



GeoConcepts, Inc.
Geology • Geotechnical Engineering

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November 5, 2010

Project 1680

Whole Foods
c/o Goldman Firth Rossi Architects
24955 Pacific Coast Highway
Malibu, California 90265

Subject: **SUPPLEMENTAL REPORT No. 3**
23401 Civic Center Way,
Malibu, California

References:

- 1) Geotechnical Review Sheet by Fugro West, Inc. for the City of Malibu, dated October 19, 2010.
- 2) Report of Geotechnical Investigation by Van Beveren & Butelo, Inc. covering the subject site and dated August 7, 2007.
- 3) Supplemental Report No. 1 by GeoConcepts, Inc. covering the subject site and dated March 30, 2010 (revised April 22, 2010).
- 4) Supplemental Report No. 2 by GeoConcepts, Inc. covering the subject site and dated September 27, 2010 (revised October 5, 2010).

Dear Gentlemen,

Pursuant to your request, presented herein is a response to Reference 1. A copy of the review letter is attached. Items contained in the review letter are responded to below. To facilitate the review, the following responses are provided per the review letter:

Review Comments:

Item #1: Previous seismic trenching performed on the site is depicted on the attached geologic map. On site seismic trenching is extremely limited by the very shallow depth to groundwater and the very young sediment above the groundwater. However, it is believed that adequate seismic trenching covers the proposed development for the following reasons; According to the Leighton and Associates, Inc. report dated March 18, 1994 covering the Malibu Civic Center area, "No evidence of active faulting was found." According to the report by the California Division of Mine and Geology Fault Evaluation Report FER-229 dated October 3, 1994 of the Malibu Coast Fault, "There is no known evidence of Holocene displacement on the main trace of the Malibu Coast fault."

On August 16, 2007, the fault zone near the east side of Malibu Bluff Park was removed from the State of California Earthquake Fault Zone map by the California Geologic Survey. Clearly, the State of California and private consultants agree that no evidence of active faulting on the Malibu Coast fault within the Malibu Civic area is known. Because these very extensive investigation on the Malibu Coast Fault concluded that the Malibu Coast is inactive in the Malibu Civic Area, adequate seismic trenching covers the proposed development.

Item #2: The design of the irrigation is being provided by others. It is our understanding that the proposed daily irrigation of the proposed landscaping will not significantly affect the groundwater levels. Therefore, no additional analysis is required at this time. If it is determined that the groundwater levels will significantly rise additional analysis should be performed.

Although, no significant rise in the groundwater level is projected at the subject site, additional liquefaction analysis has been performed based on the site being elevated from the existing grade up to about four (4) feet from the current grade and a rise in the groundwater level to the existing ground surface. The analysis was performed utilizing the data from the liquefaction analysis within Reference No. 2 above.

Exploration	Van-Beveren Existing Conditions Liquefaction Induced Settlement (in)	Liquefaction Induced Settlement (in) with Grade Raised 4 Feet	Liquefaction Induced Settlement (in) with Grade Raised 4 Feet and Groundwater Level Raised to Existing Surface
CPT-1	4	2.03	2.26
CPT-2	4	3.78	3.95
CPT-3	3	1.63	2.18
CPT-4	4	4.68	4.82
Boring 1	1.75	0.75	0.85
Boring 2	1.5	0.46	0.49
Boring 3	2.75	1.85	2.02
Boring 4	4	2.2	2.41
Average	3.13	2.17	2.37

Based on the additional liquefaction analysis the recommendations provided within References No. 2-4 remain applicable.

Building Plan Check Stage Review Comments:

Item #1-5: Acknowledged.

Should you have any questions regarding this report, please do not hesitate to contact the undersigned at your convenience.

Respectfully submitted,
GeoConcepts, Inc.

Scott J. Walter
GE 2476
Exp: 9/30/12
RLS/SJW/RMH: 1680-9

Robert L. Sousa
CEG 1315
Exp: 5/31/11

Enclosures: Liquefaction Analysis
 Revised Geologic Map
 Revised Cross Sections A & B
 Review Letter by the City of Malibu

Distribution: (4) Addressee
 (2) City of Malibu

0.00	2.00	0.44	5.00	2.02	0.01	2.03
5.00	2.08	0.43	4.79	2.02	0.00	2.02
10.00	0.54	0.52	1.05	1.83	0.00	1.83
15.00	1.64	0.57	2.89	1.62	0.00	1.62
20.00	2.08	0.60	3.47	1.62	0.00	1.62
25.00	0.12	0.62	0.19*	1.31	0.00	1.31
30.00	0.45	0.63	0.71*	1.24	0.00	1.24
35.00	0.35	0.62	0.57*	0.71	0.00	0.71
40.00	1.47	0.60	2.44	0.27	0.00	0.27
45.00	2.07	0.58	3.54	0.27	0.00	0.27

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft2)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 CPT1A VB.liq
 Title: Whole Foods VBB CPT-1A
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=CPT1A
 Depth of Hole=49.50 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 7.60 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf %	Gamma pcf	Fines %	D50 mm
0.00	56.64	0.45	0.80	130.00	0.00	0.50
5.50	100.00	0.63	0.63	130.00	0.00	0.50
10.50	68.10	0.77	1.13	130.00	0.00	0.50
15.50	150.90	2.27	1.50	130.00	0.00	0.50
20.50	238.50	1.93	0.81	130.00	0.00	0.50
25.50	8.75	0.24	2.77	130.00	0.00	0.50
30.50	42.96	1.12	2.60	130.00	0.00	0.50
35.50	135.00	1.08	0.80	130.00	0.00	0.50
40.50	297.80	3.00	1.01	130.00	0.00	0.50
45.50	281.30	2.18	0.77	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fsl	=CSRfs
0.00	130.00	0.236	130.00	0.236	1.00	0.000	0.450	0.29	1.50	0.44
5.00	130.00	0.543	67.60	0.543	0.99	0.000	0.450	0.29	1.50	0.43
10.00	130.00	0.851	67.60	0.703	0.98	0.000	0.450	0.35	1.50	0.52
15.00	130.00	1.158	67.60	0.863	0.97	0.000	0.450	0.38	1.50	0.57
20.00	130.00	1.465	67.60	1.023	0.95	0.000	0.450	0.40	1.50	0.60
25.00	130.00	1.772	67.60	1.182	0.94	0.000	0.450	0.41	1.50	0.62
30.00	130.00	2.079	67.60	1.342	0.93	0.000	0.450	0.42	1.50	0.63
35.00	130.00	2.386	67.60	1.502	0.89	0.000	0.450	0.41	1.50	0.62

40.00	130.00	2.694	67.60	1.661	0.85	0.000	0.450	0.40	1.50	0.60
45.00	130.00	3.001	67.60	1.821	0.81	0.000	0.450	0.39	1.50	0.58

CSR is based on water table at 5.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from CPT data, using Modify Robertson's Method:
(Fines content is determined by qc and fric.)

