, e/L = 0.0334, Fs-overturning = 14.97

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	13.00	1	3.39	3.39	3.61	3.609	20.026	4.846	0.0290	Miragrid 3XT
2	2.67	13.00	1	3.09	3.09	3.81	3.813	13.811	6.364	0.0177	Miragrid 3XT
3	4.67	13.00	1	3.67	3.67	5.37	5.366	10.904	9.344	0.0090	Miragrid 3XT
4	6.67	13.00	1	4.28	4.28	7.67	7.668	5.997	18.447	0.0030	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 6.40, Meyerhof stress = 1239 lb/ft².
Foundation Interface: Direct sliding, Fs = 2.305, Eccentricity, e/L = 0.0514, Fs-overturning = 9.73

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	13.00	1	2.56	2.56	3.93	3.930	15.145	3.439	0.0457	Miragrid 3XT
2	2.67	13.00	1	1.99	1.99	3.52	3.524	8.864	4.160	0.0303	Miragrid 3XT
3	4.67	13.00	1	1.84	1.84	3.87	3.869	5.461	5.405	0.0174	Miragrid 3XT
4	6.67	13.00	1	1.30	1.30	3.35	3.347	1.818	8.704	0.0069	Miragrid 3XT

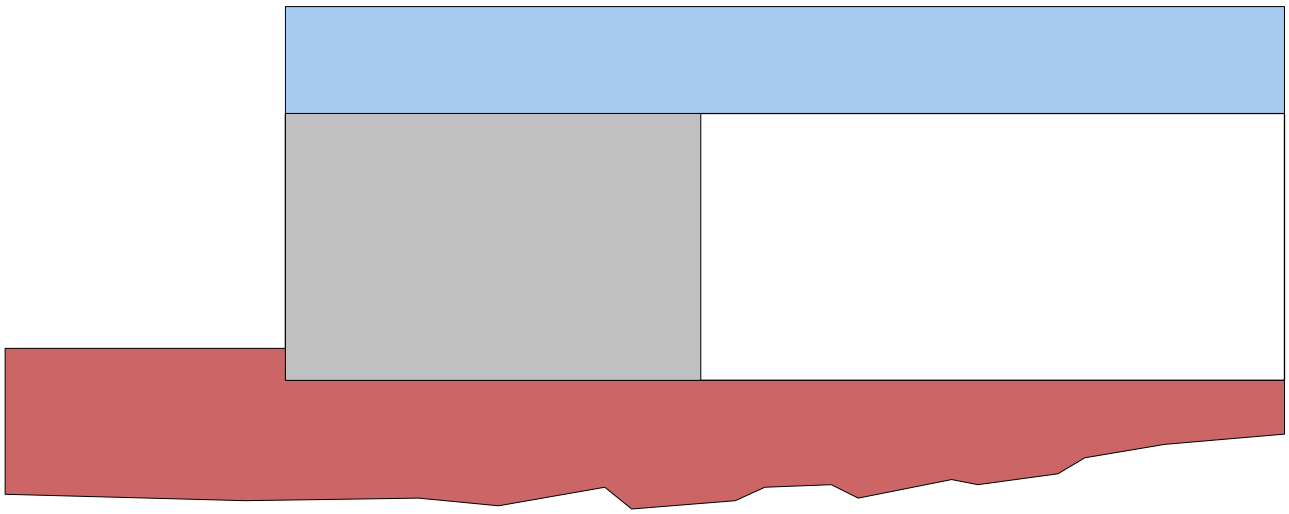
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 2.514
(it corresponds to a critical circle at Xc = -6.90, Yc = 41.93 and R = 45.15 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.624
(it corresponds to a critical circle at Xc = -6.90, Yc = 55.10 and R = 59.83 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	8154	7921	[lb/ft ²]
Meyerhof stress, σ_V	1197.5	1239	[lb/ft ²]
Eccentricity, e	0.32	0.53	[ft]
Eccentricity, e/L	0.025	0.040	
Fs calculated	6.81	6.40	
Base length	13.00	13.00	[ft]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 3.177 and Fs-seismic = 2.305

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	13.00	4.846	3.439	1	Miragrid 3XT
2	2.67	13.00	6.364	4.160	1	Miragrid 3XT
3	4.67	13.00	9.344	5.405	1	Miragrid 3XT
4	6.67	13.00	18.447	8.704	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0334, e/L seismic = 0.0514; Overturning: Fs-static = 14.97, Fs-seismic = 9.73

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	13.00	0.0290	0.0457	1	Miragrid 3XT
2	2.67	13.00	0.0177	0.0303	1	Miragrid 3XT
3	4.67	13.00	0.0090	0.0174	1	Miragrid 3XT
4	6.67	13.00	0.0030	0.0069	1	Miragrid 3XT

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	1768	489.81	157.88	N/A	3.609	N/A	3.930	Miragrid 3XT
2	2.67	1768	463.55	258.73	N/A	3.813	N/A	3.524	Miragrid 3XT
3	4.67	1768	329.45	328.39	N/A	5.366	N/A	3.869	Miragrid 3XT
4	6.67	1768	230.52	530.07	N/A	7.668	N/A	3.347	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	489.8	157.9	11.55	0.45	9809.0	N/A	20.026	9809.0	N/A	15.145
2	2.67	1.000	463.6	258.7	10.20	1.80	6402.1	N/A	13.811	6402.1	N/A	8.864
3	4.67	1.000	329.4	328.4	8.85	3.15	3592.4	N/A	10.904	3592.4	N/A	5.461
4	6.67	1.000	230.5	530.1	7.50	4.50	1382.4	N/A	5.997	1382.4	N/A	1.818

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection peak		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	490	7.45	7.45	1658	1658	1768	N/A	3.39	N/A	3.39	N/A	3.61	Miragrid 3XT
2	2.67	464	8.65	8.65	1434	1434	1768	N/A	3.09	N/A	3.09	N/A	3.81	Miragrid 3XT
3	4.67	329	10.95	10.95	1211	1211	1768	N/A	3.67	N/A	3.67	N/A	5.37	Miragrid 3XT
4	6.67	231	11.89	11.89	987	987	1768	N/A	4.28	N/A	4.28	N/A	7.67	Miragrid 3XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection break		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	648	5.24	5.24	1658	1658	1768	N/A	2.56	N/A	2.56	N/A	3.93	Miragrid 3XT
2	2.67	722	5.05	5.05	1434	1434	1768	N/A	1.99	N/A	1.99	N/A	3.52	Miragrid 3XT
3	4.67	658	4.82	4.82	1211	1211	1768	N/A	1.84	N/A	1.84	N/A	3.87	Miragrid 3XT
4	6.67	761	2.93	2.93	987	987	1768	N/A	1.30	N/A	1.30	N/A	3.35	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 2.514

(it corresponds to a critical circle at Xc = -6.90, Yc = 41.93 and R = 45.15 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1041.93 and R = 45.15 [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 1.624

(it corresponds to a critical circle at Xc = -6.90, Yc = 55.10 and R = 59.83 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1055.10 and R = 59.83 [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 = 24.0° c = 0.00 [lb/ft ²]											
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1001.0	1001.0	1001.0	1001.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0

AASHTO 2002 ASD DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 2+50

Description:

Temporary Condition: Water level at 582.00 ft (Ground Level in front of Wall).

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

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.....0-Temp Condition.BEN

Original date and time of creating this file: 12/06/2021

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

SOIL DATA

REINFORCED SOIL

Unit weight,	γ	120.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	30.0 °

RETAINED SOIL

Unit weight,	γ	120.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight,	$\gamma_{equiv.}$	120.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	24.0 °
Equivalent cohesion,	$c_{equiv.}$	0.0 lb/ft ^{2}

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3333 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 60.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.4217 (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 = 19.32 N γ = 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237
Design acceleration coefficient in Internal Stability: Kh = Am = 0.287
Design acceleration coefficient in External Stability: Kh_d = 0.287 => Kh = Am = 0.287

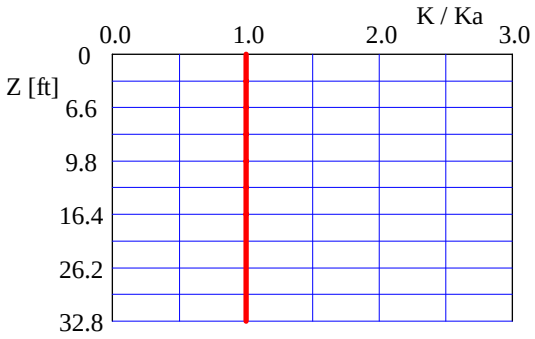
Kae (Kh > 0) = 0.6883 Kae (Kh = 0) = 0.4217 Δ Kae = 0.2665
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Friction angle along geogrid-soil interface, ρ	26.56				
Pullout resistance factor, F*	0.80·tanϕ	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	0.8				

Variation of Lateral Earth Pressure Coefficient With Depth

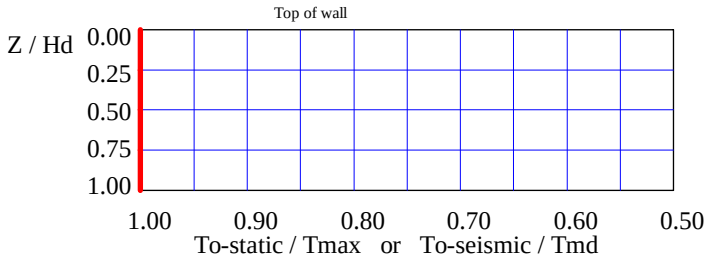
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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 σ (1)	CRult (2)	Geogrid Type #2 σ	CRult	Geogrid Type #3 σ	CRult	Geogrid Type #4 σ	CRult	Geogrid Type #5 σ	CRult
0.0	0.23								
1000.0	0.50	N/A		N/A		N/A		N/A	
2000.0	0.58								
2180.0	0.60								

Geogrid Type #1 3) σ	CRcr	Geogrid Type #2 σ	CRcr	Geogrid Type #3 σ	CRcr	Geogrid Type #4 σ	CRcr	Geogrid Type #5 σ	CRcr
0.0	0.23								
1000.0	0.50	N/A		N/A		N/A		N/A	
2000.0	0.58								
2180.0	0.60								

(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 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

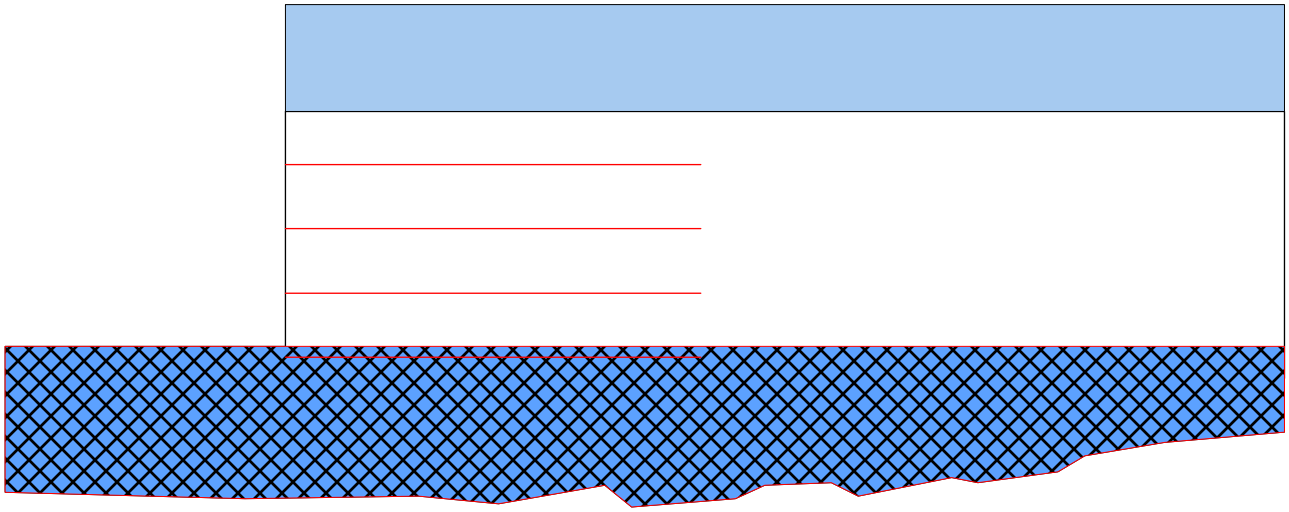
Design height, Hd	8.33	[ft]	{ Embedded depth is E = 1.00 ft, and height above top of finished bottom grade is H = 7.33 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

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], and live load is 150.0 [lb/ft ²]

Hydrostatic water pressure exist in analysis. hw1 = 1.00 and hw2 = 1.00 ft.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 2.77, Meyerhof stress = 1178 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.389, Eccentricity, e/L = 0.0446, Fs-overturning = 11.19

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	13.00	1	2.95	3.12	3.118	14.777	2.967	0.0372	Miragrid 3XT
2	2.67	13.00	1	2.62	3.20	3.196	10.405	3.775	0.0222	Miragrid 3XT
3	4.67	13.00	1	3.10	4.50	4.497	8.515	5.000	0.0113	Miragrid 3XT
4	6.67	13.00	1	3.61	6.43	6.427	4.906	7.402	0.0037	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 2.28, Meyerhof stress = 1297 lb/ft².

Foundation Interface: Direct sliding, Fs = 1.348, Eccentricity, e/L = 0.0937, Fs-overturning = 5.34

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	13.00	1	1.75	2.50	2.503	10.918	1.692	0.0770	Miragrid 3XT
2	2.67	13.00	1	1.57	2.60	2.601	7.828	2.231	0.0434	Miragrid 3XT
3	4.67	13.00	1	1.75	3.49	3.488	6.011	3.139	0.0202	Miragrid 3XT
4	6.67	13.00	1	1.89	4.70	4.701	3.210	5.293	0.0056	Miragrid 3XT

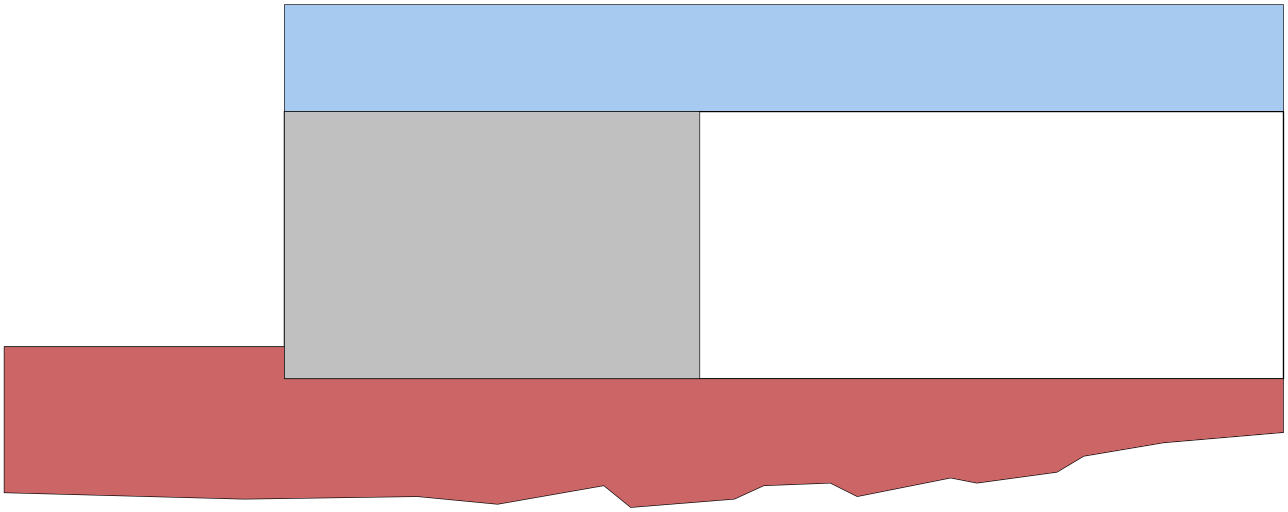
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.752
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 42.33 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.131
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 42.33 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Ultimate bearing capacity, q-ult	3260	2962	[lb/ft ²]
Meyerhof stress, σ_V	1178.2	1297	[lb/ft ²]
Eccentricity, e	0.50	1.05	[ft]
Eccentricity, e/L	0.038	0.081	
Fs calculated	2.77	2.28	
Base length	13.00	13.00	[ft]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.389 and Fs-seismic = 1.348

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	13.00	2.967	1.692	1	Miragrid 3XT
2	2.67	13.00	3.775	2.231	1	Miragrid 3XT
3	4.67	13.00	5.000	3.139	1	Miragrid 3XT
4	6.67	13.00	7.402	5.293	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0446, e/L seismic = 0.0937; Overturning: Fs-static = 11.19, Fs-seismic = 5.34

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	13.00	0.0372	0.0770	1	Miragrid 3XT
2	2.67	13.00	0.0222	0.0434	1	Miragrid 3XT
3	4.67	13.00	0.0113	0.0202	1	Miragrid 3XT
4	6.67	13.00	0.0037	0.0056	1	Miragrid 3XT

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	1768	567.01	200.41	N/A	3.118	N/A	2.503	Miragrid 3XT
2	2.67	1768	553.07	182.07	N/A	3.196	N/A	2.601	Miragrid 3XT
3	4.67	1768	393.07	163.72	N/A	4.497	N/A	3.488	Miragrid 3XT
4	6.67	1768	275.03	145.37	N/A	6.427	N/A	4.701	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	567.0	200.4	12.61	0.39	8378.9	N/A	14.777	8378.9	N/A	10.918
2	2.67	1.000	553.1	182.1	11.46	1.54	5754.7	N/A	10.405	5754.7	N/A	7.828
3	4.67	1.000	393.1	163.7	10.30	2.70	3346.8	N/A	8.515	3346.8	N/A	6.011
4	6.67	1.000	275.0	145.4	9.15	3.85	1349.4	N/A	4.906	1349.4	N/A	3.210

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	567	0.48	0.48	1674	1768	N/A	2.95	N/A	3.12	Miragrid 3XT
2	2.67	553	0.41	0.41	1447	1768	N/A	2.62	N/A	3.20	Miragrid 3XT
3	4.67	393	0.35	0.35	1220	1768	N/A	3.10	N/A	4.50	Miragrid 3XT
4	6.67	275	0.28	0.28	994	1768	N/A	3.61	N/A	6.43	Miragrid 3XT

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	767	0.48	0.38	1339	1768	N/A	1.75	N/A	2.50	Miragrid 3XT
2	2.67	735	0.41	0.33	1158	1768	N/A	1.57	N/A	2.60	Miragrid 3XT
3	4.67	557	0.35	0.28	976	1768	N/A	1.75	N/A	3.49	Miragrid 3XT
4	6.67	420	0.28	0.23	795	1768	N/A	1.89	N/A	4.70	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 1.752
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 42.33 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1035.34 and R = 42.33 [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 1.131
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 42.33 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1035.34 and R = 42.33 [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 = 24.0° c = 0.00 [lb/ft ²]											
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1001.0	1001.0	1001.0	1001.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0
Water table:											
x [ft]	0.0	32.8	65.6	98.4	131.2	164.0	196.9	229.7	262.5	295.3	328.1
y [ft]	1001.0	1001.0	1001.0	1001.0	1001.0	1001.0	1001.0	1001.0	1001.0	1001.0	1001.0

NCMA DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 2+77

Description:

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

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Original date and time of creating this file: 12/06/2021

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

SOIL DATA

REINFORCED SOIL

Unit weight,	γ	120.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	30.0 °

RETAINED SOIL

Unit weight,	γ	120.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight,	$\gamma_{equiv.}$	120.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	24.0 °
Equivalent cohesion,	$c_{equiv.}$	0.0 lb/ft ^{2}

Water table does not affect bearing capacity
Note: A separate analysis has been performed for temporary 100-year flood event.