Depth ft	qc atm	fric. atm	n	Q	Rf	Ic %	Cq	Fines atm	Kc atm	qc1n	qc1f	CRR7.5
0.00		1.00	1.13E7	0.80	3.76							
0.00	113.28	0.90	1.13E7	0.80	3.76	1.00	NoLiq	1.00	113.28	113.28	2.08	
5.00		1.00	5.51E2	0.69	1.28							
5.00		0.50	3.06E2	0.69	1.44							
5.00	169.67	1.16	3.06E2	0.69	1.44	1.80	2.07	0.00	306.13	306.13	2.08	
10.00		1.00	2.15E2	1.05	1.68							
10.00		0.50	1.59E2	1.05	1.77							
10.00	117.31	1.22	0.50	1.59E2	1.05	1.77	1.36	7.58	0.07	159.11	170.88	0.54
15.00		1.00	2.90E2	1.35	1.69							
15.00		0.50	2.44E2	1.35	1.73							
15.00	204.94	2.76	0.50	2.44E2	1.35	1.73	1.19	6.71	0.05	244.37	256.07	1.64
20.00		1.00	3.42E2	0.73	1.43							
20.00		0.50	3.19E2	0.73	1.45							
20.00	296.35	2.16	0.50	3.19E2	0.73	1.45	1.08	2.19	0.00	319.00	319.00	2.08
25.00		1.00	3.03E1	1.41	2.41							
25.00		0.50	3.21E1	1.41	2.39							
25.00	32.51	0.44	0.50	3.21E1	1.41	2.39	0.99	26.15	0.56	32.14	73.82	0.12
30.00		1.00	3.47E1	3.26	2.59							
30.00		0.50	3.95E1	3.26	2.55							
30.00	42.91	1.34	0.50	3.95E1	3.26	2.55	0.92	33.10	0.75	39.46	158.03	0.45
35.00		1.00	1.14E2	0.85	1.82							
35.00		0.50	1.34E2	0.85	1.77							
35.00	155.18	1.31	0.50	1.34E2	0.85	1.77	0.86	7.47	0.07	133.94	143.39	0.35
40.00		1.00	1.99E2	0.90	1.66							
40.00		0.50	2.46E2	0.90	1.59							
40.00	301.92	2.68	0.50	2.46E2	0.90	1.59	0.82	4.25	0.00	246.36	246.36	1.47
45.00		1.00	2.51E2	0.90	1.59							
45.00		0.50	3.25E2	0.90	1.52							
45.00	419.55	3.77	0.50	3.25E2	0.90	1.52	0.78	3.07	0.00	325.48	325.48	2.08

Fines have been calculated, and correction is made by Modify Robertson Method.
Fines=NoLiq means the soils are not liquefiable.

CRR is based on water table at 7.60 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.08	1.00	2.08	1.00	2.00	0.44	5.00 ^
5.00	0.20	2.08	1.00	2.08	1.00	2.08	0.43	4.79
10.00	0.35	0.54	1.00	0.54	1.00	0.54	0.52	1.05
15.00	0.46	1.64	1.00	1.64	1.00	1.64	0.57	2.89
20.00	0.56	2.08	1.00	2.08	1.00	2.08	0.60	3.47
25.00	0.66	0.12	1.00	0.12	1.00	0.12	0.62	0.19 *
30.00	0.77	0.45	1.00	0.45	1.00	0.45	0.63	0.71 *
35.00	0.87	0.35	1.00	0.35	1.00	0.35	0.62	0.57 *
40.00	0.98	1.47	1.00	1.47	1.00	1.47	0.60	2.44
45.00	1.08	2.08	0.99	2.07	1.00	2.07	0.58	3.54

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)

^ No-liquefiable Soils or above Water Table.

(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	3.76	1.56	113.28	72.58	NoLiq	0.00	72.58
5.00	1.44	5.83	306.13	52.49	2.07	0.00	52.49
10.00	1.77	5.22	170.88	32.73	7.58	0.00	32.73

15.00	1.73	5.30	256.07	48.30	6.71	0.00	48.30
20.00	1.45	5.82	319.00	54.85	2.19	0.00	54.85
25.00	2.39	4.08	73.82	18.11	26.15	0.00	18.11
30.00	2.55	3.78	158.03	41.78	33.10	0.00	41.78
35.00	1.77	5.23	143.39	27.41	7.47	0.00	27.41
40.00	1.59	5.56	246.36	44.34	4.25	0.00	44.34
45.00	1.52	5.70	325.48	57.12	3.07	0.00	57.12

(Nl)60s has been fines corrected in liquefaction analysis, therefore d(Nl)60=0.
(Nl)60 is converted from qc1, (Nl)60s is after fines correction
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRs _f / MSF*	=CSR _m	F.S. %	Fines %	(Nl)60s %	Dr %	ec in.	dsz in.	dsp in.	S	
49.45	0.56	1.00	0.56	3.61	0.06	65.86	100.00	0.000	0.0E0	0.000	0.000
45.00	0.58	1.00	0.58	3.54	3.07	57.12	100.00	0.000	0.0E0	0.270	0.270
40.00	0.60	1.00	0.60	2.44	4.25	44.34	100.00	0.000	0.0E0	0.000	0.270
35.00	0.62	1.00	0.62	0.57	7.47	27.41	84.49	1.454	8.7E-3	0.435	0.705
30.00	0.63	1.00	0.63	0.71	33.10	41.78	100.00	0.000	0.0E0	0.536	1.241
25.00	0.62	1.00	0.62	0.19	26.15	18.11	67.11	2.372	1.4E-2	0.064	1.305
20.00	0.60	1.00	0.60	3.47	2.19	54.85	100.00	0.000	0.0E0	0.311	1.616
15.00	0.57	1.00	0.57	2.89	6.71	48.30	100.00	0.000	0.0E0	0.000	1.616
10.00	0.52	1.00	0.52	1.05	7.58	32.73	96.57	0.136	8.2E-4	0.217	1.833
5.00	0.43	1.00	0.43	4.79	2.07	52.49	100.00	0.000	0.0E0	0.192	2.025

Settlement of Saturated Sands=2.025 in.

qc1 and (Nl)60 is after fines correction in liquefaction analysis

(Nl)60s is converted from qc1 and after fines correction

dsz is per each segment, dz=0.05 ft

dsp is per each print interval, dp=5.00 ft

S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(Nl)60s	CSRs _f	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
4.95	0.30	0.20	52.78	0.43	744.81	1.8E-4	0.0332	0.0105	1.06	0.0111	1.33E-4	0.000	
0.000													
0.00	0.00	0.00	72.58	0.44	4.75	9.2E-7	0.0010	0.0003	1.06	0.0003	0.00E0	0.008	
0.008													

Settlement of Unsaturated Sands=0.008 in.

(Nl)60s is converted from qc1 and after fines correction

dsz is per each segment, dz=0.05 ft

dsp is per each print interval, dp=5.00 ft

S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=2.033 in.

Differential Settlement=1.017 to 1.342 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft² = 2 kip/ft²)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m² = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]

sigC' Effective confining pressure [atm]
rd Acceleration reduction coefficient by Seed
a_max. Peak Ground Acceleration (PGA) in ground surface
mZ Linear acceleration reduction coefficient X depth
a_min. Minimum acceleration under linear reduction, mZ
CRRv CRR after overburden stress correction, $CRRv=CRR7.5 * Ksig$
CRR7.5 Cyclic resistance ratio (M=7.5)
Ksig Overburden stress correction factor for CRR7.5
CRRm After magnitude scaling correction $CRRm=CRRv * MSF$
MSF Magnitude scaling factor from M=7.5 to user input M
CSR Cyclic stress ratio induced by earthquake
CSRfs $CSRfs=CSR*fs1$ (Default $fs1=1$)
fs1 First CSR curve in graphic defined in #9 of Advanced page
fs2 2nd CSR curve in graphic defined in #9 of Advanced page
F.S. Calculated factor of safety against liquefaction $F.S.=CRRm/CSRsf$
Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr Rod Length Corrections
Cn Overburden Pressure Correction
(N1)60 SPT after corrections, $(N1)60=SPT * Cr * Cn * Cebs$
d(N1)60 Fines correction of SPT
(N1)60f $(N1)60f=(N1)60 + d(N1)60$
Cq Overburden stress correction factor
qc1 CPT after Overburden stress correction
dqcl Fines correction of CPT
qclf CPT after Fines and Overburden correction, $qclf=qc1 + dqcl$
qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qclf CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s $(N1)60$ after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation $CSRm=CSRsf / MSF*$
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, $MSF*=1$, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, $dz=0.050$ ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff γ_{eff} , Effective shear Strain
g*Ge/Gm $\gamma_{eff} * G_{eff}/G_{max}$, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, $ec=Cec * ec7.5$
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

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LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 CPT2 VB.liq
Title: Whole Foods VBB CPT-2
Subtitle:

Surface Elev.=0
Hole No.=CPT-2
Depth of Hole= 70.50 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 9.30 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=CPT-2
Depth of Hole=70.50 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 9.30 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot one CSR curve (fsl=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf pcf	gamma %	Fines mm	D50
0.00	4.72	0.09	2.01	130.00	0.00	0.50
5.50	71.32	0.57	0.79	130.00	0.00	0.50
10.50	343.30	6.84	1.99	130.00	0.00	0.50
15.50	222.40	1.56	0.70	130.00	0.00	0.50
20.50	11.30	0.39	3.42	130.00	0.00	0.50
25.50	8.30	0.26	3.08	130.00	0.00	0.50
30.50	173.30	1.16	0.67	130.00	0.00	0.50
35.50	103.80	0.54	0.52	130.00	0.00	0.50
40.50	31.30	0.81	2.58	130.00	0.00	0.50
45.50	20.64	0.64	3.11	130.00	0.00	0.50
50.50	26.43	0.75	2.84	130.00	0.00	0.50
55.50	15.37	0.31	1.99	130.00	0.00	0.50
60.50	103.80	1.55	1.49	130.00	0.00	0.50
65.50	42.62	1.83	4.30	130.00	0.00	0.50
70.50	571.20	0.00	0.00	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=3.77 in.
Settlement of Unsaturated Sands=0.01 in.
Total Settlement of Saturated and Unsaturated Sands=3.78 in.
Differential Settlement=1.891 to 2.496 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.44	5.00	3.77	0.01	3.78
5.00	1.04	0.43	2.40	3.77	0.00	3.77
10.00	2.08	0.52	4.01	3.77	0.00	3.77
15.00	2.08	0.57	3.66	3.77	0.00	3.77
20.00	2.00	0.60	5.00	3.60	0.00	3.60
25.00	2.00	0.62	5.00	3.60	0.00	3.60
30.00	0.40	0.63	0.64*	3.00	0.00	3.00
35.00	0.21	0.62	0.34*	2.24	0.00	2.24
40.00	0.17	0.60	0.28*	1.04	0.00	1.04
45.00	2.00	0.58	5.00	0.46	0.00	0.46
50.00	2.00	0.56	5.00	0.42	0.00	0.42
55.00	2.00	0.54	5.00	0.42	0.00	0.42
60.00	0.24	0.51	0.46*	0.40	0.00	0.40
65.00	2.00	0.49	5.00	0.00	0.00	0.00
70.00	1.90	0.46	4.15	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft2)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 CPT2 VB.liq
 Title: Whole Foods VBB CPT-2
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=CPT-2
 Depth of Hole=70.50 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 9.30 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf %	Gamma pcf	Fines %	D50 mm
0.00	4.72	0.09	2.01	130.00	0.00	0.50
5.50	71.32	0.57	0.79	130.00	0.00	0.50
10.50	343.30	6.84	1.99	130.00	0.00	0.50
15.50	222.40	1.56	0.70	130.00	0.00	0.50
20.50	11.30	0.39	3.42	130.00	0.00	0.50
25.50	8.30	0.26	3.08	130.00	0.00	0.50
30.50	173.30	1.16	0.67	130.00	0.00	0.50
35.50	103.80	0.54	0.52	130.00	0.00	0.50
40.50	31.30	0.81	2.58	130.00	0.00	0.50
45.50	20.64	0.64	3.11	130.00	0.00	0.50
50.50	26.43	0.75	2.84	130.00	0.00	0.50
55.50	15.37	0.31	1.99	130.00	0.00	0.50
60.50	103.80	1.55	1.49	130.00	0.00	0.50
65.50	42.62	1.83	4.30	130.00	0.00	0.50
70.50	571.20	0.00	0.00	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fsl	=CSRfs
0.00	130.00	0.236	130.00	0.236	1.00	0.000	0.450	0.29	1.50	0.44
5.00	130.00	0.543	67.60	0.543	0.99	0.000	0.450	0.29	1.50	0.43
10.00	130.00	0.851	67.60	0.703	0.98	0.000	0.450	0.35	1.50	0.52

15.00	130.00	1.158	67.60	0.863	0.97	0.000	0.450	0.38	1.50	0.57
20.00	130.00	1.465	67.60	1.023	0.95	0.000	0.450	0.40	1.50	0.60
25.00	130.00	1.772	67.60	1.182	0.94	0.000	0.450	0.41	1.50	0.62
30.00	130.00	2.079	67.60	1.342	0.93	0.000	0.450	0.42	1.50	0.63
35.00	130.00	2.386	67.60	1.502	0.89	0.000	0.450	0.41	1.50	0.62
40.00	130.00	2.694	67.60	1.661	0.85	0.000	0.450	0.40	1.50	0.60
45.00	130.00	3.001	67.60	1.821	0.81	0.000	0.450	0.39	1.50	0.58
50.00	130.00	3.308	67.60	1.981	0.77	0.000	0.450	0.37	1.50	0.56
55.00	130.00	3.615	67.60	2.141	0.73	0.000	0.450	0.36	1.50	0.54
60.00	130.00	3.922	67.60	2.300	0.69	0.000	0.450	0.34	1.50	0.51
65.00	130.00	4.229	67.60	2.460	0.65	0.000	0.450	0.32	1.50	0.49
70.00	130.00	4.536	67.60	2.620	0.60	0.000	0.450	0.31	1.50	0.46

CSR is based on water table at 5.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from CPT data, using Modify Robertson's Method:
(Fines content is determined by qc and fric.)

Depth ft	qc atm	fric. atm	n	Q	Rf	Ic %	Cq	Fines atm	Kc atm	qc1n	qc1f	CRR7.5
0.00		1.00	9.44E5	2.01	2.93							
0.00	9.44	0.19	9.44E5	2.01	2.93	1.00	NoLiq	1.00	9.44	9.44	2.08	
5.00		1.00	3.92E2	0.91	1.47							
5.00		0.50	2.18E2	0.91	1.63							
5.00	120.77	1.09	2.18E2	0.91	1.63	1.80	4.92	0.00	217.90	217.90	1.04	
10.00		1.00	7.67E2	1.69	1.56							
10.00		0.50	5.92E2	1.69	1.61							
10.00	455.95	7.69	0.50	5.92E2	1.69	1.61	1.30	4.48	0.00	500.00	500.00	2.08
15.00		1.00	4.25E2	0.70	1.36							
15.00		0.50	3.70E2	0.70	1.40							
15.00	320.85	2.25	0.50	3.70E2	0.70	1.40	1.15	1.49	0.00	369.64	369.64	2.08
20.00		1.00	1.46E1	3.67	2.92							
20.00	14.54	0.49	1.00	1.46E1	3.67	2.92	1.00	NoLiq	1.00	14.54	14.54	2.08
25.00		1.00	8.16E0	3.92	3.14							
25.00	10.29	0.34	1.00	8.16E0	3.92	3.14	1.00	NoLiq	1.00	10.29	10.29	2.08
30.00		1.00	1.15E2	1.30	1.94							
30.00		0.50	1.29E2	1.30	1.90							
30.00	143.73	1.84	0.50	1.29E2	1.30	1.90	0.90	10.46	0.15	129.46	151.57	0.40
35.00		1.00	8.93E1	0.56	1.80							
35.00		0.50	1.07E2	0.56	1.73							
35.00	126.45	0.69	0.50	1.07E2	0.56	1.73	0.85	6.77	0.05	107.16	112.49	0.21
40.00		1.00	6.25E1	0.96	2.06							
40.00		0.50	7.99E1	0.96	1.97							
40.00	99.48	0.93	0.50	7.99E1	0.96	1.97	0.80	12.27	0.19	79.85	99.09	0.17
45.00		1.00	2.10E1	2.50	2.69							
45.00	38.78	0.90	1.00	2.10E1	2.50	2.69	1.00	NoLiq	1.00	38.78	38.78	2.08
50.00		1.00	2.18E1	2.73	2.70							
50.00	43.92	1.11	1.00	2.18E1	2.73	2.70	1.00	NoLiq	1.00	43.92	43.92	2.08
55.00		1.00	6.52E0	2.36	3.10							
55.00	16.63	0.31	1.00	6.52E0	2.36	3.10	1.00	NoLiq	1.00	16.63	16.63	2.08
60.00		1.00	3.88E1	2.51	2.48							
60.00		0.50	5.99E1	2.51	2.34							
60.00	88.68	2.13	0.50	5.99E1	2.51	2.34	0.68	24.14	0.51	59.91	122.54	0.25
65.00		1.00	1.93E1	4.39	2.87							
65.00	49.43	2.00	1.00	1.93E1	4.39	2.87	1.00	NoLiq	1.00	49.43	49.43	2.08
70.00		1.00	2.43E2	0.39	1.36							
70.00		0.50	3.88E2	0.39	1.20							
70.00	614.73	2.41	0.50	3.88E2	0.39	1.20	0.63	0.00	0.00	387.99	387.99	2.08