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2973
Inclination of internal slip plane, ψ = 55.98°.
Ka (external stability) = 0.3682

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 19.32 N γ = 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237

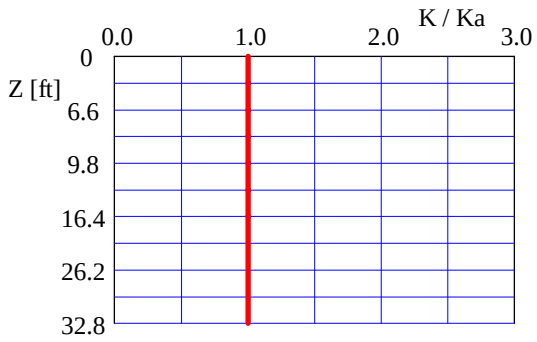
Kae (Kh > 0) = 0.4711 Kae (Kh = 0) = 0.3682 Δ Kae = 0.1029
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Cds = tan(ro) / tan(Phi.reinforced)	0.87				
Ci	0.80	N/A	N/A	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

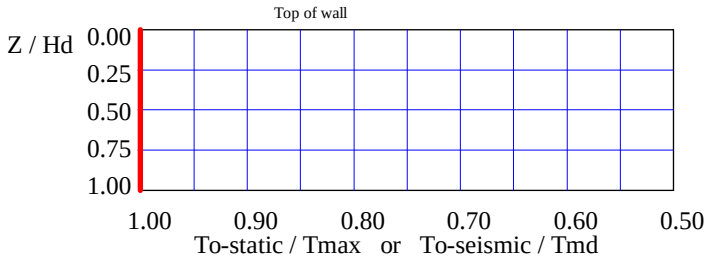
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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



Peak Strength Criterion

Geogrid Type #1 Weight of blocks	(1) (2) Tultconn	Geogrid Type #2 Weight of blocks	Tultconn	Geogrid Type #3 Weight of blocks	Tultconn	Geogrid Type #4 Weight of blocks	Tultconn	Geogrid Type #5 Weight of blocks	Tultconn
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Service Strength Criterion @ 3/4"

Geogrid Type #1 (3) Weight of blocks	Tconn @ 3/4"	Geogrid Type #2 Weight of blocks	Tconn @ 3/4"	Geogrid Type #3 Weight of blocks	Tconn @ 3/4"	Geogrid Type #4 Weight of blocks	Tconn @ 3/4"	Geogrid Type #5 Weight of blocks	Tconn @ 3/4"
0.0	801.00								
1000.0	1733.00	N/A		N/A		N/A		N/A	
2000.0	2038.00								
2180.0	2093.00								

Ultimate Strength Criterion

Weight of blocks	Vu (4)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

Service Strength Criterion

Weight of blocks	Vu' (5)
0.0	1181.00
1000.0	2181.00
2000.0	3181.00
2500.0	3681.00

(1) (2) (3) (4) (5) Weight of blocks, Tultconn., Tconn@3/4", Vu and Vu' are in [lb/ft]

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	1.00	N/A	N/A	N/A	N/A

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

Design height, Hd	5.67	[ft]	{ Embedded depth is E = 0.67 ft, and height above top of finished bottom grade is H = 5.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00°

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], and live load is 150.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:

SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 6.25, Meyerhof stress = 855 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.756, Eccentricity, e/L = 0.0414, Fs-overturning = 12.08

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	8.50	1	4.86	4.86	6.32	6.320	13.954	5.329	0.0339	Miragrid 3XT
2	2.00	8.50	1	4.57	4.57	6.67	6.668	9.429	7.168	0.0211	Miragrid 3XT
3	4.00	8.50	1	4.28	4.28	7.65	7.654	3.839	15.205	0.0070	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 5.86, Meyerhof stress = 886 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.054, Eccentricity, e/L = 0.0608, Fs-overturning = 8.22

	GEOGRID			CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	Fs @ 3/4" [service criterion]	Fs-peak [failure criterion]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.67	8.50	1	3.53	3.53	6.61	6.607	10.131	3.863	0.0513	Miragrid 3XT
2	2.00	8.50	1	2.78	2.78	5.85	5.848	5.743	4.845	0.0342	Miragrid 3XT
3	4.00	8.50	1	1.66	1.66	4.27	4.268	1.487	8.690	0.0132	Miragrid 3XT

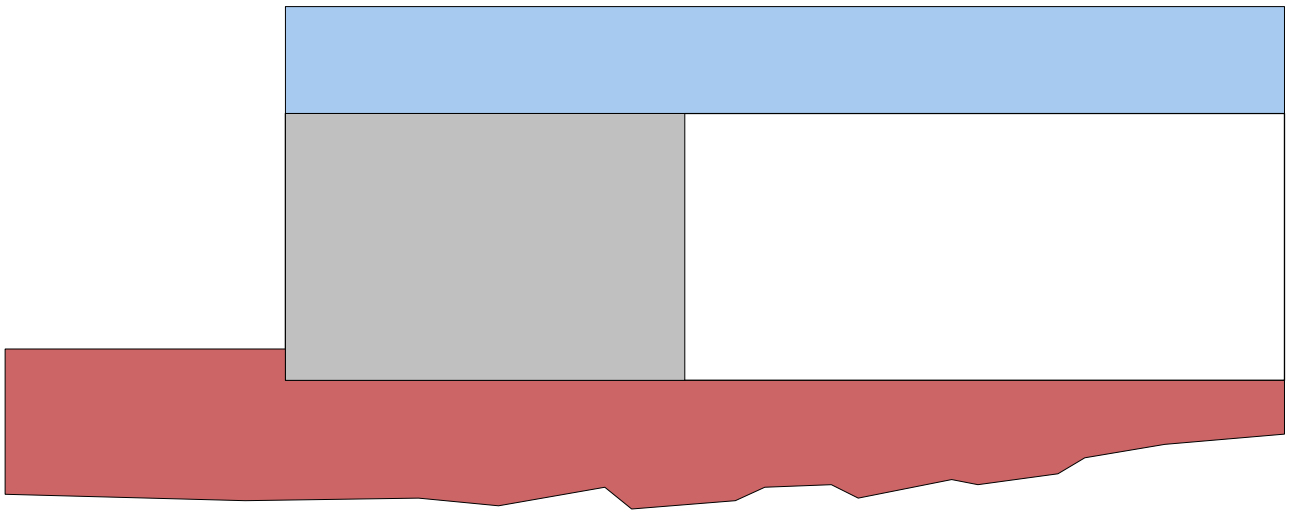
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 2.480
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.617
(it corresponds to a critical circle at Xc = -6.90, Yc = 41.93 and R = 45.15 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	5342	5185	[lb/ft ²]
Meyerhof stress, σ_V	855.2	886	[lb/ft ²]
Eccentricity, e	0.21	0.35	[ft]
Eccentricity, e/L	0.025	0.041	
Fs calculated	6.25	5.86	
Base length	8.50	8.50	[ft]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.756 and Fs-seismic = 2.054

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	8.50	5.329	3.863	1	Miragrid 3XT
2	2.00	8.50	7.168	4.845	1	Miragrid 3XT
3	4.00	8.50	15.205	8.690	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0414, e/L seismic = 0.0608; Overturning: Fs-static = 12.08, Fs-seismic = 8.22

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	8.50	0.0339	0.0513	1	Miragrid 3XT
2	2.00	8.50	0.0211	0.0342	1	Miragrid 3XT
3	4.00	8.50	0.0070	0.0132	1	Miragrid 3XT

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	1768	279.70	105.54	N/A	6.320	N/A	6.607	Miragrid 3XT
2	2.00	1768	265.10	170.20	N/A	6.668	N/A	5.848	Miragrid 3XT
3	4.00	1768	230.96	365.46	N/A	7.654	N/A	4.268	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	279.7	105.5	7.05	0.45	3902.8	N/A	13.954	3902.8	N/A	10.131
2	2.00	1.000	265.1	170.2	6.15	1.35	2499.7	N/A	9.429	2499.7	N/A	5.743
3	4.00	1.000	231.0	365.5	4.80	2.70	886.6	N/A	3.839	886.6	N/A	1.487

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection peak		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	280	13.50	13.50	1360	1360	1768	N/A	4.86	N/A	4.86	N/A	6.32	Miragrid 3XT
2	2.00	265	10.95	10.95	1211	1211	1768	N/A	4.57	N/A	4.57	N/A	6.67	Miragrid 3XT
3	4.00	231	11.86	11.86	987	987	1768	N/A	4.28	N/A	4.28	N/A	7.65	Miragrid 3XT

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Connection force, To [lb/ft]	FS - Bulging		Available connection strength, Tcl-failure criterion [lb/ft]	Available connection strength, Tcs-service criterion [lb/ft]	Available Geogrid strength, Tavailable [lb/ft]	Fs-overall connection break		Fs-overall connection service		Fs-overall Geogrid strength		Product name
			Peak	Deformation				Specified	Actual	Specified	Actual	Specified	Actual	
1	0.67	385	8.54	8.54	1360	1360	1768	N/A	3.53	N/A	3.53	N/A	6.61	Miragrid 3XT
2	2.00	435	5.91	5.91	1211	1211	1768	N/A	2.78	N/A	2.78	N/A	5.85	Miragrid 3XT
3	4.00	596	3.74	3.74	987	987	1768	N/A	1.66	N/A	1.66	N/A	4.27	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 2.480
(it corresponds to a critical circle at Xc = -6.90, Yc = 35.34 and R = 39.11 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1035.34 and R = 39.11 [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 1.617
(it corresponds to a critical circle at Xc = -6.90, Yc = 41.93 and R = 45.15 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1041.93 and R = 45.15 [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 = 24.0° c = 0.00 [lb/ft ²]											
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0

AASHTO 2002 ASD DESIGN METHOD
Chick-fil-A #04723

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Chick-fil-A #04723
Project Number: 15215199
Client: Chick-fil-A, Inc.
Designer: AF
Station Number: WALL 1 - STA 2+77

Description:

Temporary Condition: Water Level at base of wall.

Company's information:

Name: Terracon Consultants, Inc.
Street: 4685 South Ash Ave, Suite H-4

Tempe, AZ 85282
Telephone #: 480 897 8200
Fax #:
E-Mail: Aria.Fathi@Terracon.com

Original file path and name: C:\Users\afathi2\OneDrive - Terracon Consultants Inc\De.....
.....7-Temp Condition.BEN

Original date and time of creating this file: 12/06/2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight,	γ	120.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	30.0 °

RETAINED SOIL

Unit weight,	γ	120.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	24.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight,	$\gamma_{equiv.}$	120.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	24.0 °
Equivalent cohesion,	$c_{equiv.}$	0.0 lb/ft ^{2}

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3333 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 60.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.4217 (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 = 19.32 N γ = 9.44

SEISMICITY

Maximum ground acceleration coefficient, A = 0.237
Design acceleration coefficient in Internal Stability: Kh = Am = 0.287
Design acceleration coefficient in External Stability: Kh_d = 0.287 => Kh = Am = 0.287

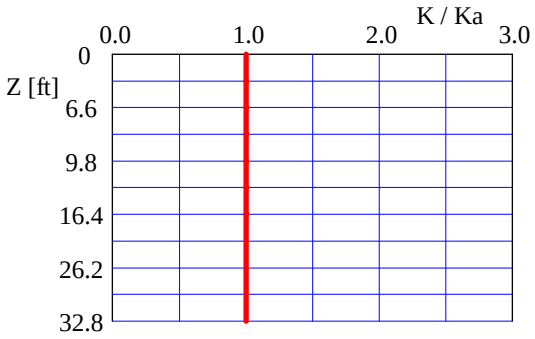
Kae (Kh > 0) = 0.6883 Kae (Kh = 0) = 0.4217 Δ Kae = 0.2665
Seismic soil-geogrid friction coefficient, F* is 100.0% of its specified static value.

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]	3500.0				
Durability reduction factor, RFd	1.10				
Installation-damage reduction factor, RFid	1.25				
Creep reduction factor, RFc	1.44	N/A	N/A	N/A	N/A
Fs-overall for strength	N/A				
Coverage ratio, Rc	1.000				
Friction angle along geogrid-soil interface, ρ	26.56				
Pullout resistance factor, F*	0.80·tanϕ	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	0.8				

Variation of Lateral Earth Pressure Coefficient With Depth

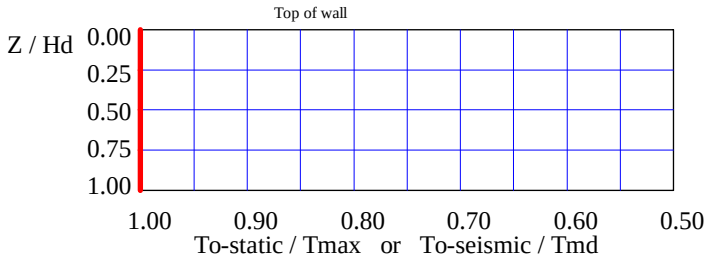
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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 0.50 ft.
Average unit weight of block is γ_f = 120.00 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 σ (1)	CRult (2)	Geogrid Type #2 σ	CRult	Geogrid Type #3 σ	CRult	Geogrid Type #4 σ	CRult	Geogrid Type #5 σ	CRult
0.0	0.29								
500.0	0.34	N/A		N/A		N/A		N/A	
1000.0	0.39								
2000.0	0.49								

Geogrid Type #1 3) σ	CRcr	Geogrid Type #2 σ	CRcr	Geogrid Type #3 σ	CRcr	Geogrid Type #4 σ	CRcr	Geogrid Type #5 σ	CRcr
0.0	0.29								
500.0	0.34	N/A		N/A		N/A		N/A	
1000.0	0.39								
2000.0	0.49								

(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 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Miragrid ..	N/A	N/A	N/A	N/A
Connection strength reduction factor, RFd	1.00	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

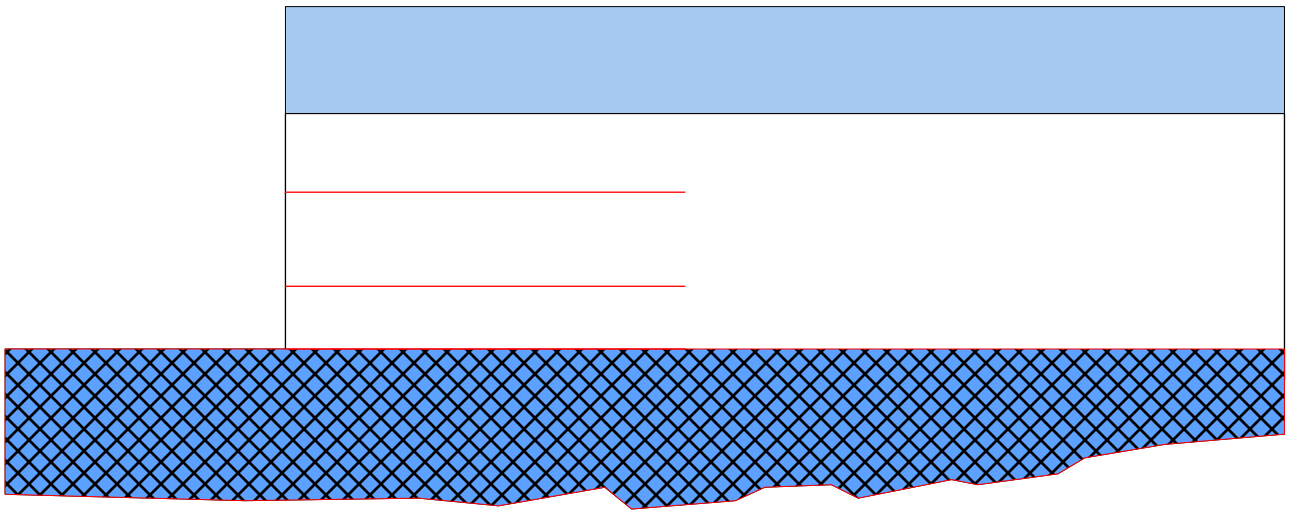
Design height, Hd	5.67	[ft]	{ Embedded depth is E = 0.67 ft, and height above top of finished bottom grade is H = 5.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

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], and live load is 150.0 [lb/ft ²]

Hydrostatic water pressure exist in analysis. hw1 = 0.67 and hw2 = 0.67 ft.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = 2.43, Meyerhof stress = 866 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.073, Eccentricity, e/L = 0.0553, Fs-overturning = 9.03

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	8.50	1	3.78	5.45	5.449	11.081	2.688	0.0425	Miragrid 3XT
2	2.00	8.50	1	3.70	5.59	5.589	7.550	3.268	0.0265	Miragrid 3XT
3	4.00	8.50	1	3.94	6.41	6.415	3.320	4.836	0.0088	Miragrid 3XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 1.99, Meyerhof stress = 956 lb/ft².

Foundation Interface: Direct sliding, Fs = 1.222, Eccentricity, e/L = 0.1083, Fs-overturning = 4.62

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	8.50	1	2.21	4.34	4.337	8.092	1.614	0.0812	Miragrid 3XT
2	2.00	8.50	1	2.20	4.51	4.514	5.621	2.051	0.0473	Miragrid 3XT
3	4.00	8.50	1	2.37	5.21	5.214	2.493	3.457	0.0131	Miragrid 3XT

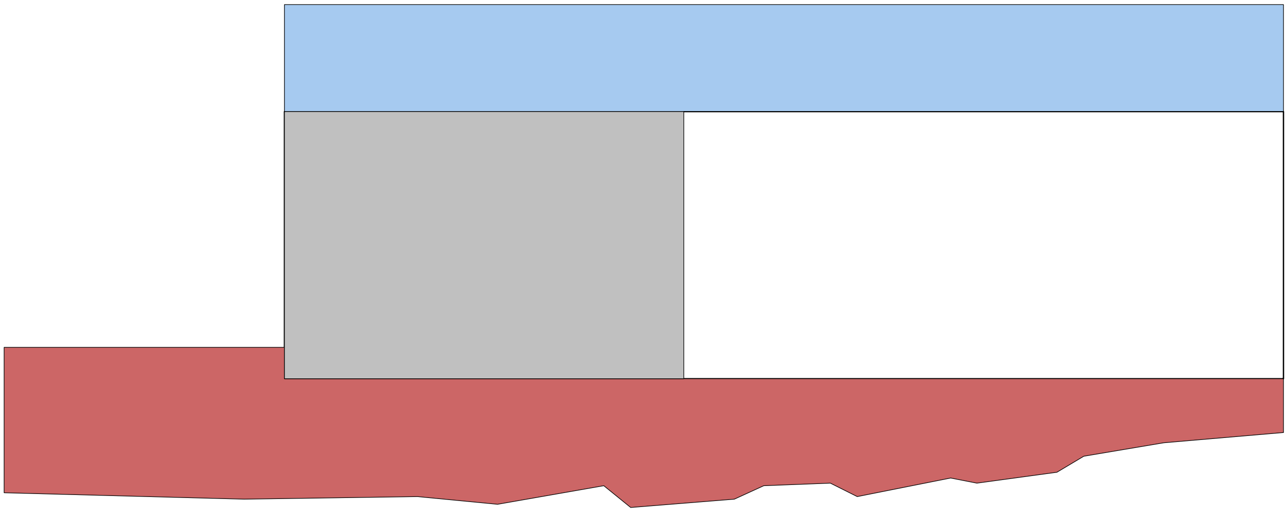
GLOBAL/COMPOUND STABILITY ANALYSIS (Using Bishop method and ROR = 0.0)

STATIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.713
(it corresponds to a critical circle at Xc = -6.90, Yc = 22.17 and R = 27.78 [ft]).

SEISMIC CONDITIONS: For the specified search grid, the calculated minimum Fs is 1.111
(it corresponds to a critical circle at Xc = -6.90, Yc = 28.76 and R = 33.28 [ft]).

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Ultimate bearing capacity, q-ult	2103	1905	[lb/ft ²]
Meyerhof stress, σ_V	865.7	956	[lb/ft ²]
Eccentricity, e	0.38	0.75	[ft]
Eccentricity, e/L	0.045	0.088	
Fs calculated	2.43	1.99	
Base length	8.50	8.50	[ft]



SCALE:

DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: Fs-static = 2.073 and Fs-seismic = 1.222

#	Geogrid Elevation [ft]	Geogrid Length [ft]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.67	8.50	2.688	1.614	1	Miragrid 3XT
2	2.00	8.50	3.268	2.051	1	Miragrid 3XT
3	4.00	8.50	4.836	3.457	1	Miragrid 3XT

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0553, e/L seismic = 0.1083; Overturning: Fs-static = 9.03, Fs-seismic = 4.62

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.67	8.50	0.0425	0.0812	1	Miragrid 3XT
2	2.00	8.50	0.0265	0.0473	1	Miragrid 3XT
3	4.00	8.50	0.0088	0.0131	1	Miragrid 3XT

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	1768	324.40	119.84	N/A	5.449	N/A	4.337	Miragrid 3XT
2	2.00	1768	316.29	108.50	N/A	5.589	N/A	4.514	Miragrid 3XT
3	4.00	1768	275.56	91.44	N/A	6.415	N/A	5.214	Miragrid 3XT

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [ft]	Coverage Ratio	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	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	324.4	119.8	8.11	0.39	3594.6	N/A	11.081	3594.6	N/A	8.092
2	2.00	1.000	316.3	108.5	7.35	1.15	2387.9	N/A	7.550	2387.9	N/A	5.621
3	4.00	1.000	275.6	91.4	6.19	2.31	914.8	N/A	3.320	914.8	N/A	2.493

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	324	0.35	0.35	1225	1768	N/A	3.78	N/A	5.45	Miragrid 3XT
2	2.00	316	0.33	0.33	1169	1768	N/A	3.70	N/A	5.59	Miragrid 3XT
3	4.00	276	0.31	0.31	1085	1768	N/A	3.94	N/A	6.41	Miragrid 3XT

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	444	0.35	0.28	980	1768	N/A	2.21	N/A	4.34	Miragrid 3XT
2	2.00	425	0.33	0.27	935	1768	N/A	2.20	N/A	4.51	Miragrid 3XT
3	4.00	367	0.31	0.25	868	1768	N/A	2.37	N/A	5.21	Miragrid 3XT

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

A horizontal seismic coefficient, Kh=half of 'A', equal to 0.118 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 1.713

(it corresponds to a critical circle at Xc = -6.90, Yc = 22.17 and R = 27.78 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1022.17 and R = 27.78 [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 1.111

(it corresponds to a critical circle at Xc = -6.90, Yc = 28.76 and R = 33.28 [ft] where (x=0, y=0) is taken at the TOE or Xc = 102.46, Yc = 1028.76 and R = 33.28 [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 = 24.0° c = 0.00 [lb/ft ²]											
x [ft]	0.0	89.5	97.0	109.4	150.0	160.0	170.0	180.0	180.0	300.0	320.0
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1060.0
Water table:											
x [ft]	0.0	32.8	65.6	98.4	131.2	164.0	196.9	229.7	262.5	295.3	328.1
y [ft]	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7	1000.7

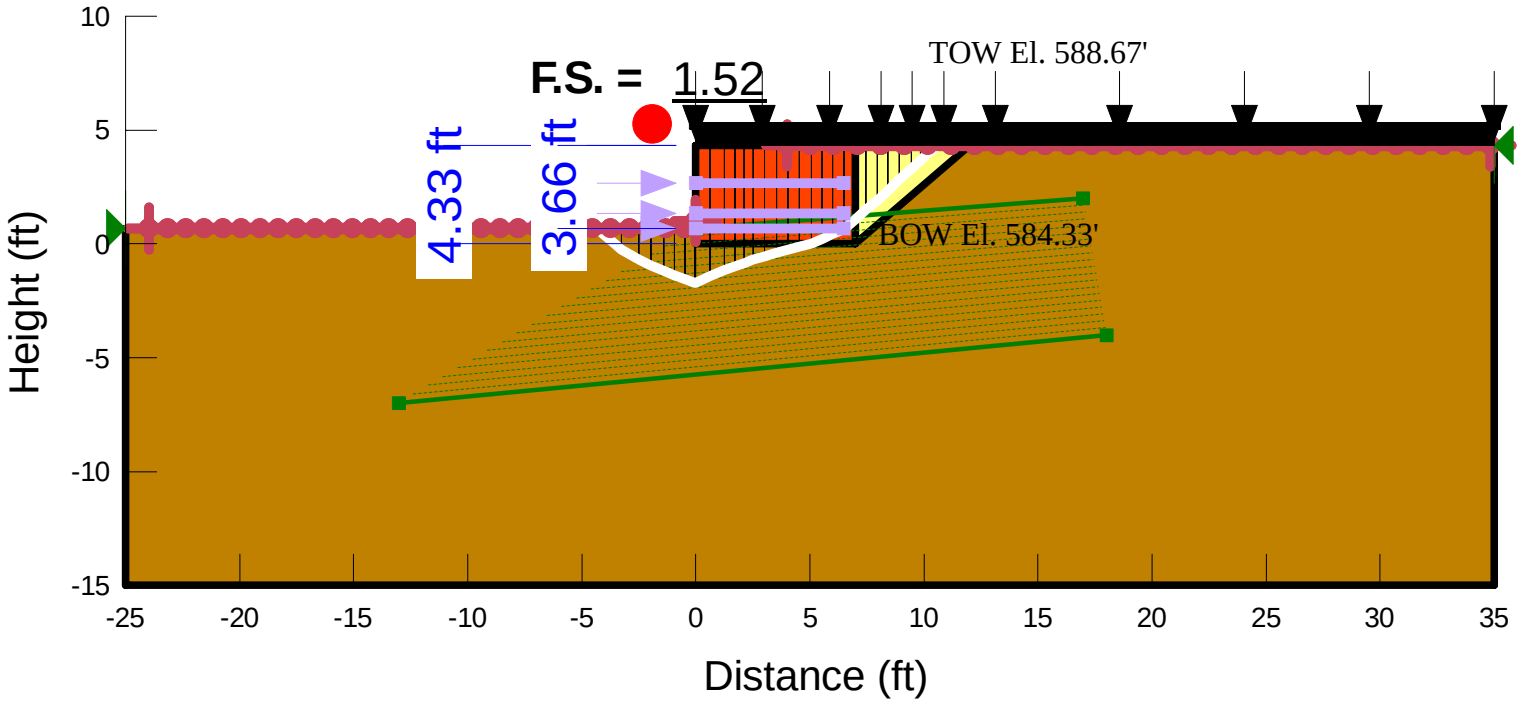
ATTACHMENT 2

Global Stability Graphical Output Analysis

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 0+70
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 6.5 ft
Analysis Type: Static

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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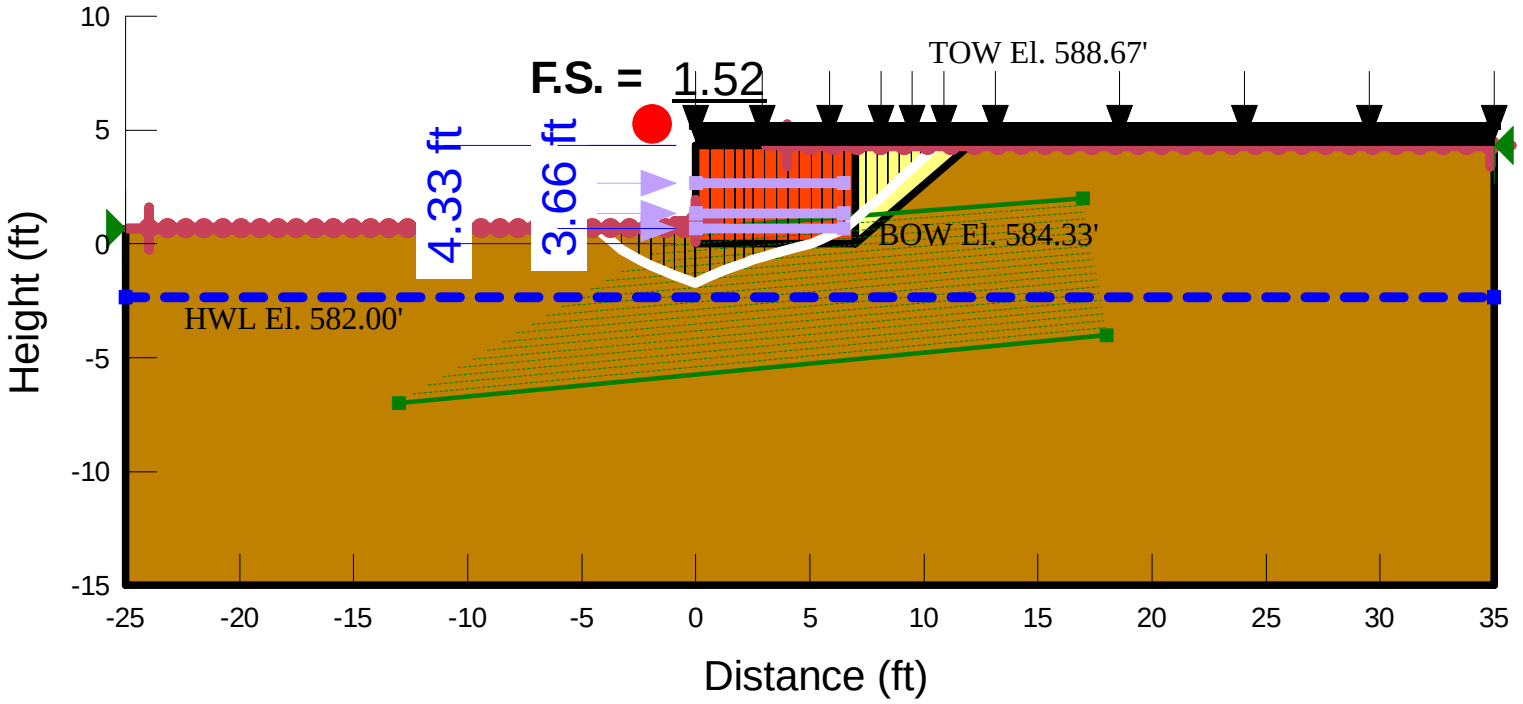
Static	
Wall 1 - STA 0+70.gsz	
12/10/2021	1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 0+70
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 6.5 ft
Analysis Type: 100 Year Flood Event (Elv. 582 ft)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Line
	Foundation Soil	Mohr-Coulomb	120	0	24	1
	Reinforced Soil	Mohr-Coulomb	120	0	30	1
	Retained Soil	Mohr-Coulomb	120	0	24	1