Fines have been calculated, and correction is made by Modify Robertson Method.
Fines=NoLiq means the soils are not liquefiable.

CRR is based on water table at 9.30 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.08	1.00	2.08	1.00	2.00	0.44	5.00 ^
5.00	0.20	1.04	1.00	1.04	1.00	1.04	0.43	2.40
10.00	0.39	2.08	1.00	2.08	1.00	2.08	0.52	4.01
15.00	0.49	2.08	1.00	2.08	1.00	2.08	0.57	3.66
20.00	0.59	2.08	1.00	2.08	1.00	2.00	0.60	5.00 ^

25.00	0.70	2.08	1.00	2.08	1.00	2.00	0.62	5.00	^
30.00	0.80	0.40	1.00	0.40	1.00	0.40	0.63	0.64	*
35.00	0.90	0.21	1.00	0.21	1.00	0.21	0.62	0.34	*
40.00	1.01	0.17	1.00	0.17	1.00	0.17	0.60	0.28	*
45.00	1.11	2.08	0.99	2.06	1.00	2.00	0.58	5.00	^
50.00	1.22	2.08	0.97	2.02	1.00	2.00	0.56	5.00	^
55.00	1.32	2.08	0.96	1.99	1.00	2.00	0.54	5.00	^
60.00	1.42	0.25	0.94	0.24	1.00	0.24	0.51	0.46	*
65.00	1.53	2.08	0.93	1.93	1.00	2.00	0.49	5.00	^
70.00	1.63	2.08	0.92	1.90	1.00	1.90	0.46	4.15	

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	2.93	3.08	9.44	3.06	NoLiq	0.00	3.06
5.00	1.63	5.48	217.90	39.75	4.92	0.00	39.75
10.00	1.61	5.53	500.00	90.41	4.48	0.00	90.41
15.00	1.40	5.92	369.64	62.46	1.49	0.00	62.46
20.00	2.92	3.11	14.54	4.67	NoLiq	0.00	4.67
25.00	3.14	2.71	10.29	3.80	NoLiq	0.00	3.80
30.00	1.90	4.98	151.57	30.41	10.46	0.00	30.41
35.00	1.73	5.30	112.49	21.24	6.77	0.00	21.24
40.00	1.97	4.85	99.09	20.42	12.27	0.00	20.42
45.00	2.69	3.53	38.78	10.98	NoLiq	0.00	10.98
50.00	2.70	3.51	43.92	12.50	NoLiq	0.00	12.50
55.00	3.10	2.78	16.63	5.99	NoLiq	0.00	5.99
60.00	2.34	4.17	122.54	29.38	24.14	0.00	29.38
65.00	2.87	3.20	49.43	15.47	NoLiq	0.00	15.47
70.00	1.20	6.28	387.99	61.78	0.00	0.00	61.78

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
(N1)60 is converted from qc1, (N1)60s is after fines correction
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
70.45	0.46	1.00	0.46	4.16	0.00	57.35	100.00	0.000	0.0E0	0.000	0.000
70.00	0.46	1.00	0.46	4.15	0.00	61.78	100.00	0.000	0.0E0	0.000	0.000
65.00	0.49	1.00	0.49	5.00	NoLiq	15.47	62.18	0.000	0.0E0	0.000	0.000
60.00	0.51	1.00	0.51	0.46	24.14	29.38	88.67	1.365	8.2E-3	0.404	0.404
55.00	0.54	1.00	0.54	5.00	NoLiq	5.99	39.79	0.000	0.0E0	0.013	0.417
50.00	0.56	1.00	0.56	5.00	NoLiq	12.50	56.19	0.000	0.0E0	0.000	0.417
45.00	0.58	1.00	0.58	5.00	NoLiq	10.98	52.83	0.000	0.0E0	0.042	0.459
40.00	0.60	1.00	0.60	0.28	12.27	20.42	71.30	2.137	1.3E-2	0.576	1.035
35.00	0.62	1.00	0.62	0.34	6.77	21.24	72.77	2.071	1.2E-2	1.206	2.242
30.00	0.63	1.00	0.63	0.64	10.46	30.41	91.00	0.945	5.7E-3	0.755	2.997
25.00	0.62	1.00	0.62	5.00	NoLiq	3.80	32.82	0.000	0.0E0	0.599	3.595
20.00	0.60	1.00	0.60	5.00	NoLiq	4.67	35.71	0.000	0.0E0	0.000	3.595
15.00	0.57	1.00	0.57	3.66	1.49	62.46	100.00	0.000	0.0E0	0.175	3.770
10.00	0.52	1.00	0.52	4.01	4.48	90.41	100.00	0.000	0.0E0	0.000	3.770
5.00	0.43	1.00	0.43	2.40	4.92	39.75	100.00	0.000	0.0E0	0.000	3.770

Settlement of Saturated Sands=3.770 in.

qc1 and (N1)60 is after fines correction in liquefaction analysis
(N1)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
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4.95	0.30	0.20	39.98	0.43	679.02	1.9E-4	0.0381	0.0120	1.06	0.0127	1.52E-4	0.000
0.000												
0.00	0.00	0.00	3.06	0.44	1.66	2.7E-6	0.0010	0.0048	1.06	0.0050	0.00E0	0.011
0.012												

Settlement of Unsaturated Sands=0.012 in.
(N1)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=3.782 in.
Differential Settlement=1.891 to 2.496 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