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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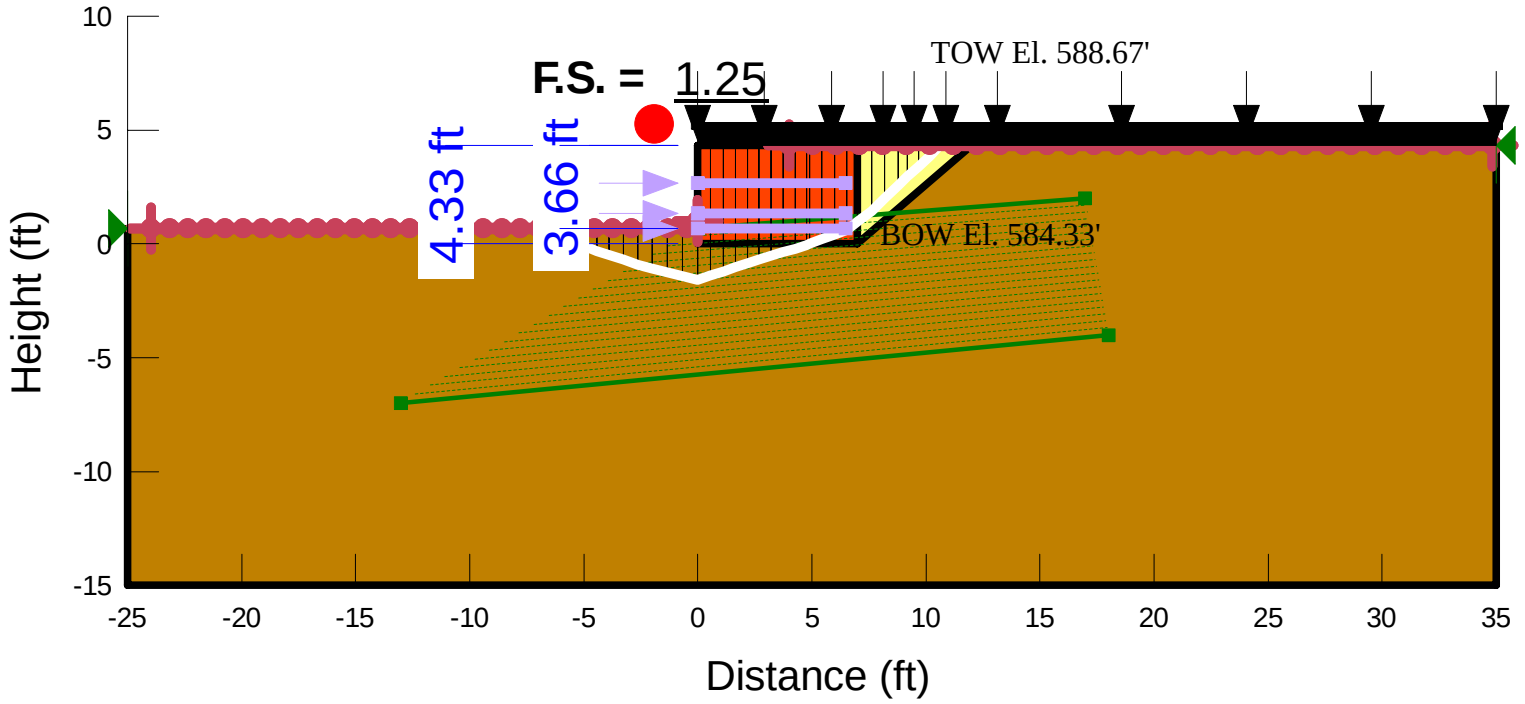
100 Year Flood Event (Elv. 582 ft)
Wall 1 - STA 0+70.gsz
12/14/2021 1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 0+70
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 6.5 ft
Analysis Type: Seismic (kh = 0.119)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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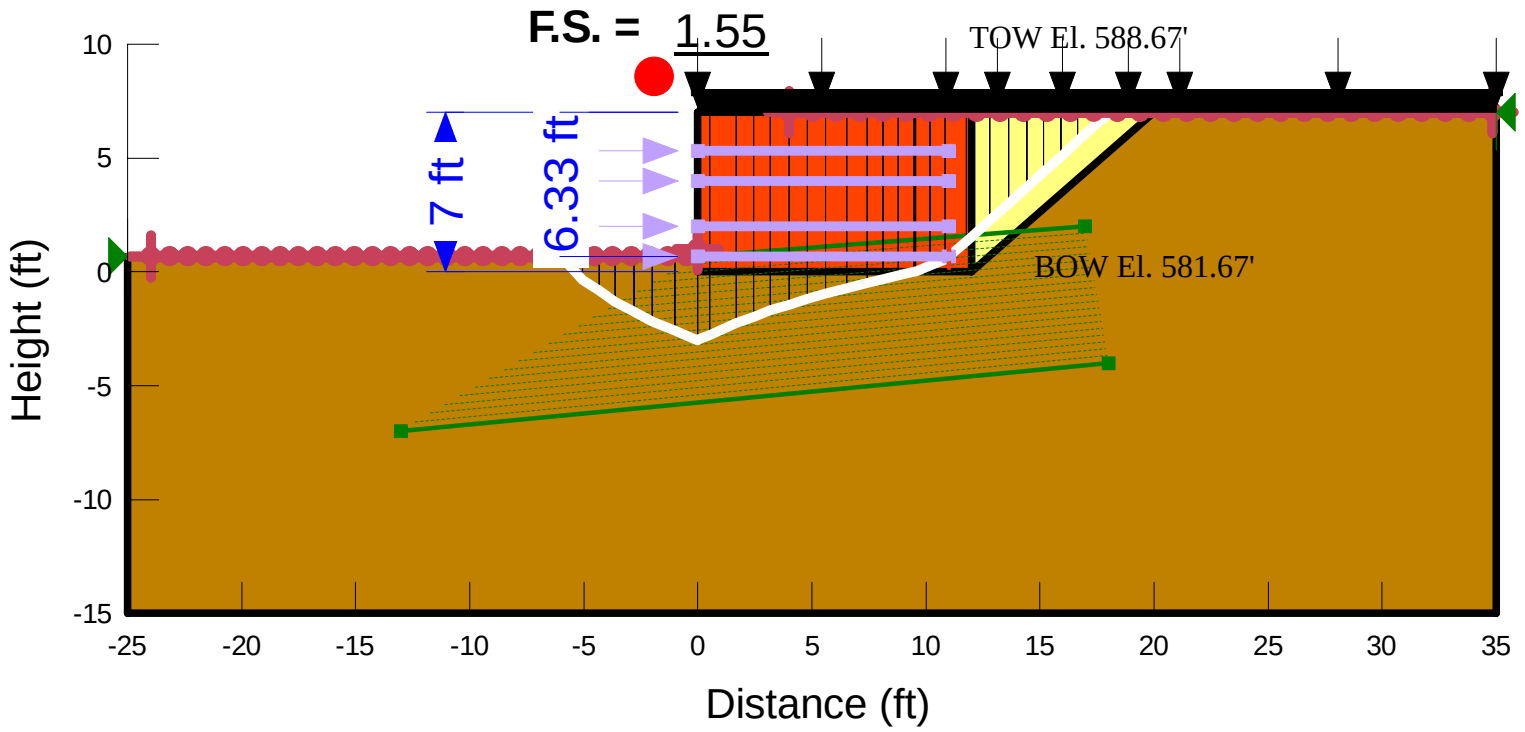
Seismic (kh = 0.119)
Wall 1 - STA 0+70.gsz
12/10/2021 1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+18
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 11 ft
Analysis Type: Static

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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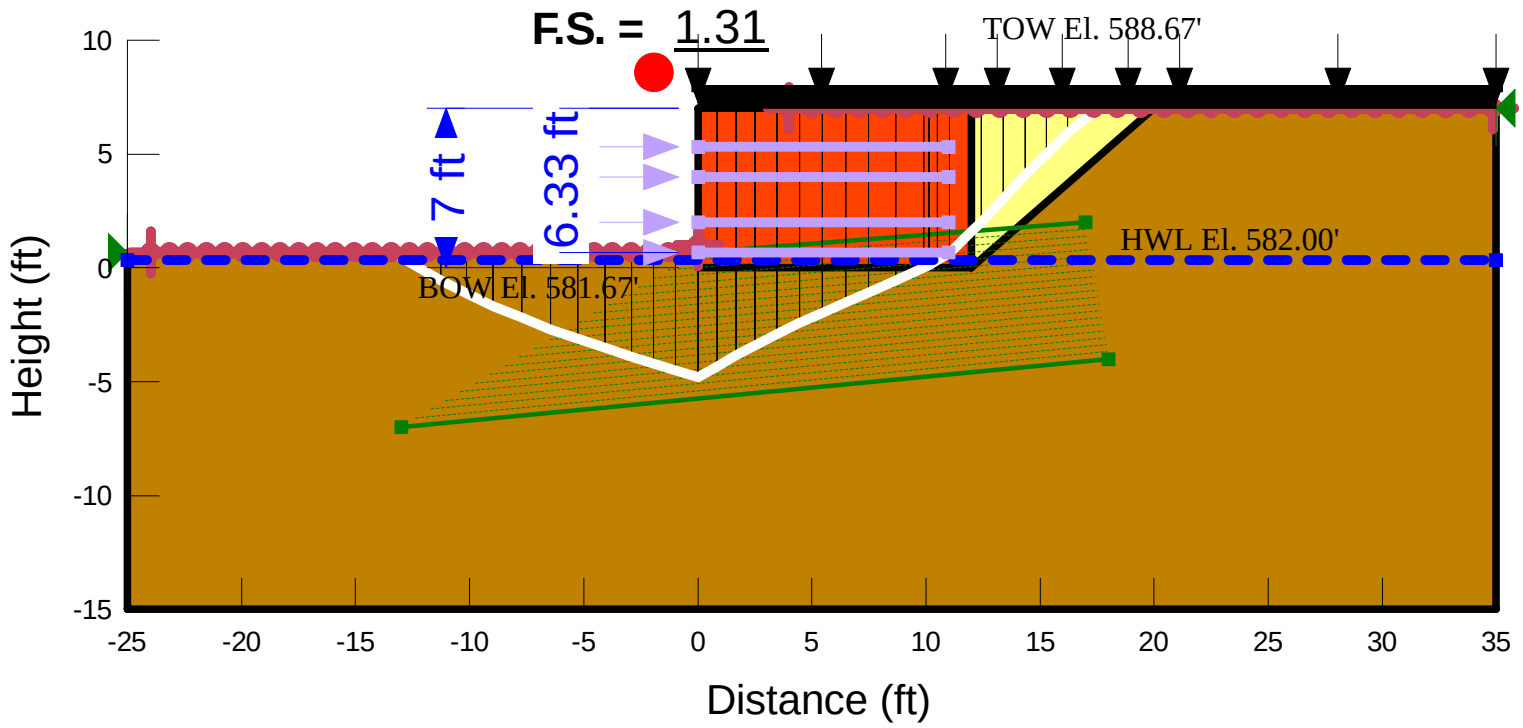
Static
Wall 1 - STA 2+18.gsz
12/14/2021 1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+18
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 11 ft
Analysis Type: 100 Yr Flood Event (Elv. 582 ft)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Line
	Foundation Soil	Mohr-Coulomb	120	0	24	1
	Reinforced Soil	Mohr-Coulomb	120	0	30	1
	Retained Soil	Mohr-Coulomb	120	0	24	1

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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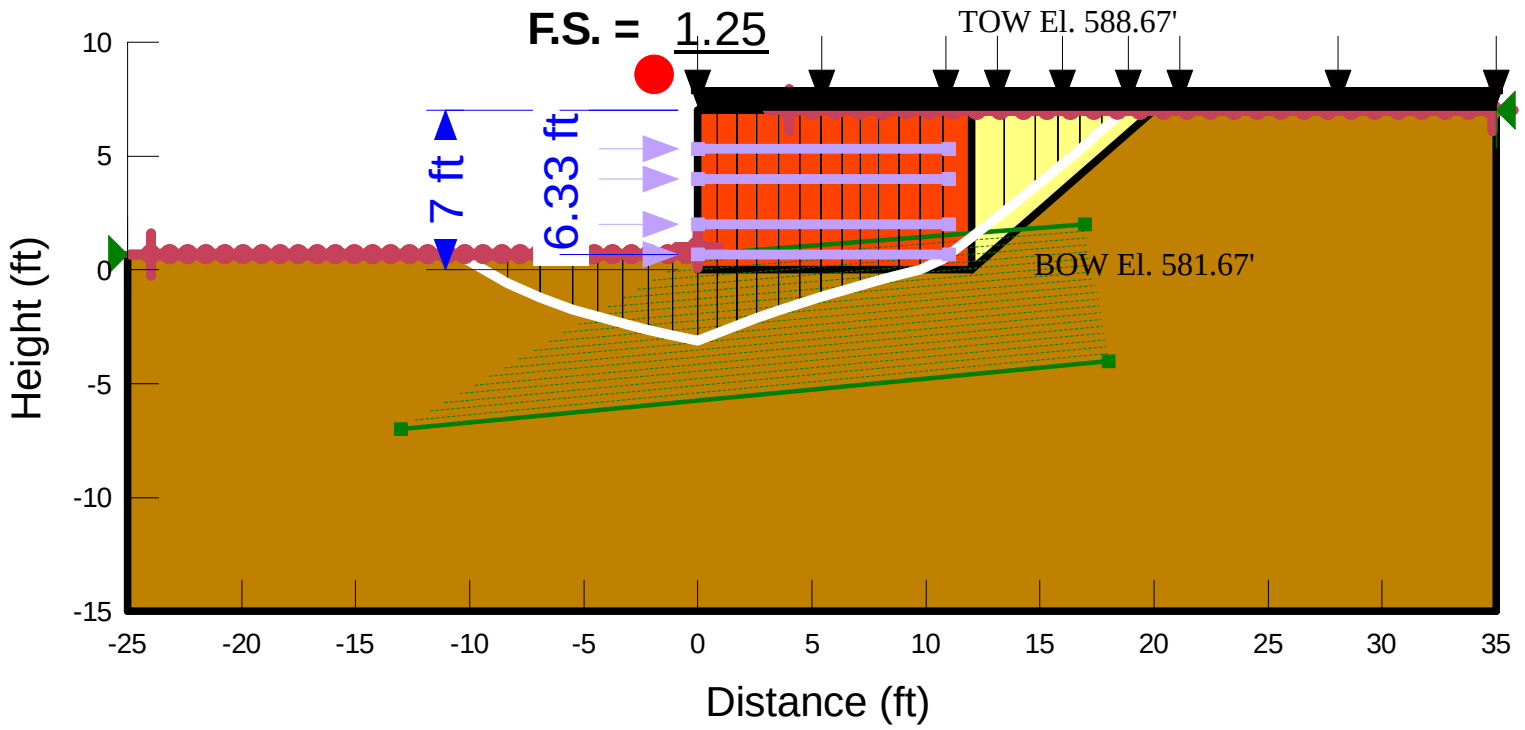
100 Yr Flood Event (Elv. 582 ft)
Wall 1 - STA 2+18.gsz
12/14/2021 1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+18
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 11 ft
Analysis Type: Seismic (kh = 0.119)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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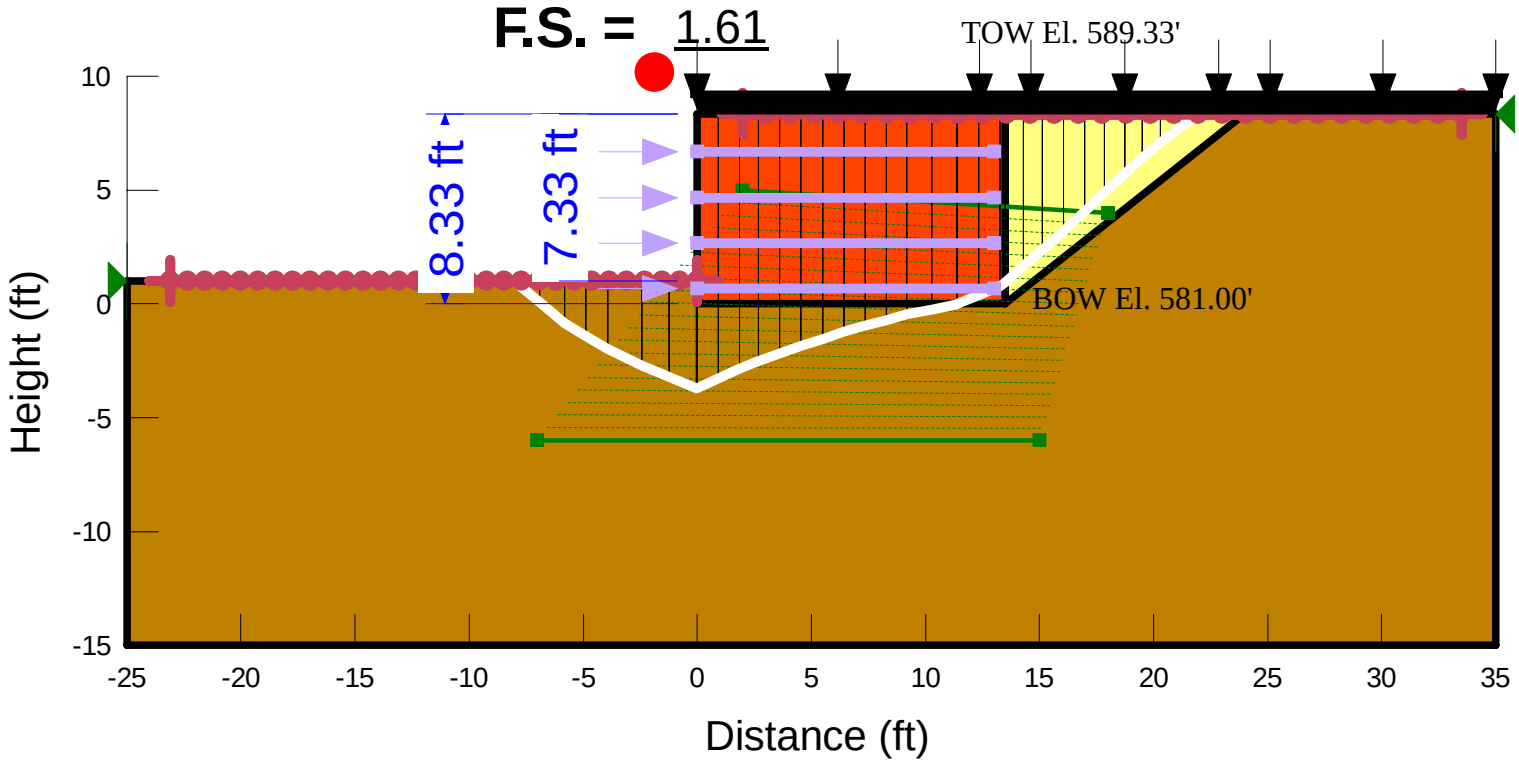
Seismic (kh = 0.119)
Wall 1 - STA 2+18.gsz
12/14/2021 1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+50
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 13 ft

Analysis Type: Static

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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Static

Wall 1 - STA 2+50.gsz

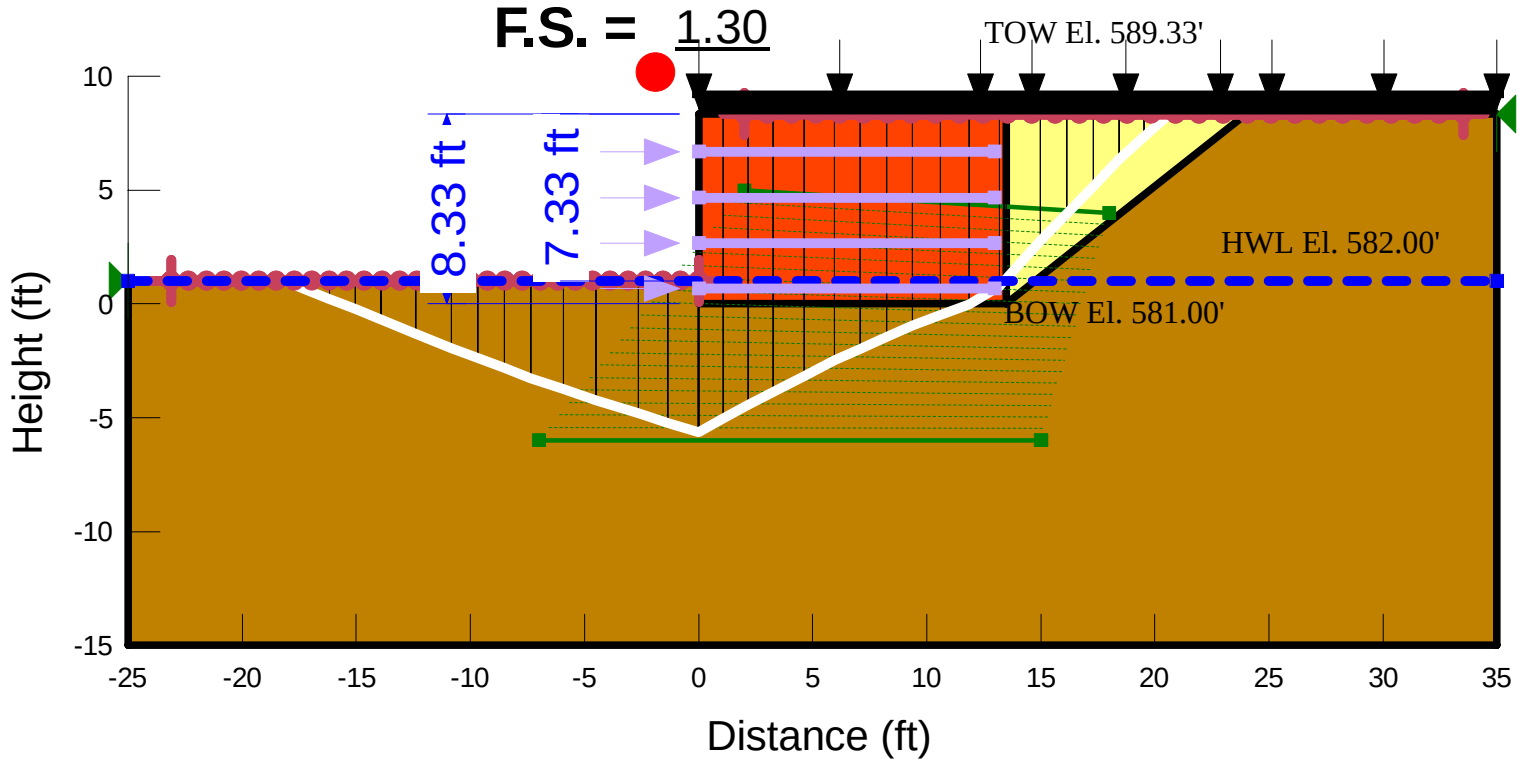
12/14/2021 1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+50
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 13 ft

Analysis Type: 100 yr Flood Event (Elv. 582 ft)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Line
	Foundation Soil	Mohr-Coulomb	120	0	24	1
	Reinforced Soil	Mohr-Coulomb	120	0	30	1
	Retained Soil	Mohr-Coulomb	120	0	24	1

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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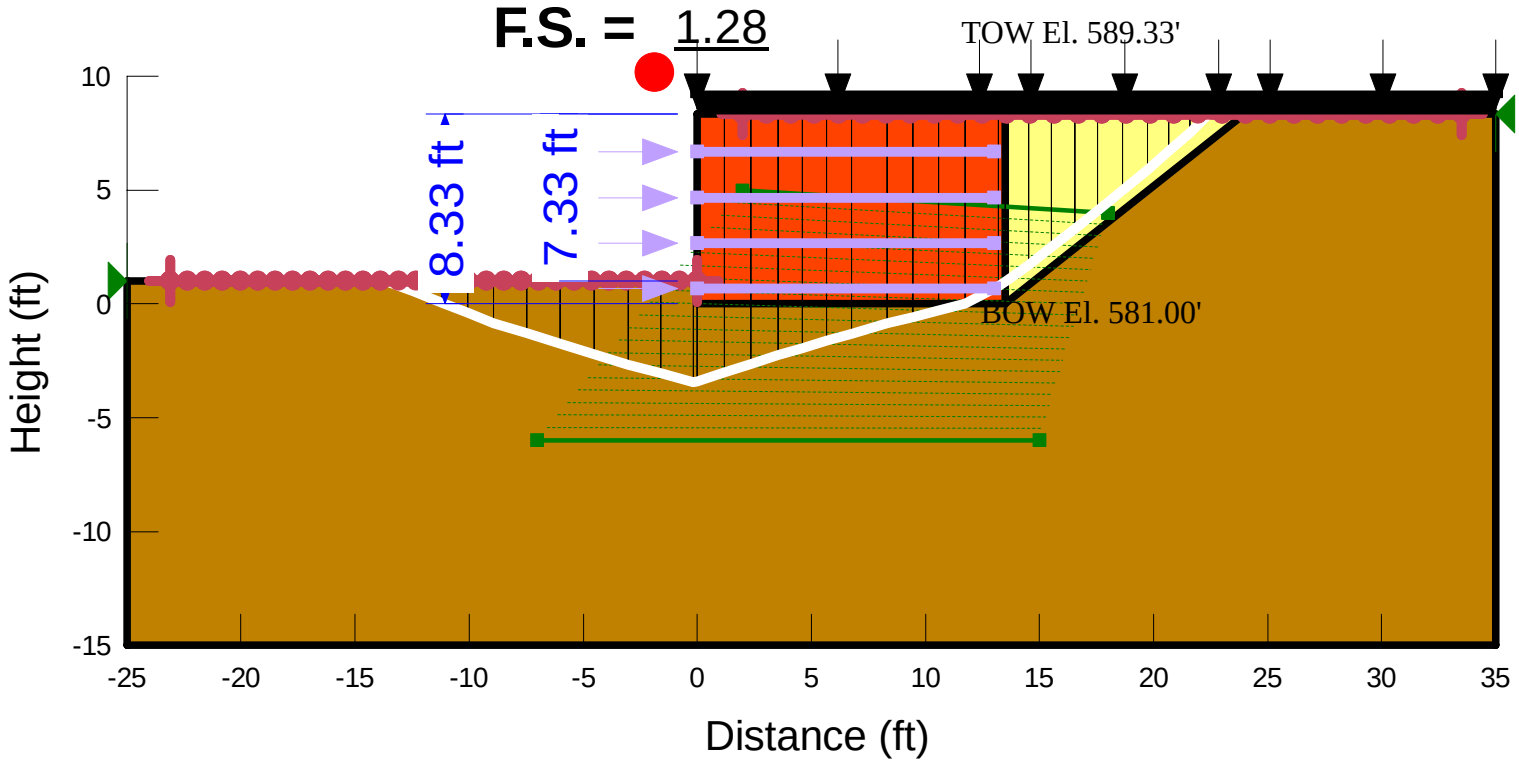
100 yr Flood Event (Elv. 582 ft)	
Wall 1 - STA 2+50.gsz	
12/14/2021	1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+50
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 13 ft

Analysis Type: Seismic (kh = 0.119)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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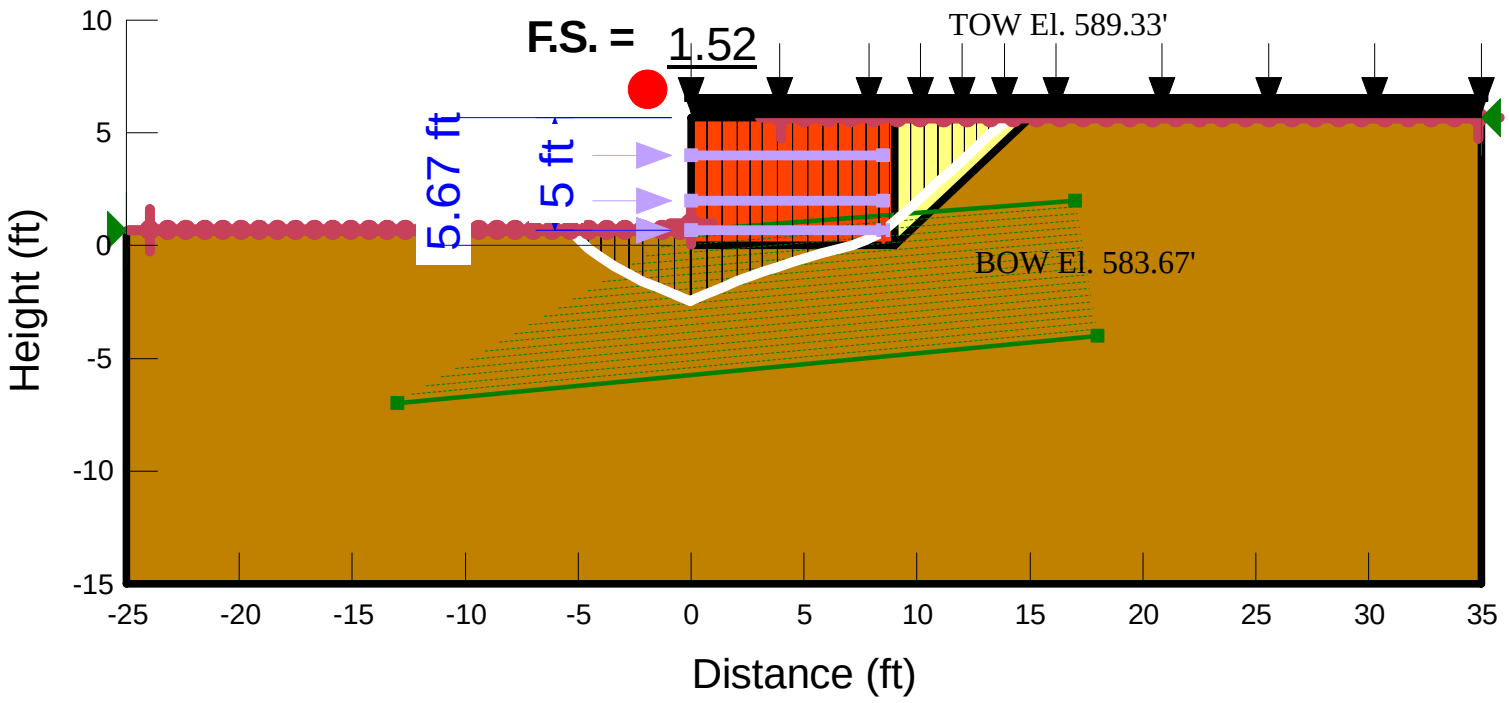
Seismic (kh = 0.119)
Wall 1 - STA 2+50.gsz
12/14/2021 1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 1+20 & 2+77
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 8.5 ft
Analysis Type: Static

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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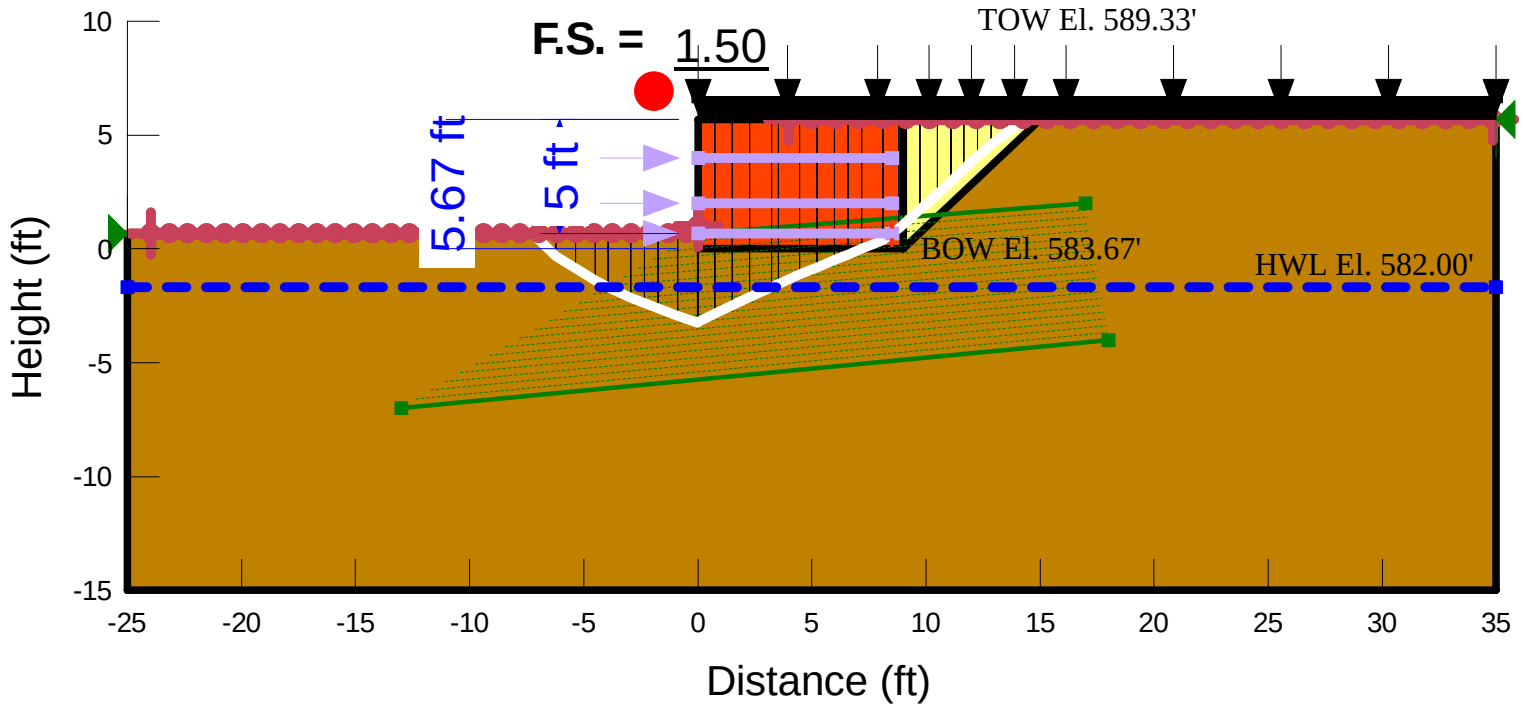
Static
Wall 1 - STA 1+20 & 2+77.gsz
12/10/2021 1:102.14624

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 2+77
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 8.5 ft
Analysis Type: 100 yr Flood Event (Elv. 582 ft)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Line
	Foundation Soil	Mohr-Coulomb	120	0	24	1
	Reinforced Soil	Mohr-Coulomb	120	0	30	1
	Retained Soil	Mohr-Coulomb	120	0	24	1