-
- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft² = 2 kip/ft²)
 - 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m² = 0.001 Mpa)
 - SPT Field data from Standard Penetration Test (SPT)
 - BPT Field data from Becker Penetration Test (BPT)
 - qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
 - fs Friction from CPT testing [atm (tsf)]
 - Rf Ratio of fs/qc (%)
 - gamma Total unit weight of soil
 - gamma' Effective unit weight of soil
 - Fines Fines content [%]
 - D50 Mean grain size
 - Dr Relative Density
 - sigma Total vertical stress [atm]
 - sigma' Effective vertical stress [atm]
 - sigC' Effective confining pressure [atm]
 - rd Acceleration reduction coefficient by Seed
 - a_max. Peak Ground Acceleration (PGA) in ground surface
 - mZ Linear acceleration reduction coefficient X depth
 - a_min. Minimum acceleration under linear reduction, mZ
 - CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
 - CRR7.5 Cyclic resistance ratio (M=7.5)
 - Ksig Overburden stress correction factor for CRR7.5
 - CRRm After magnitude scaling correction CRRm=CRRv * MSF
 - MSF Magnitude scaling factor from M=7.5 to user input M
 - CSR Cyclic stress ratio induced by earthquake
 - CSRfs CSRfs=CSR*fs1 (Default fs1=1)
 - fs1 First CSR curve in graphic defined in #9 of Advanced page
 - fs2 2nd CSR curve in graphic defined in #9 of Advanced page
 - F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
 - Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
 - Cr Rod Length Corrections
 - Cn Overburden Pressure Correction
 - (N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
 - d(N1)60 Fines correction of SPT
 - (N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
 - Cq Overburden stress correction factor
 - qc1 CPT after Overburden stress correction
 - dqc1 Fines correction of CPT
 - qc1f CPT after Fines and Overburden correction, qc1f=qc1 + dqc1
 - qc1n CPT after normalization in Robertson's method
 - Kc Fine correction factor in Robertson's Method
 - qc1f CPT after Fines correction in Robertson's Method
 - Ic Soil type index in Suzuki's and Robertson's Methods
 - (N1)60s (N1)60 after settlement fines corrections
 - CSRm After magnitude scaling correction for Settlement calculation CSRm=CSRsf / MSF*
 - CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
 - MSF* Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
 - ec Volumetric strain for saturated sands
 - dz Calculation segment, dz=0.050 ft
 - dsz Settlement in each segment, dz
 - dp User defined print interval
 - dsp Settlement in each print interval, dp
 - Gmax Shear Modulus at low strain
 - g_eff gamma_eff, Effective shear Strain

g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq No-Liquefy Soils

References:

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1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
 2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
 3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

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LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 CPT3 VB.liq
 Title: Whole Foods VBB CPT-3
 Subtitle:

Surface Elev.=0
 Hole No.=CPT 3
 Depth of Hole= 49.50 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 8.80 ft
 Max. Acceleration= 0.45 g
 Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
 Hole No.=CPT 3
 Depth of Hole=49.50 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 8.80 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf pcf	gamma %	Fines mm	D50
0.00	46.24	0.39	0.84	130.00	0.00	0.50
5.50	18.30	0.48	2.62	130.00	0.00	0.50
10.50	122.80	0.63	0.51	130.00	0.00	0.50
15.50	11.49	0.35	3.05	130.00	0.00	0.50
20.50	8.96	0.31	3.45	130.00	0.00	0.50
25.50	13.40	0.46	3.46	130.00	0.00	0.50
30.50	260.80	2.17	0.83	130.00	0.00	0.50
35.50	27.24	1.01	3.71	130.00	0.00	0.50
40.50	110.10	2.83	2.57	130.00	0.00	0.50
45.50	275.60	2.35	0.85	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=1.61 in.
 Settlement of Unsaturated Sands=0.02 in.
 Total Settlement of Saturated and Unsaturated Sands=1.63 in.
 Differential Settlement=0.816 to 1.077 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.44	5.00	1.61	0.02	1.63
5.00	0.20	0.43	0.47*	1.61	0.00	1.61

10.00	1.85	0.52	3.57	0.98	0.00	0.98
15.00	0.49	0.57	0.86*	0.71	0.00	0.71
20.00	2.00	0.60	5.00	0.62	0.00	0.62
25.00	2.00	0.62	5.00	0.62	0.00	0.62
30.00	1.61	0.63	2.55	0.35	0.00	0.35
35.00	2.00	0.62	5.00	0.08	0.00	0.08
40.00	0.37	0.60	0.62*	0.08	0.00	0.08
45.00	1.33	0.58	2.27	0.06	0.00	0.06

* F.S.<1, Liquefaction Potential Zone
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
CRRm Cyclic resistance ratio from soils
CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
S_sat Settlement from saturated sands
S_dry Settlement from Unsaturated Sands
S_all Total Settlement from Saturated and Unsaturated Sands
NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 CPT3 VB.liq
 Title: Whole Foods VBB CPT-3
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=CPT 3
 Depth of Hole=49.50 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 8.80 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf %	Gamma pcf	Fines %	D50 mm
0.00	46.24	0.39	0.84	130.00	0.00	0.50
5.50	18.30	0.48	2.62	130.00	0.00	0.50
10.50	122.80	0.63	0.51	130.00	0.00	0.50
15.50	11.49	0.35	3.05	130.00	0.00	0.50
20.50	8.96	0.31	3.45	130.00	0.00	0.50
25.50	13.40	0.46	3.46	130.00	0.00	0.50
30.50	260.80	2.17	0.83	130.00	0.00	0.50
35.50	27.24	1.01	3.71	130.00	0.00	0.50
40.50	110.10	2.83	2.57	130.00	0.00	0.50
45.50	275.60	2.35	0.85	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fsl	=CSRfs
0.00	130.00	0.236	130.00	0.236	1.00	0.000	0.450	0.29	1.50	0.44
5.00	130.00	0.543	67.60	0.543	0.99	0.000	0.450	0.29	1.50	0.43
10.00	130.00	0.851	67.60	0.703	0.98	0.000	0.450	0.35	1.50	0.52
15.00	130.00	1.158	67.60	0.863	0.97	0.000	0.450	0.38	1.50	0.57
20.00	130.00	1.465	67.60	1.023	0.95	0.000	0.450	0.40	1.50	0.60
25.00	130.00	1.772	67.60	1.182	0.94	0.000	0.450	0.41	1.50	0.62
30.00	130.00	2.079	67.60	1.342	0.93	0.000	0.450	0.42	1.50	0.63
35.00	130.00	2.386	67.60	1.502	0.89	0.000	0.450	0.41	1.50	0.62

40.00	130.00	2.694	67.60	1.661	0.85	0.000	0.450	0.40	1.50	0.60
45.00	130.00	3.001	67.60	1.821	0.81	0.000	0.450	0.39	1.50	0.58

CSR is based on water table at 5.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from CPT data, using Modify Robertson's Method:
(Fines content is determined by qc and fric.)

Depth ft	qc atm	fric. atm	n	Q	Rf	Ic %	Cq	Fines atm	Kc atm	qcln	qclf	CRR7.5
0.00		1.00	9.25E6	0.84	3.68							
0.00	92.48	0.78	1.00	9.25E6	0.84	3.68	1.00	NoLiq	1.00	92.48	92.48	2.08
5.00		1.00	1.19E2	1.87	2.04							
5.00		0.50	6.67E1	1.87	2.22							
5.00	36.99	0.69	0.50	6.67E1	1.87	2.22	1.80	19.73	0.39	66.73	110.01	0.20
10.00		1.00	3.35E2	1.38	1.66							
10.00		0.50	2.55E2	1.38	1.73							
10.00	194.39	2.68	0.50	2.55E2	1.38	1.73	1.31	6.62	0.04	255.48	267.00	1.85
15.00		1.00	3.46E1	3.25	2.59							
15.00		0.50	3.08E1	3.25	2.63							
15.00		0.70	3.28E1	3.25	2.61							
15.00	26.50	0.83	0.70	3.28E1	3.25	2.61	1.24	35.94	0.80	32.75	163.77	0.49
20.00		1.00	1.12E1	3.87	3.02							
20.00	11.26	0.39	1.00	1.12E1	3.87	3.02	1.00	NoLiq	1.00	11.26	11.26	2.08
25.00		1.00	1.17E1	4.08	3.02							
25.00	13.93	0.51	1.00	1.17E1	4.08	3.02	1.00	NoLiq	1.00	13.93	13.93	2.08
30.00		1.00	2.29E2	0.66	1.52							
30.00		0.50	2.54E2	0.66	1.49							
30.00	280.70	1.83	0.50	2.54E2	0.66	1.49	0.91	2.65	0.00	254.36	254.36	1.61
35.00		1.00	2.50E1	3.56	2.73							
35.00	36.65	1.23	1.00	2.50E1	3.56	2.73	1.00	NoLiq	1.00	36.65	36.65	2.08
40.00		1.00	5.84E1	2.94	2.40							
40.00		0.50	7.44E1	2.94	2.33							
40.00	92.27	2.65	0.50	7.44E1	2.94	2.33	0.81	23.47	0.49	74.42	146.87	0.37
45.00		1.00	1.81E2	0.75	1.63							
45.00		0.50	2.38E2	0.75	1.55							
45.00	310.55	2.31	0.50	2.38E2	0.75	1.55	0.77	3.52	0.00	238.40	238.40	1.34

Fines have been calculated, and correction is made by Modify Robertson Method.
Fines=NoLiq means the soils are not liquefiable.