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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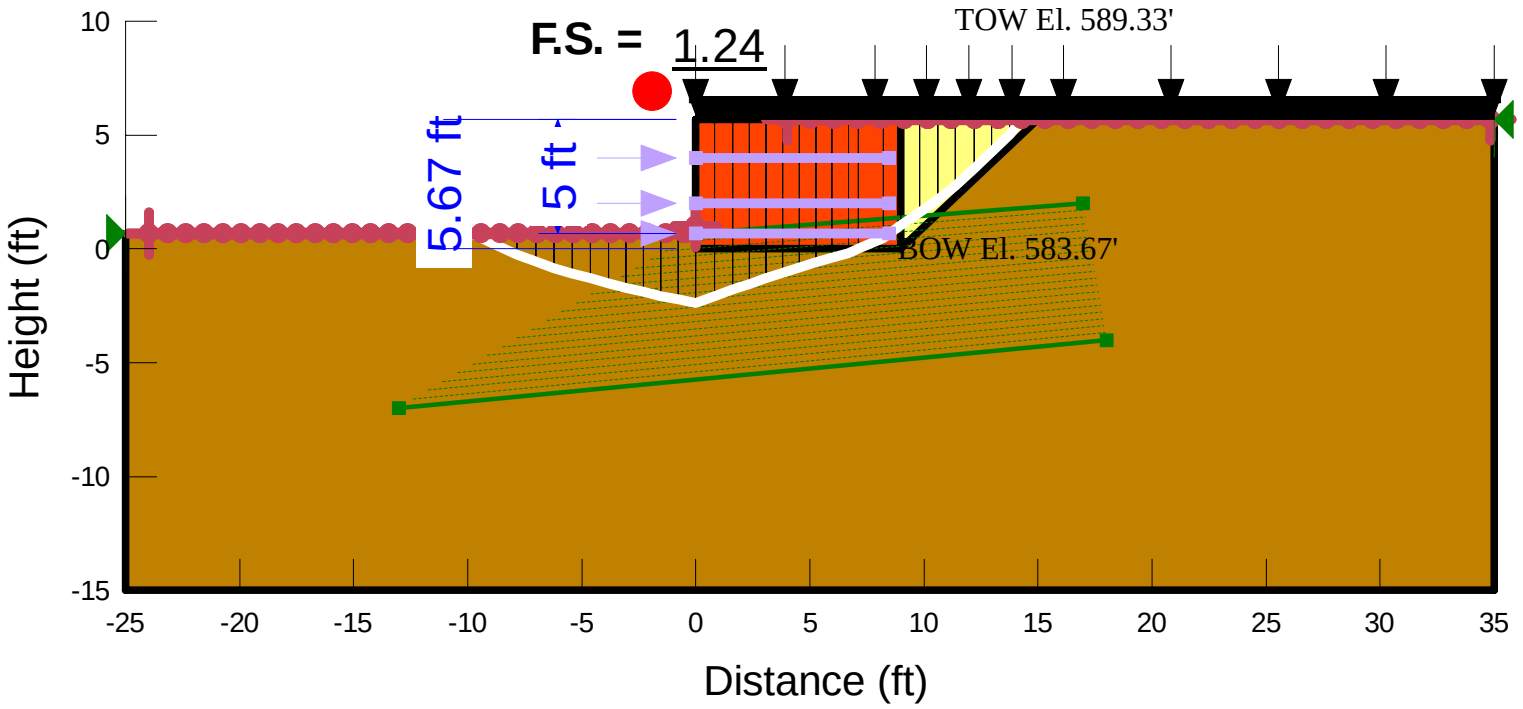
100 yr Flood Event (Elv. 582 ft)
Wall 1 - STA 2+77.gsz
12/14/2021 1:101.1448

Chick-fil-A #04723
Job No. 15215199
Client: Chick-fil-A
Designed By: AF
Checked By: TMK
Wall 1 - STA 1+20 & 2+77
Surcharge (Traffic Surcharge): 150 pcf
Geogrid Length: 8.5 ft
Analysis Type: Seismic (kh = 0.119)

Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Foundation Soil	Mohr-Coulomb	120	0	24
	Reinforced Soil	Mohr-Coulomb	120	0	30
	Retained Soil	Mohr-Coulomb	120	0	24

Color	Name	Type	Tensile Capacity (lbf)
	Miragrid 3XT	Geosynthetic	1,768



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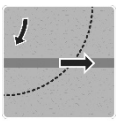
Seismic (kh = 0.119)
Wall 1 - STA 1+20 & 2+77.gsz
12/10/2021 1:101.1448

ATTACHMENT 3

Block to Block and Geogrid to Block Shear Strength Capacity Technical Data Sheets

TENCATE GEOSYNTHETICS
Americas



Miragrid® 3XT

Miragrid® 3XT geogrid is composed of high molecular weight, high tenacity polyester multifilament yarns woven in tension and finished with a PVC coating. Miragrid® 3XT geogrid is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

Miragrid® 3XT geogrid is used as soil reinforcement in MSE structures such as; segmental retaining walls, precast modular block walls, wire faced walls, geosynthetic wrapped faced walls and steepened slopes. Miragrid® 3XT is also used in MSE stabilized platforms for voids bridging, embankments on soft soils, landfill veneer stability, reducing differential settlement and for foundation seismic stability.

TenCate Geosynthetics Americas is accredited by Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP).

Mechanical Properties	Test Method	Unit	Machine Direction Value
Tensile Strength @ Ultimate (MARV[1])	ASTM D6637 (Method B)	lbs/ft (kN/m)	3500 (51.1)
Tensile Strength @ 5% strain (MARV[1])	ASTM D6637 (Method B)	lbs/ft (kN/m)	1056 (15.4)
Creep Rupture Strength[2]	ASTM D5262/D6992	lbs/ft (kN/m)	2431 (35.5)
Long Term Design Strength[3]		lbs/ft (kN/m)	2104 (30.7)

[1] Minimum Average Roll Values (MARV) shown above are based on QC Testing per a defined lot not to exceed 12 months. Testing Frequency follows ASTM D4354, Table 1.
[2] 75-year design life based on NTPEP Report REGEO-2016-01-063.
[3] Long Term Design Strength for sand, silt, clay. RF_{CR} = 1.44; RF_{ID} = 1.05; RF_{D} = 1.1
(Installation damage reduction factor for other soils available upon request).

Physical Properties	Unit	Roll Characteristic
Mass/Unit Area (ASTM D5261)	oz/yd^2 (g/m^2)	7.4 (251)
Roll Dimensions[4] (width x length)	ft (m)	6 x 300 (1.8 x 91) 12 x 150 (3.6 x 46) 12 X 1000 (3.6 x 305)
Roll Area	yd^2 (m^2)	200 (167) 200 (167) 1333 (1114)
Estimated Roll Weight	lbs (kg)	115 (52) 115 (52) 670 (304)

[4] Special order roll lengths are available upon request.

Miragrid® 3XT and Tensile Strength direction are continuously printed in white on the edge of the roll.

365 South Holland Drive
Pendergrass, GA 30567

Tel 706 693 2226
Tel 888 795 0808

Fax 706 693 4400
www.tencate.com

FGS000005
ETQR32

GAI-LAP-25-97

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

November 14, 2002

Mr. Don Armstrong
Anchor Wall Systems
5959 Baker Road, Suite 390
Minnetonka, MN 55345

Fax: 952-979-8454 E-mail: darmstrong@anchorwall.com

Subject: Test Results for Connection Block-to-Block Shear Testing of
Anchor Diamond Pro HC Blocks

Dear Don:

This report presents the final results for large-scale segmental concrete block connection shear tests. Included are data developed for a range of normal compressive loads representing increasing wall heights. All testing work was performed in general accordance with NCMA Test Method SRWU-2 for Connection Shear Strength. Generated results were used to develop general connection shear strength versus normal load design curves.

TRI is pleased to present this final report. The data presented herein appears to be consistent with commonly reported values. Please feel free to call if we can answer any questions or provide any additional information.

Sincerely,

C. Joel Sprague, P.E.
Senior Engineer
Geosynthetics Division

Cc: Mark Sebesta, James Wilson

CONNECTION SHEAR STRENGTH REPORT

ANCHOR DIAMOND PRO HC BLOCK-TO-BLOCK

Overview

The testing reported herein provides the connection shear properties between Anchor Diamond Pro HC segmental concrete block units used in construction of mechanically stabilized earth (MSE) walls. The results of a series of tests were used to define a relationship between connection shear strength and normal load, representing the height of stacked units above the connection elevation.

Terminology

Peak Connection Shear Strength - the maximum shear capacity of the connection between segmental concrete units.

Service State Connection Shear Strength - the connection shear capacity between segmental concrete units at a service state displacement criterion of 2% of the block height *or other service state criteria*.

Displacement Criteria – a user prescribed maximum horizontal movement, in (mm), of the overlying segmental concrete unit over the underlying segmental concrete unit.

Segmental Concrete Unit Width – the segmental concrete unit dimension parallel to the wall face.

Summary of Testing

Dry stacked segmental concrete block units are assembled as specified by the user. The top course of segmental concrete block units is then loaded vertically to a constant normal load and simultaneously loaded horizontally under a constant rate of displacement until a sustained loss of shear capacity and/or an excessive horizontal movement (greater than 25± mm) of the block is recorded.

Peak connection shear capacity, and shear capacity after a user prescribed displacement criteria has occurred, are used to define connection shear strength based on *peak and service state* criteria, respectively. Using horizontal block displacement measurements, both of these values have been obtained from each test. Shear loads and strengths are reported per unit width of block, lbs/ft (kN/m). A series of tests has been performed to establish a mathematical relationship between connection shear strength and normal load on the connection.

Since this connection shear strength test is meant to be a performance test, it has been conducted using full-scale system components. As a performance test on full-scale system components it accounts for some of the variabilities in construction procedures and materials tolerance normally present for these types of retaining wall systems.

Apparatus

The TRI connection shear testing apparatus' principal components include:

- loading frame
- normal load piston/actuator
- vertical loading platen with stiff rubber mat to apply uniform vertical pressure to top of concrete blocks.
- vertical load cell to measure normal load.
- loading platen capable of applying a uniform horizontal force to the test block.
- horizontal piston/actuator to apply a horizontal shearing load.
- horizontal load cell to measure block shear force.
- two (2) Linear Variable Displacement Transducers (LVDT) horizontal displacement measurement devices to record displacement of the segmental concrete block.

Concrete Units

Full-size segmental concrete units as received from the manufacturer were used. Table 1 presents information on the tested segmental concrete units.

Table 1. Segmental Concrete Units Tested

	As-Received	Specification
Segmental concrete unit style	Anchor Diamond Pro HC	Anchor Diamond Pro HC
segmental concrete units dimensions (W x D* x H)	18 in x 12 in x 8 in	18 in x 12 in x 8 in
segmental concrete unit weight with infill material	69 lb/ft	varies with infill
mechanical connectors	Rear "lip"	Rear "lip"
joint configuration	running bond	running bond

*front-to-back distance

In-fill Material

Aggregate infill material as described in Table 2 was placed within the open cell area of the blocks.

Table 2. In fill material

	As-Received	Specification
fill: number 57 stone	See Appendix	ASTM D448

Testing Outline

Three tests were conducted to adequately define a relationship between connection shear strength and normal load applied to the connection. The tests were conducted at three unique normal loads within the range of loads typical of wall design, as directed by the user. No multiple tests were performed at one normal load to verify repeatability.

The general range for repeatability of peak connection shear strength of three nominally identical tests is commonly +/- 10% from the mean of the three tests.

Specific Test Procedure

The segmental concrete units were placed such that an "as manufactured" running bond joint was coincident with the center of horizontal load application. The test setup was constructed using the granular infill, full-scale segmental concrete block units and connectors (if applicable) specified by the user.

Crushed stone granular infill conforming to size number 57 gradations in ASTM D 448 was placed and compacted within the segmental concrete units to the density specified by the user.

Underlying courses of segmental concrete units were rigidly braced to prevent lateral movement of the units during horizontal shearing of the overlying course. A loading platten was then attached to the block overlying the geosynthetic. A displacement recording device was also attached to the overlying block. This device calculates the average displacement of the block during the test.

The predetermined normal (vertical) load was applied to the top of the concrete units and maintained by measuring the normal load using a load cell and adjusting to maintain this constant value for the duration of testing. The range of normal loads chosen for testing and the equivalent stacked height of concrete units is shown in Table 3.

A constant rate of displacement of 0.03 in/min was maintained using the horizontal actuator/piston. During the entire test, normal load, tensile load, and horizontal block displacement were recorded at regular time intervals. The test was continued until there was a sustained loss of shear resistance recorded at the loading platten.

For each test, the shear load versus average block displacement recorded at the back of the top concrete unit was recorded and used to calculate *Peak Connection Shear Strength* and *Service State Connection Shear Strength*.

Results

The tests of the facing connection shear strength between the segmental concrete units detailed herein were in accordance with generally accepted testing protocol. A summary of results is presented in Table 3 and Figure 1.

Table 3. Summary of Connection Shear Test Results
Block Type: Anchor Diamond Pro HC

Test #	Normal Load (lb/ft)	Wall Height (ft)	Number of Blocks	0.16-inch Shear Capacity (lbs/ft)	Peak Shear Capacity (lbs/ft)
1	500	4.8	7.3	837	1658
2	1000	9.7	14.5	1231	2232
3	1500	14.5	21.8	1259	2661

Service State Displacement Criteria = 2% of block height = 0.16 in

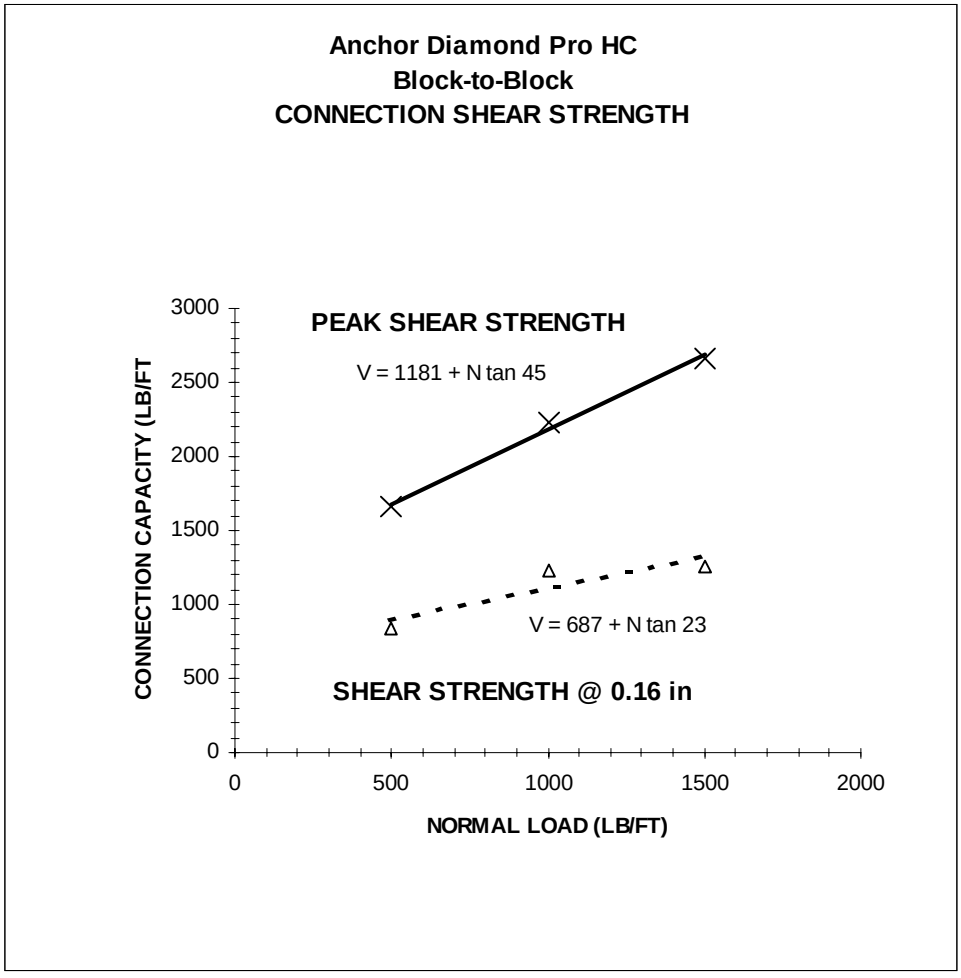


Figure 1. Connection Shear Strength Versus Normal Load

APPENDIX A – RECORDED DATA

Table A-1. Summary of Connection Shear Strength Data
Anchor Diamond Pro HC

Test #	Wall Section Width (ft)	Average Normal Load (lb/ft)	0.16-inch Shear Capacity (lbs/ft)	Peak Shear Capacity (lbs/ft)
1	1.5	500	837	1658
2	1.5	1000	1231	2232
3	1.5	1500	1259	2661

Infilled Block + Loading plate weight above shear plane = 233 lbs

Figures A-1 thru A-3. Normal Load / Shear Force vs. Shear Displacement Curves

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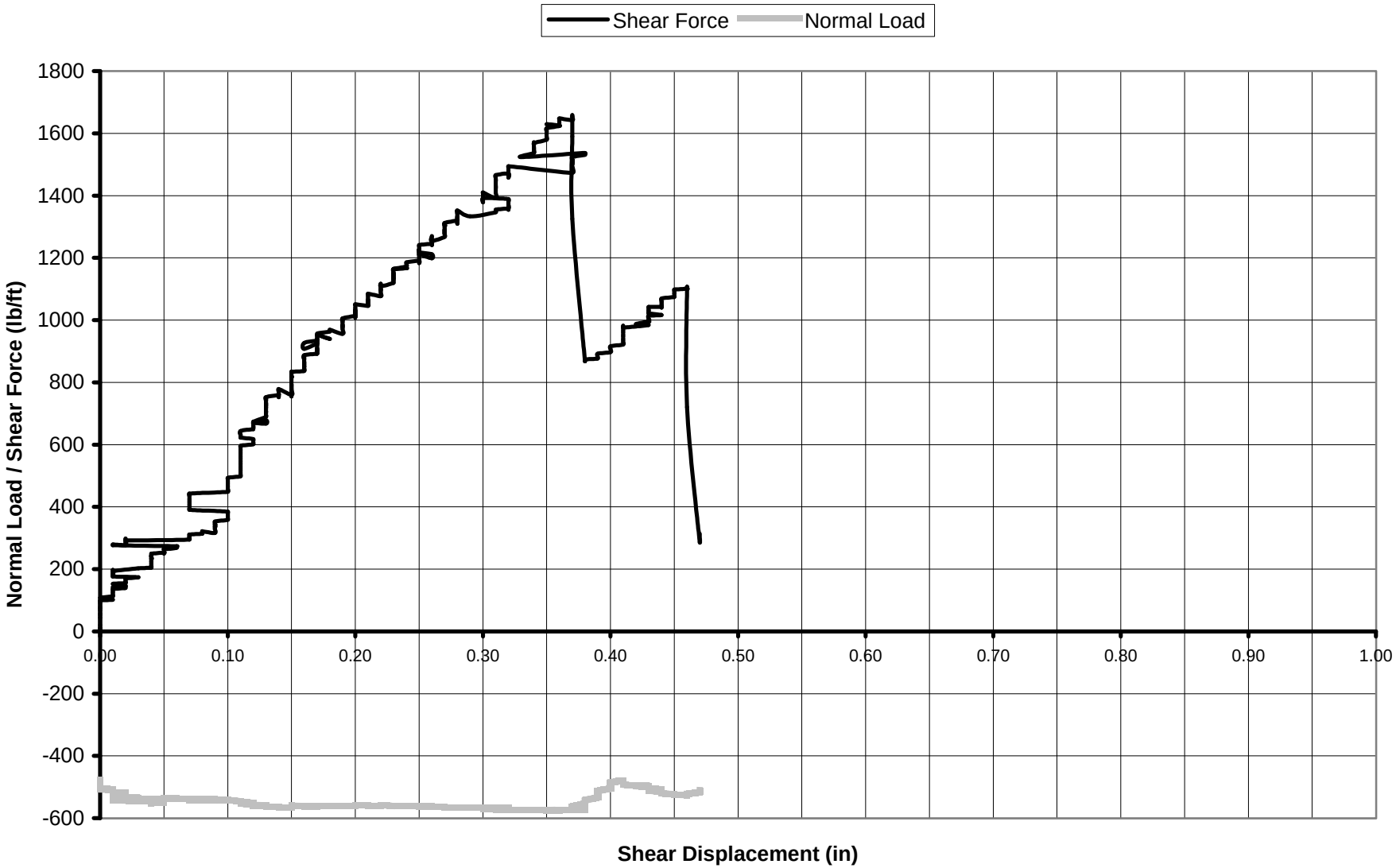
Anchor Diamond Pro Block-to-Block Shear (500 plf)



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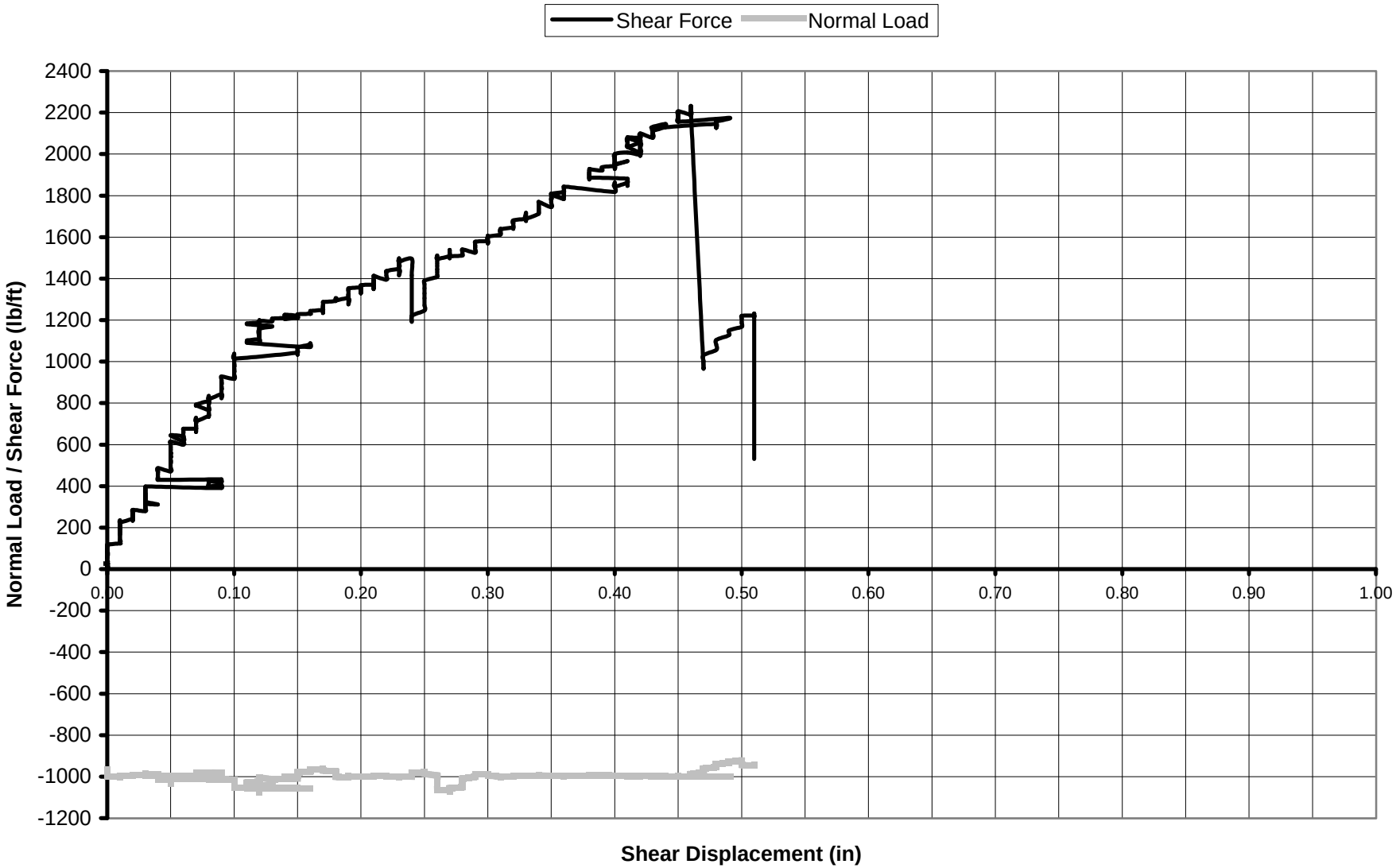

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APPENDIX B - GRANULAR INFILL

The grain size distribution curve of the granular infill placed in and between segmental concrete units is shown in Figure B-1.

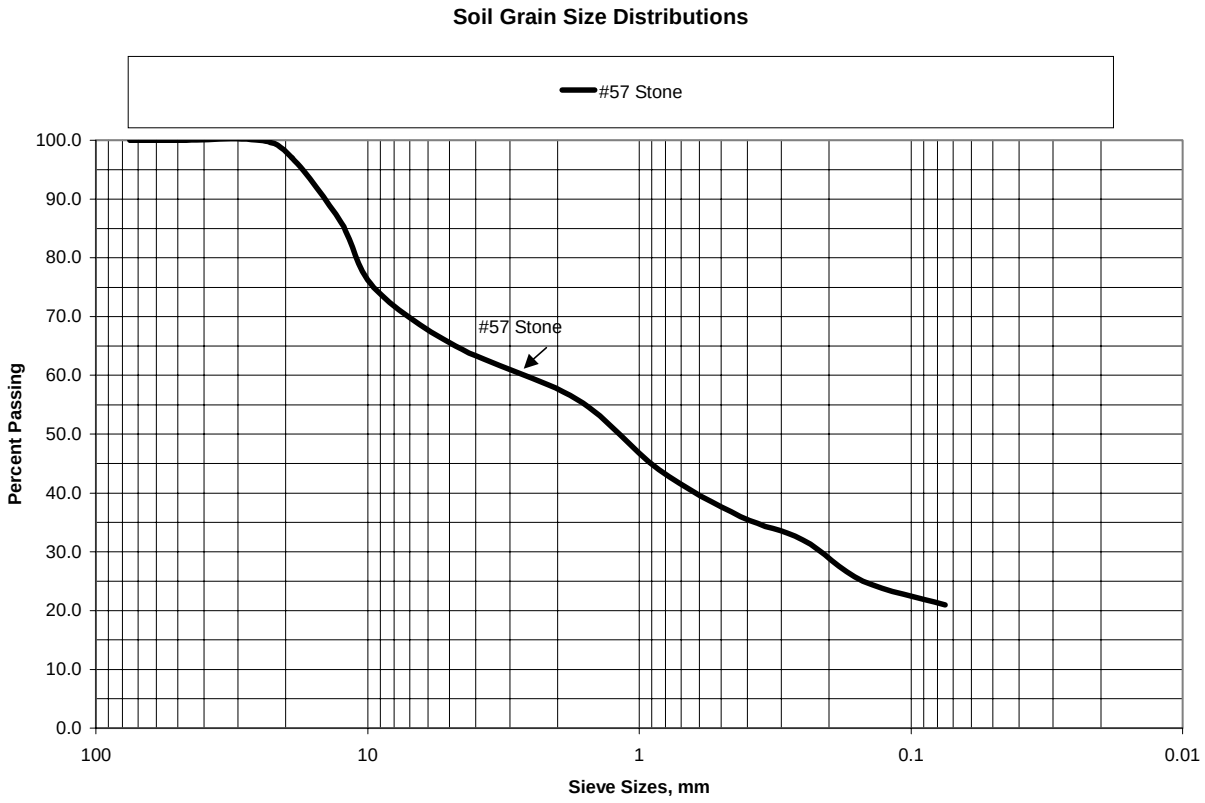

Figure B-1. Infill grain size distribution curve

Granular infill was hand tamped in-place. Density was not measured.

REPORT

RESULTS OF
DIAMOND PRO BLOCK UNITS
WITH MIRAGRID 3XT GEOGRID
CONNECTION CAPACITY TESTING

submitted to

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CONFIDENTIAL

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Introduction

This report gives the results of a connection testing program carried out to evaluate the mechanical/frictional performance of the connection between Diamond Pro® modular concrete block units and Miragrid 3XT geogrid.

The test program was initiated in response to an email authorization to proceed from Mr. John Henderson of TC Mirafi received 14 January 2010.

The tests were carried out at the laboratories of Bathurst, Clarabut Geotechnical Testing, Inc. in Kingston, Ontario, under the supervision of Mr. Peter Clarabut.

Objectives of test program

The facing-geogrid connection between Diamond Pro concrete block units and Miragrid 3XT geogrid was investigated using a large-scale connection test apparatus.

The principal objective of the testing was to evaluate the mechanical/frictional performance of these connections. A second objective was to make preliminary recommendations for the selection of long-term tensile connection capacities to be used in the design and analysis of geogrid-reinforced soil wall systems that employ Diamond Pro blocks in combination with Miragrid 3XT geogrid.

Materials

Diamond Pro blocks are hollow core concrete blocks weighing approximately 75 pounds per unit. The nominal dimensions of the block are 12 inches wide (toe to heel) by 8 inches high by 18 inches long. Construction alignment is achieved by means of a concrete lip located at the back and bottom of the block. The installation arrangement is illustrated in **Figure 1**. A photograph of Diamond Pro blocks used in this series of tests is shown in **Figure 2**. The blocks used in this series of tests were supplied by Anchor Wall Systems and designated BIC-05-018 and received at our laboratory on 1 December 2005.

Miragrid 3XT is a bi-directional geogrid composed of 100% polyester multifilament yarn with a tensile strength of 3500 lb/ft in the machine direction (based on ASTM D 6637 method of test and reported on the manufacturers' website - www.tencate.com on 26 April 2010). The geogrid specimens used in this series of testing were cut from roll/lot # 000193285/032181740 received at our laboratory on 1 December 2009.

Apparatus and general test procedure

The method of test used in this investigation follows that reported by Bathurst and Simac (1993) and recommended by the NCMA (Simac et al. 1993) and ASTM D 6638. A brief description of the apparatus and test methodology is presented here. The test apparatus used to perform the tests is illustrated in **Figure 1**. The test apparatus allows tensile loads of up to 35,000 pounds to be applied to the geogrid while it is confined between two block layers. The

facing blocks were laterally restrained and surcharged vertically. Strips of geogrid reinforcement 39 inches (1 meter) wide were attached to a roller clamp and the geogrid extended over the facing block. The next course was then placed over the geogrid simulating the technique that would be used in the field. The hollow portions of each block and spaces between blocks were infilled with a 3/4 inch, 100% crushed limestone aggregate and lightly compacted. **Figure 3** illustrates the particle size distribution of the infill used in this test series. Two wire-line LVDT(s) were connected to the geogrid to measure geogrid displacement at the back of the blocks. Wall heights were simulated by placing one block course over the interface and applying an additional surcharge load using the vertically-oriented hydraulic jack shown in **Figure 1**. A gum rubber mat was placed over the top layer of blocks to ensure a uniform distribution of vertical surcharge pressure. The connection force was applied at a constant rate of displacement (i.e. 0.75 inches/minute) using a computer-controlled hydraulic actuator. The load and displacements measured by the actuator and the LVDT(s) were recorded continuously during the test by a microcomputer/data acquisition system. All blocks used in the tests were visually inspected to confirm that they were free of defects. Each test was continued until there was a sustained loss in connection strength due to longitudinal member failure of the geogrid. Following each test, the blocks were removed and the geogrid examined to confirm failure modes. A virgin specimen of geogrid was used for each test.

The only variable in this series of connection tests was the magnitude of surcharge load.

Connection test results for the Diamond Pro and Miragrid 3XT combination

The surcharge loads used in the test program are given in **Table 1**. Also tabulated are the failure loads observed for each test. A summary of tensile loads at peak capacity and after 3/4 inch displacement is given in **Figure 4**.

The peak connection strength between Diamond Pro units and Miragrid 3XT for walls between 2.8 and 18.0 feet in height ranged between 32 and 60% of the index tensile strength of 3500 lb/ft in the machine direction (based on ASTM D 6637 method of test and reported on the manufacturers' website - www.tencate.com on 26 April 2010).

Two repeat tests were performed and the results in **Figure 4** illustrate that there is some variability in connection capacity between nominal identical tests. This variability is less than ± 10% of the mean peak load criterion required by the NCMA (e.g. maximum variability is less than 2.9%) and is likely the result of small differences in the setting up of the blocks, placement and compaction of the granular infill, and laying out of the geogrid reinforcement. The trends in data for connection capacities at 3/4 inches of displacement and peak connection capacity have been plotted using bi-linear curves.

The reduced connection capacity at lower surcharge loads in all tests may be due to the combined effect of lower surcharge pressure and more grid slippage. All tests ended in geogrid rupture after large deformation. There was also evidence of slippage of the geogrid within the concrete block-geogrid interface in all tests. Geogrid straining and slippage caused abrasion of

longitudinal members as the geogrid was pulled across the concrete surfaces. The amount of slippage was seen to diminish with an increase in wall height.

Implications to Diamond Pro block design and construction with Miragrid 3XT geogrid

The long-term design connection strength in the field must be less than the peak capacity envelope determined in each test series for the same method and quality of construction. The NCMA Segmental Retaining Wall Design Manual (First Edition, 1993) recommends that the design connection capacity at a given surcharge load for a critical wall structure be the lesser of the peak capacity divided by a minimum factor of safety (not less than 1.5) or the capacity based on a 3/4 inch displacement criterion. The *design* curve in **Figure 5** for Miragrid 3XT in combination with Diamond Pro blocks is controlled by both the 3/4 inch displacement and the peak connection capacity criteria.

The design capacity envelope illustrated in **Figure 5** should be used with caution. The actual design capacity envelope should be lower if the quality of construction in the field is less than that adopted in this controlled laboratory investigation and/or lower quality concrete is used in the manufacture of the blocks. For example, the interface concrete surfaces should be free of debris before placement of geogrid and blocks in order to minimize abrasion to the geogrid and to maximize the frictional resistance that is developed at the concrete block-geogrid interface.

It is very important that production blocks have uniform dimensions so that there is no stepping at the block joints that can lead to non-uniform frictional resistance at the block-geogrid interface, pinching of the geogrid at the block edges and possibly fracture of the concrete units.

Summary of conclusions for the Diamond Pro and Miragrid 3XT combination

A laboratory testing program was carried out to evaluate the mechanical/frictional connection performance of Diamond Pro modular block facing units in combination with Miragrid 3XT. The following conclusions can be drawn:

1. The peak connection strength between Diamond Pro units and Miragrid 3XT geogrid for walls between 2.8 and 18.0 feet in height ranged between 32 and 60% of the index tensile strength of 3500 lb/ft in the machine direction (based on ASTM D 6637 method of test and reported on the manufacturers' website - www.tencate.com on 26 April 2010).
2. The trends in data for connection capacities at 3/4 inches of displacement and peak connection capacity have been plotted using bi-linear curves.
3. Care must be taken during the installation of Diamond Pro units in order to prevent accumulation of soil and rock debris at the concrete block-geogrid interface surfaces. This debris may significantly reduce the capacity of the Diamond Pro facing unit-geogrid system.
4. The design envelope in **Figure 5** is based on an interpretation of test data as recommended in the NCMA Segmental Retaining Wall Design Manual (First Edition, 1993). The choice

of design connection strengths may vary from site to site and quality of construction in the field may require lower design values than those taken from **Figure 5**.

P. Clarabut

R. J. Bathurst, Ph.D., P. Eng.

REFERENCES

ASTM D 6638-01. Standard Test Method for Determining Connection Strength between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks), American Society for Testing and Materials, West Conshohocken, PA 19428-2958 USA.