CRR is based on water table at 8.80 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.08	1.00	2.08	1.00	2.00	0.44	5.00 ^
5.00	0.20	0.20	1.00	0.20	1.00	0.20	0.43	0.47 *
10.00	0.38	1.85	1.00	1.85	1.00	1.85	0.52	3.57
15.00	0.48	0.49	1.00	0.49	1.00	0.49	0.57	0.86 *
20.00	0.58	2.08	1.00	2.08	1.00	2.00	0.60	5.00 ^
25.00	0.69	2.08	1.00	2.08	1.00	2.00	0.62	5.00 ^
30.00	0.79	1.61	1.00	1.61	1.00	1.61	0.63	2.55
35.00	0.90	2.08	1.00	2.08	1.00	2.00	0.62	5.00 ^
40.00	1.00	0.37	1.00	0.37	1.00	0.37	0.60	0.62 *
45.00	1.10	1.34	0.99	1.33	1.00	1.33	0.58	2.27

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qcl	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	3.68	1.70	92.48	54.35	NoLiq	0.00	54.35
5.00	2.22	4.39	110.01	25.03	19.73	0.00	25.03
10.00	1.73	5.31	267.00	50.28	6.62	0.00	50.28
15.00	2.61	3.67	163.77	44.58	35.94	0.00	44.58
20.00	3.02	2.92	11.26	3.86	NoLiq	0.00	3.86

25.00	3.02	2.92	13.93	4.77	NoLiq	0.00	4.77
30.00	1.49	5.75	254.36	44.21	2.65	0.00	44.21
35.00	2.73	3.46	36.65	10.58	NoLiq	0.00	10.58
40.00	2.33	4.20	146.87	34.94	23.47	0.00	34.94
45.00	1.55	5.64	238.40	42.25	3.52	0.00	42.25

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
(N1)60 is converted from qc1, (N1)60s is after fines correction
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
49.45	0.56	1.00	0.56	3.59	3.80	56.00	100.00	0.000	0.0E0	0.000	0.000
45.00	0.58	1.00	0.58	2.27	3.52	42.25	100.00	0.000	0.0E0	0.060	0.060
40.00	0.60	1.00	0.60	0.62	23.47	34.94	100.00	0.000	0.0E0	0.022	0.082
35.00	0.62	1.00	0.62	5.00	NoLiq	10.58	51.91	0.000	0.0E0	0.000	0.082
30.00	0.63	1.00	0.63	2.55	2.65	44.21	100.00	0.000	0.0E0	0.269	0.351
25.00	0.62	1.00	0.62	5.00	NoLiq	4.77	36.02	0.000	0.0E0	0.274	0.625
20.00	0.60	1.00	0.60	5.00	NoLiq	3.86	33.03	0.000	0.0E0	0.000	0.625
15.00	0.57	1.00	0.57	0.86	35.94	44.58	100.00	0.000	0.0E0	0.084	0.709
10.00	0.52	1.00	0.52	3.57	6.62	50.28	100.00	0.000	0.0E0	0.272	0.981
5.00	0.43	1.00	0.43	0.47	19.73	25.03	79.78	1.756	1.1E-2	0.628	1.609

Settlement of Saturated Sands=1.609 in.
qc1 and (N1)60 is after fines correction in liquefaction analysis
(N1)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
4.95	0.30	0.20	24.75	0.43	578.80	2.3E-4	0.0513	0.0383	1.06	0.0404	4.85E-4	0.000	
0.000													
0.00	0.00	0.00	54.35	0.44	4.31	1.0E-6	0.0010	0.0003	1.06	0.0003	0.00E0	0.022	
0.023													

Settlement of Unsaturated Sands=0.023 in.
(N1)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=1.632 in.
Differential Settlement=0.816 to 1.077 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed

a_max. Peak Ground Acceleration (PGA) in ground surface
mZ Linear acceleration reduction coefficient X depth
a_min. Minimum acceleration under linear reduction, mZ
CRRv CRR after overburden stress correction, $CRRv=CRR7.5 * Ksig$
CRR7.5 Cyclic resistance ratio (M=7.5)
Ksig Overburden stress correction factor for CRR7.5
CRRm After magnitude scaling correction $CRRm=CRRv * MSF$
MSF Magnitude scaling factor from M=7.5 to user input M
CSR Cyclic stress ratio induced by earthquake
CSRfs $CSRfs=CSR*fs1$ (Default fs1=1)
fs1 First CSR curve in graphic defined in #9 of Advanced page
fs2 2nd CSR curve in graphic defined in #9 of Advanced page
F.S. Calculated factor of safety against liquefaction $F.S.=CRRm/CSRsf$
Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr Rod Length Corrections
Cn Overburden Pressure Correction
(N1)60 SPT after corrections, $(N1)60=SPT * Cr * Cn * Cebs$
d(N1)60 Fines correction of SPT
(N1)60f $(N1)60$ after fines corrections, $(N1)60f=(N1)60 + d(N1)60$
Cq Overburden stress correction factor
qc1 CPT after Overburden stress correction
dqcl Fines correction of CPT
qc1f CPT after Fines and Overburden correction, $qc1f=qc1 + dqcl$
qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qc1f CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s $(N1)60$ after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation $CSRm=CSRsf / MSF*$
CSRfs Cyclic stress ratio induced by earthquake with user input fs
MSF* Scaling factor from CSR, $MSF*=1$, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, $ec=Cec * ec7.5$
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
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3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).

LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 CPT4 VB.liq
Title: Whole Foods VBB CPT-4
Subtitle:

Surface Elev.=0
Hole No.=CPT-4
Depth of Hole= 70.50 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 8.00 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=CPT-4
Depth of Hole=70.50 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 8.00 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot one CSR curve (fsl=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf pcf	gamma %	Fines mm	D50
0.00	47.57	0.32	0.68	130.00	0.00	0.50
5.50	29.80	0.20	0.69	130.00	0.00	0.50
10.50	74.03	0.28	0.38	130.00	0.00	0.50
15.50	272.10	1.71	0.63	130.00	0.00	0.50
20.50	54.27	1.10	2.03	130.00	0.00	0.50
25.50	67.61	0.78	1.15	130.00	0.00	0.50
30.50	8.94	0.14	1.56	130.00	0.00	0.50
35.50	13.08	0.18	1.40	130.00	0.00	0.50
40.50	79.52	0.60	0.75	130.00	0.00	0.50
45.50	27.23	0.82	3.02	130.00	0.00	0.50
50.50	30.64	0.95	3.11	130.00	0.00	0.50
55.50	14.90	0.32	2.17	130.00	0.00	0.50
60.50	43.44	1.31	3.01	130.00	0.00	0.50
65.50	277.20	2.18	0.79	130.00	0.00	0.50
70.50	336.50	0.66	0.20	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=4.67 in.
Settlement of Unsaturated Sands=0.01 in.
Total Settlement of Saturated and Unsaturated Sands=4.68 in.
Differential Settlement=2.340 to 3.089 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.44	5.00	4.67	0.01	4.68
5.00	2.08	0.43	4.79	4.67	0.00	4.67
10.00	0.22	0.52	0.43*	3.50	0.00	3.50
15.00	2.08	0.57	3.66	2.98	0.00	2.98
20.00	0.59	0.60	0.98*	2.96	0.00	2.96
25.00	0.18	0.62	0.28*	2.28	0.00	2.28
30.00	2.00	0.63	5.00	1.28	0.00	1.28
35.00	2.00	0.62	5.00	0.98	0.00	0.98
40.00	0.11	0.60	0.19*	0.89	0.00	0.89
45.00	2.00	0.58	5.00	0.26	0.00	0.26
50.00	2.00	0.56	5.00	0.26	0.00	0.26
55.00	2.00	0.54	5.00	0.26	0.00	0.26
60.00	2.00	0.51	5.00	0.26	0.00	0.26
65.00	0.73	0.49	1.49	0.00	0.00	0.00
70.00	1.15	0.46	2.51	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft2)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 CPT4 VB.liq
 Title: Whole Foods VBB CPT-4
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=CPT-4
 Depth of Hole=70.50 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 8.00 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf %	Gamma pcf	Fines %	D50 mm
0.00	47.57	0.32	0.68	130.00	0.00	0.50
5.50	29.80	0.20	0.69	130.00	0.00	0.50
10.50	74.03	0.28	0.38	130.00	0.00	0.50
15.50	272.10	1.71	0.63	130.00	0.00	0.50
20.50	54.27	1.10	2.03	130.00	0.00	0.50
25.50	67.61	0.78	1.15	130.00	0.00	0.50
30.50	8.94	0.14	1.56	130.00	0.00	0.50
35.50	13.08	0.18	1.40	130.00	0.00	0.50
40.50	79.52	0.60	0.75	130.00	0.00	0.50
45.50	27.23	0.82	3.02	130.00	0.00	0.50
50.50	30.64	0.95	3.11	130.00	0.00	0.50
55.50	14.90	0.32	2.17	130.00	0.00	0.50
60.50	43.44	1.31	3.01	130.00	0.00	0.50
65.50	277.20	2.18	0.79	130.00	0.00	0.50
70.50	336.50	0.66	0.20	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fsl	=CSRfs
0.00	130.00	0.236	130.00	0.236	1.00	0.000	0.450	0.29	1.50	0.44
5.00	130.00	0.543	67.60	0.543	0.99	0.000	0.450	0.29	1.50	0.43
10.00	130.00	0.851	67.60	0.703	0.98	0.000	0.450	0.35	1.50	0.52

15.00	130.00	1.158	67.60	0.863	0.97	0.000	0.450	0.38	1.50	0.57
20.00	130.00	1.465	67.60	1.023	0.95	0.000	0.450	0.40	1.50	0.60
25.00	130.00	1.772	67.60	1.182	0.94	0.000	0.450	0.41	1.50	0.62
30.00	130.00	2.079	67.60	1.342	0.93	0.000	0.450	0.42	1.50	0.63
35.00	130.00	2.386	67.60	1.502	0.89	0.000	0.450	0.41	1.50	0.62
40.00	130.00	2.694	67.60	1.661	0.85	0.000	0.450	0.40	1.50	0.60
45.00	130.00	3.001	67.60	1.821	0.81	0.000	0.450	0.39	1.50	0.58
50.00	130.00	3.308	67.60	1.981	0.77	0.000	0.450	0.37	1.50	0.56
55.00	130.00	3.615	67.60	2.141	0.73	0.000	0.450	0.36	1.50	0.54
60.00	130.00	3.922	67.60	2.300	0.69	0.000	0.450	0.34	1.50	0.51
65.00	130.00	4.229	67.60	2.460	0.65	0.000	0.450	0.32	1.50	0.49
70.00	130.00	4.536	67.60	2.620	0.60	0.000	0.450	0.31	1.50	0.46

CSR is based on water table at 5.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from CPT data, using Modify Robertson's Method:
(Fines content is determined by qc and fric.)

Depth ft	qc atm	fric. atm	n	Q	Rf	Ic %	Cq	Fines atm	Kc atm	qc1n	qc1f	CRR7.5
0.00		1.00	9.51E6	0.68	3.66							
0.00	95.14	0.65	9.51E6	0.68	3.66	1.00	NoLiq	1.00	95.14	95.14	2.08	
5.00		1.00	8.47E4	0.00	2.17							
5.00		0.50	4.70E4	0.00	2.01							
5.00	26025.67	0.38	0.50	4.70E4	0.00	2.01	1.80	13.22	0.22	500.00	640.59	2.08
10.00		1.00	1.51E2	0.46	1.56							
10.00		0.50	1.13E2	0.46	1.67							
10.00	84.37	0.38	0.50	1.13E2	0.46	1.67	1.34	5.50	0.01	113.22	114.75	0.22
15.00		1.00	4.19E2	0.63	1.33							
15.00		0.50	3.55E2	0.63	1.37							
15.00	300.61	1.89	0.50	3.55E2	0.63	1.37	1.18	1.20	0.00	355.50	355.50	2.08
20.00		1.00	1.74E2	1.08	1.76							
20.00		0.50	1.64E2	1.08	1.77							
20.00	153.41	1.65	0.50	1.64E2	1.08	1.77	1.07	7.59	0.07	164.02	176.19	0.59
25.00		1.00	7.10E1	1.25	2.09							
25.00		0.50	7.37E1	1.25	2.08							
25.00	74.97	0.92	0.50	7.37E1	1.25	2.08	0.98	15.07	0.27	73.71	100.81	0.18
30.00		1.00	1.65E1	1.47	2.65							
30.00	21.50	0.29	1.00	1.65E1	1.47	2.65	1.00	NoLiq	1.00	21.50	21.50	2.08
35.00		1.00	9.12E0	1.82	2.91							
35.00	14.50	0.22	1.00	9.12E0	1.82	2.91	1.00	NoLiq	1.00	14.50	14.50	2.08
40.00		1.00	3.49E1	1.03	2.29							
40.00		0.50	4.49E1	1.03	2.20							
40.00	55.21	0.54	0.50	4.49E1	1.03	2.20	0.81	18.87	0.37	44.87	71.27	0.11
45.00		1.00	1.27E1	3.10	2.92							
45.00	24.04	0.66	1.00	1.27E1	3.10	2.92	1.00	NoLiq	1.00	24.04	24.04	2.08
50.00		1.00	2.00E1	3.12	2.76							
50.00	39.79	1.15	1.00	2.00E1	3.12	2.76	1.00	NoLiq	1.00	39.79	39.79	2.08
55.00		1.00	6.43E0	2.65	3.13							
55.00	16.20	0.34	1.00	6.43E0	2.65	3.13	1.00	NoLiq	1.00	16.20	16.20	2.08
60.00		1.00	1.91E1	3.23	2.79							
60.00	44.79	1.33	1.00	1.91E1	3.23	2.79	1.00	NoLiq	1.00	44.79	44.79	2.08
65.00		1.00	1.26E2	0.86	1.79							
65.00		0.50	1.94E2	0.86	1.65							
65.00	295.65	2.52	0.50	1.94E2	0.86	1.65	0.66	5.26	0.01	194.43	195.79	0.78
70.00		1.00	1.46E2	0.56	1.62							
70.00		0.50	2.33E2	0.56	1.47							
70.00	366.31	2.01	0.50	2.33E2	0.56	1.47	0.64	2.36	0.00	232.98	232.98	1.26

Fines have been calculated, and correction is made by Modify Robertson Method.
Fines=NoLiq means the soils are not liquefiable.