Bathurst, R.J. and Simac, M.R., 1993. Laboratory Testing of Modular Unit/Geogrid Facing Connections, *ASTM Symposium on Geosynthetic Soil Reinforcement Testing Procedures*, San Antonio, 19 January 1993.

Simac, M.R., Bathurst, R.J., Berg, R.R. and Lothspeich, S.E., 1993. *NCMA Segmental Retaining Wall Design Manual (First Edition),* National Concrete Masonry Association, 2302 Horse Pen Road, Herndon, VA 22071-3406.

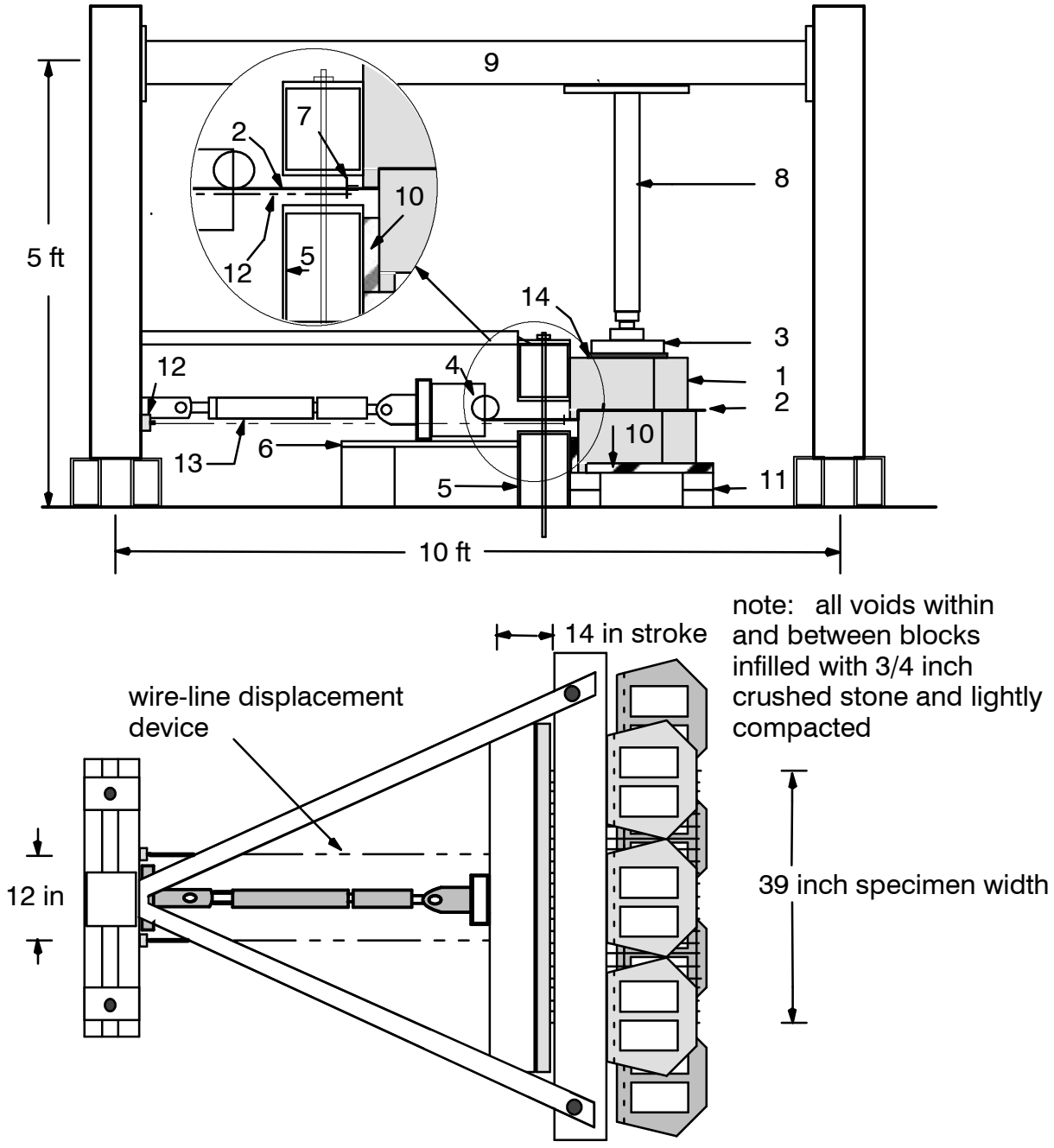
Table 1

Test Program:
Diamond Pro modular block unit combination - Miragrid 3XT geogrid connection

Test number	normal load (lb/ft)	approximate wall height (feet)	approximate number of blocks	tensile capacity (lb/ft) at 3/4 inch displacement	peak tensile capacity (lb/ft)
1	993	8.2	12.3	1053	1782
2	339	2.8	4.2	682	1108
3	663	5.5	8.2	931	1445
4	1000	8.2	12.4	1113	1699
5	1323	10.9	16.3	1241	1789
6	1640	13.5	20.3	1364	1968
7	993	8.2	12.3	1058	1713
8	2183	18.0	27.0	1540	2085

LEGEND

1	Diamond Pro	6	guide rail	11	platform
2	Miragrid 3XT	7	LVDT clamp	12	wire-line LVDT
3	loading platen	8	surcharge actuator	13	computer controlled hydraulic actuator
4	roller clamp	9	loading frame		
5	lateral restraining system	10	spacers	14	gum rubber mat



note: all voids within and between blocks infilled with 3/4 inch crushed stone and lightly compacted

Figure 1: Schematic of connection test apparatus showing Diamond Pro block units and Miragrid 3XT geogrid

Figure 2: Photograph of Diamond Pro block units in the connection test apparatus

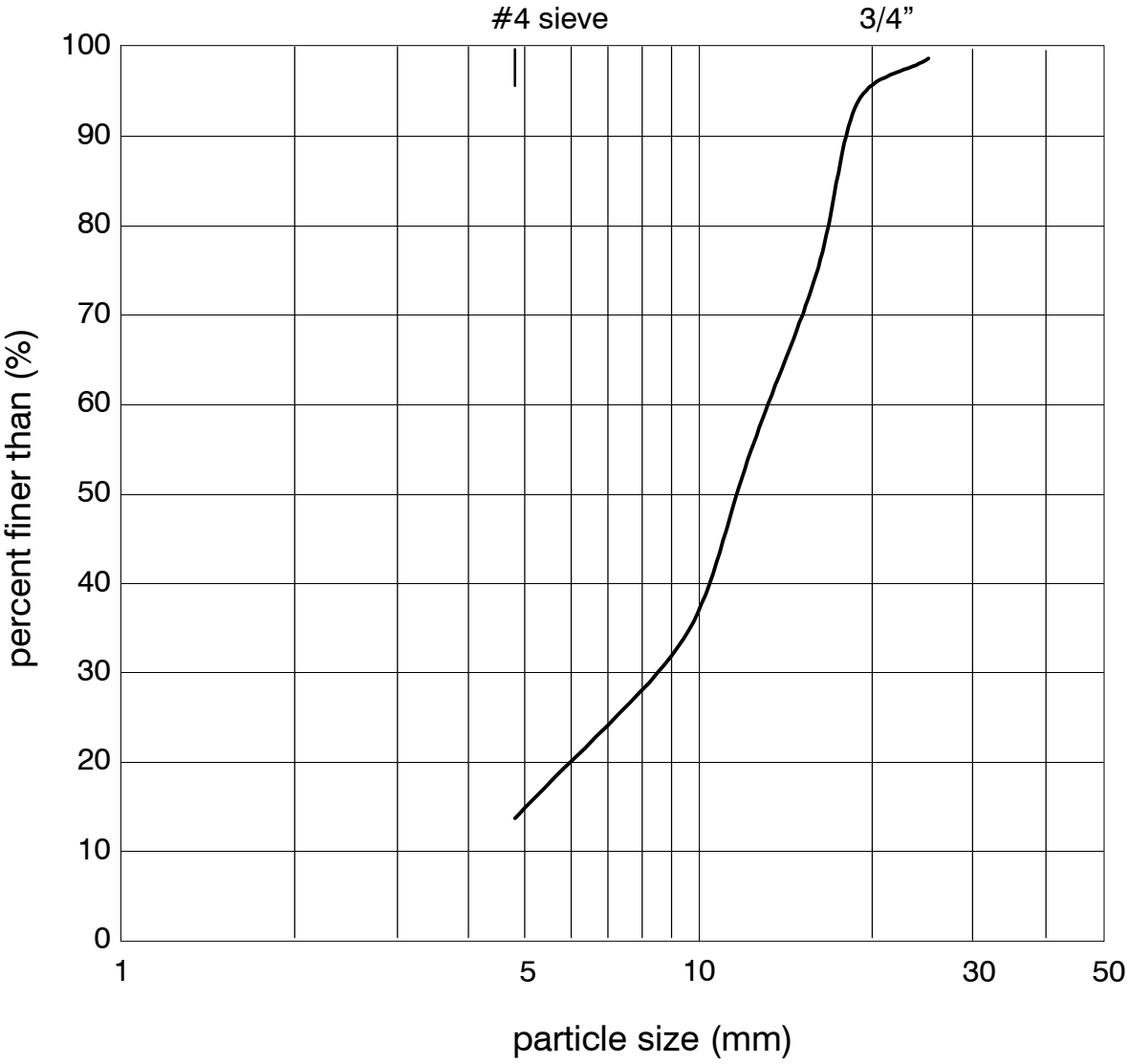


Figure 3: Particle size distribution for 100% crushed granular stone used in Diamond Pro block connection capacity tests

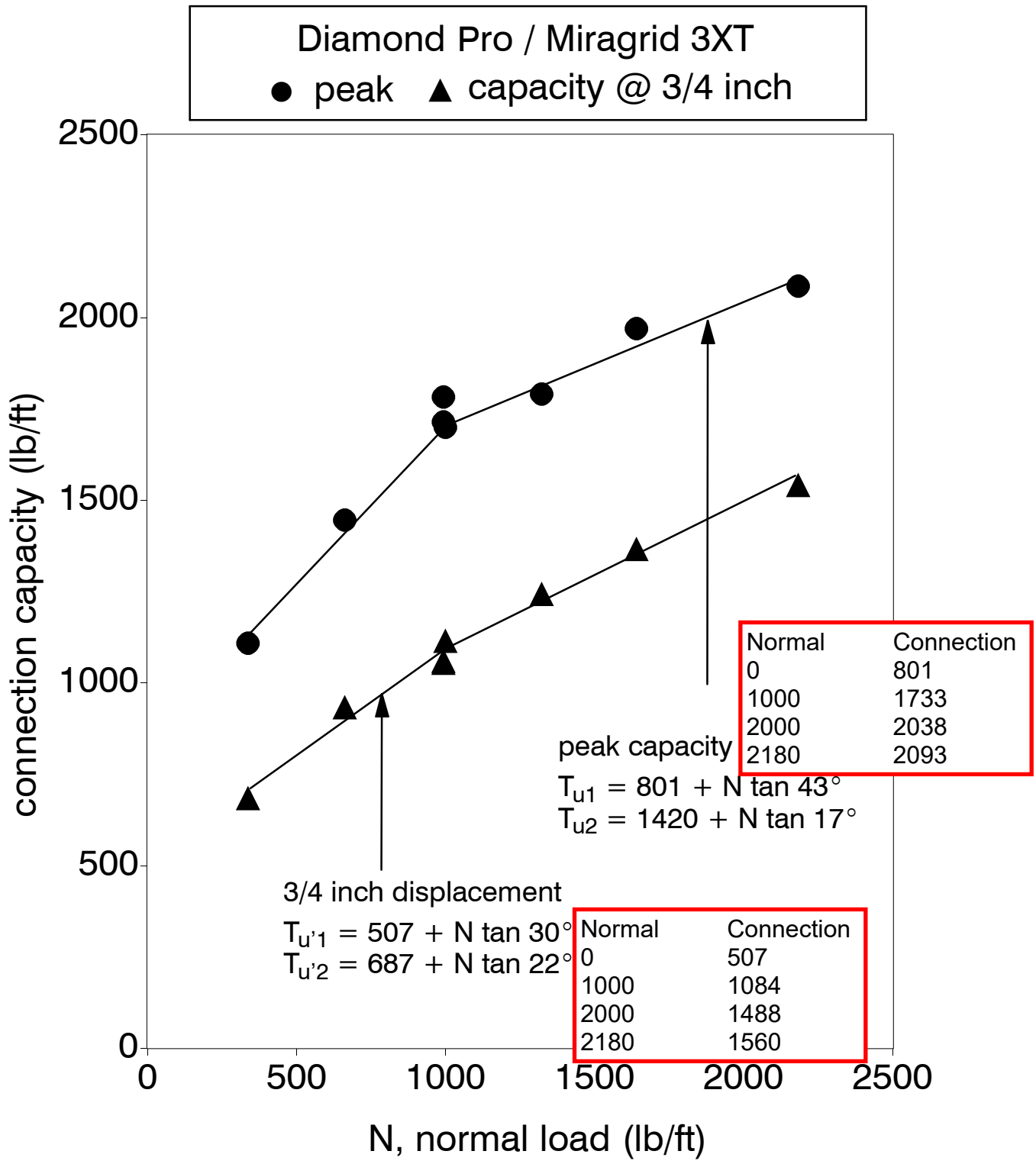


Figure 4: Summary of connection capacities for Diamond Pro block units and Miragrid 3XT geogrid

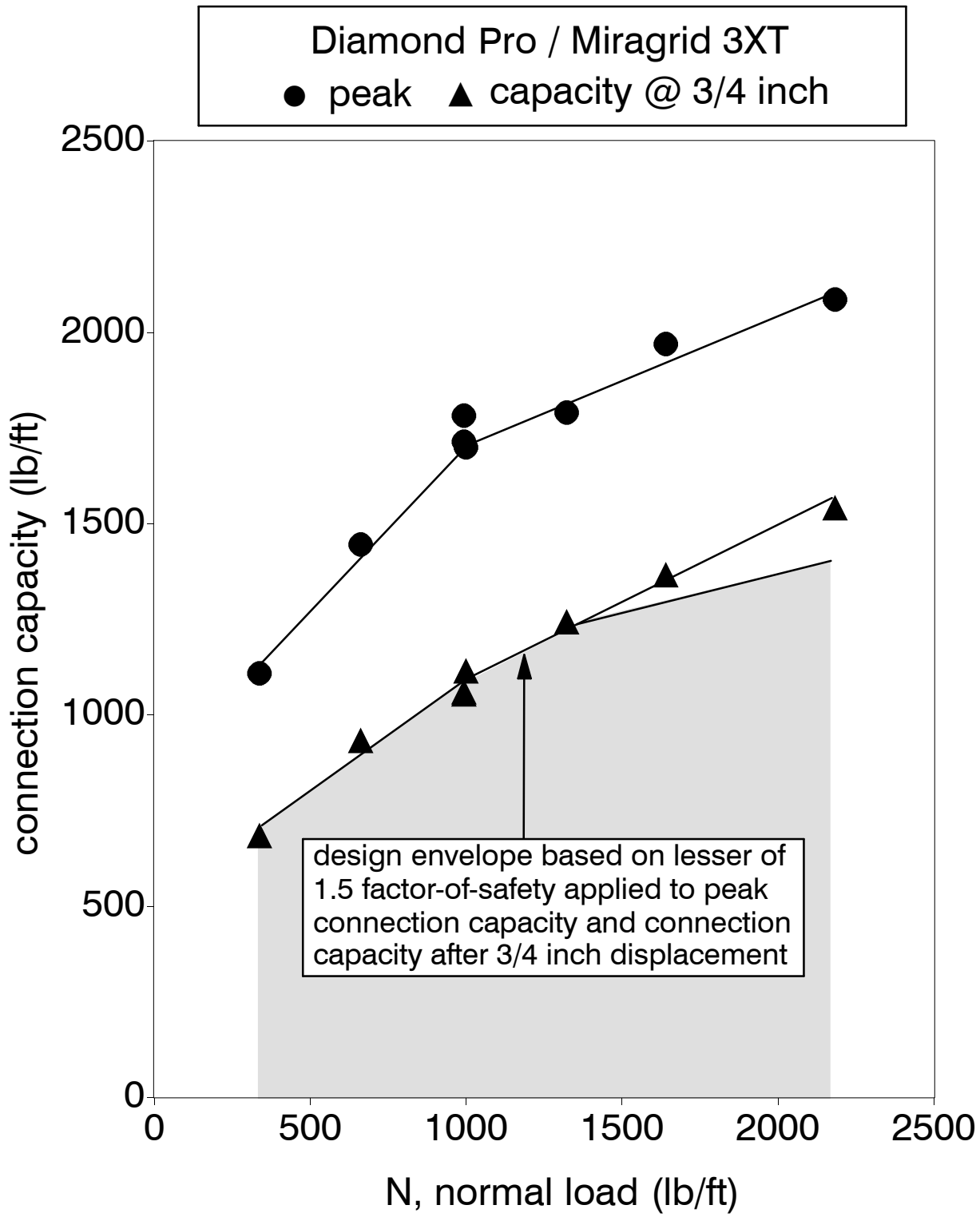


Figure 5: Preliminary design capacity envelope for Diamond Pro block units and Miragrid 3XT geogrid