CRR is based on water table at 8.00 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.08	1.00	2.08	1.00	2.00	0.44	5.00 ^
5.00	0.20	2.08	1.00	2.08	1.00	2.08	0.43	4.79
10.00	0.36	0.22	1.00	0.22	1.00	0.22	0.52	0.43 *
15.00	0.46	2.08	1.00	2.08	1.00	2.08	0.57	3.66
20.00	0.57	0.59	1.00	0.59	1.00	0.59	0.60	0.98 *

25.00	0.67	0.18	1.00	0.18	1.00	0.18	0.62	0.28	*
30.00	0.78	2.08	1.00	2.08	1.00	2.00	0.63	5.00	^
35.00	0.88	2.08	1.00	2.08	1.00	2.00	0.62	5.00	^
40.00	0.98	0.11	1.00	0.11	1.00	0.11	0.60	0.19	*
45.00	1.09	2.08	0.99	2.06	1.00	2.00	0.58	5.00	^
50.00	1.19	2.08	0.98	2.03	1.00	2.00	0.56	5.00	^
55.00	1.30	2.08	0.96	2.00	1.00	2.00	0.54	5.00	^
60.00	1.40	2.08	0.95	1.97	1.00	2.00	0.51	5.00	^
65.00	1.50	0.78	0.93	0.73	1.00	0.73	0.49	1.49	
70.00	1.61	1.26	0.92	1.15	1.00	1.15	0.46	2.51	

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	3.66	1.73	95.14	54.97	NoLiq	0.00	54.97
5.00	2.01	4.79	640.59	100.00	13.22	0.00	100.00
10.00	1.67	5.42	114.75	21.17	5.50	0.00	21.17
15.00	1.37	5.96	355.50	59.62	1.20	0.00	59.62
20.00	1.77	5.22	176.19	33.75	7.59	0.00	33.75
25.00	2.08	4.67	100.81	21.61	15.07	0.00	21.61
30.00	2.65	3.61	21.50	5.96	NoLiq	0.00	5.96
35.00	2.91	3.12	14.50	4.65	NoLiq	0.00	4.65
40.00	2.20	4.44	71.27	16.05	18.87	0.00	16.05
45.00	2.92	3.10	24.04	7.74	NoLiq	0.00	7.74
50.00	2.76	3.39	39.79	11.73	NoLiq	0.00	11.73
55.00	3.13	2.72	16.20	5.95	NoLiq	0.00	5.95
60.00	2.79	3.34	44.79	13.39	NoLiq	0.00	13.39
65.00	1.65	5.45	195.79	35.95	5.26	0.00	35.95
70.00	1.47	5.79	232.98	40.22	2.36	0.00	40.22

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
(N1)60 is converted from qc1, (N1)60s is after fines correction
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
70.45	0.46	1.00	0.46	2.54	0.00	37.73	100.00	0.000	0.0E0	0.000	0.000
70.00	0.46	1.00	0.46	2.51	2.36	40.22	100.00	0.000	0.0E0	0.000	0.000
65.00	0.49	1.00	0.49	1.49	5.26	35.95	100.00	0.000	0.0E0	0.001	0.001
60.00	0.51	1.00	0.51	5.00	NoLiq	13.39	58.05	0.000	0.0E0	0.263	0.263
55.00	0.54	1.00	0.54	5.00	NoLiq	5.95	39.70	0.000	0.0E0	0.000	0.263
50.00	0.56	1.00	0.56	5.00	NoLiq	11.73	54.51	0.000	0.0E0	0.000	0.263
45.00	0.58	1.00	0.58	5.00	NoLiq	7.74	44.80	0.000	0.0E0	0.000	0.263
40.00	0.60	1.00	0.60	0.19	18.87	16.05	63.29	2.604	1.6E-2	0.631	0.895
35.00	0.62	1.00	0.62	5.00	NoLiq	4.65	35.65	0.000	0.0E0	0.090	0.984
30.00	0.63	1.00	0.63	5.00	NoLiq	5.96	39.71	0.000	0.0E0	0.301	1.285
25.00	0.62	1.00	0.62	0.28	15.07	21.61	73.44	2.041	1.2E-2	0.993	2.278
20.00	0.60	1.00	0.60	0.98	7.59	33.75	99.21	0.038	2.3E-4	0.682	2.961
15.00	0.57	1.00	0.57	3.66	1.20	59.62	100.00	0.000	0.0E0	0.020	2.980
10.00	0.52	1.00	0.52	0.43	5.50	21.17	72.64	2.077	1.2E-2	0.523	3.503
5.00	0.43	1.00	0.43	4.79	13.22	100.00	100.00	0.000	0.0E0	1.168	4.670

Settlement of Saturated Sands=4.670 in.

qc1 and (N1)60 is after fines correction in liquefaction analysis
(N1)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
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4.95	0.30	0.20	100.00	0.43	921.46	1.4E-4	0.0249	0.0079	1.06	0.0083	1.00E-4	0.000
0.000												
0.00	0.00	0.00	54.97	0.44	4.33	1.0E-6	0.0010	0.0003	1.06	0.0003	0.00E0	0.010
0.010												

Settlement of Unsaturated Sands=0.010 in.
(N1)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=4.680 in.
Differential Settlement=2.340 to 3.089 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft² = 2 kip/ft²)
1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m² = 0.001 Mpa)
SPT Field data from Standard Penetration Test (SPT)
BPT Field data from Becker Penetration Test (BPT)
qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
fs Friction from CPT testing [atm (tsf)]
Rf Ratio of fs/qc (%)
gamma Total unit weight of soil
gamma' Effective unit weight of soil
Fines Fines content [%]
D50 Mean grain size
Dr Relative Density
sigma Total vertical stress [atm]
sigma' Effective vertical stress [atm]
sigC' Effective confining pressure [atm]
rd Acceleration reduction coefficient by Seed
a_max. Peak Ground Acceleration (PGA) in ground surface
mZ Linear acceleration reduction coefficient X depth
a_min. Minimum acceleration under linear reduction, mZ
CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
CRR7.5 Cyclic resistance ratio (M=7.5)
Ksig Overburden stress correction factor for CRR7.5
CRRm After magnitude scaling correction CRRm=CRRv * MSF
MSF Magnitude scaling factor from M=7.5 to user input M
CSR Cyclic stress ratio induced by earthquake
CSRfs CSRfs=CSR*fs1 (Default fs1=1)
fs1 First CSR curve in graphic defined in #9 of Advanced page
fs2 2nd CSR curve in graphic defined in #9 of Advanced page
F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRfs
Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr Rod Length Corrections
Cn Overburden Pressure Correction
(N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
d(N1)60 Fines correction of SPT
(N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
Cq Overburden stress correction factor
qc1 CPT after Overburden stress correction
dqcl Fines correction of CPT
qc1f CPT after Fines and Overburden correction, qc1f=qc1 + dqcl
qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qc1f CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation CSRm=CSRfs / MSF*
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain

g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq No-Liquefy Soils

References:

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 2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
 3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

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LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 SPT1 VB.liq
Title: Whole Foods VBB SPT1
Subtitle:

Surface Elev.=0
Hole No.=SPT1
Depth of Hole= 41.00 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 7.70 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=SPT1
Depth of Hole=41.00 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 7.70 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot two CSR (fs1=1, fs2=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	32.40	130.00	15.00
8.50	32.40	130.00	15.00
11.00	20.40	130.00	15.00
13.50	20.40	130.00	15.00
16.00	20.40	130.00	20.00
18.50	7.20	130.00	57.00
21.00	15.60	130.00	38.00
23.00	15.60	130.00	38.00
25.50	10.80	130.00	67.00
28.50	32.40	130.00	15.00
31.00	32.40	130.00	15.00
36.00	38.40	130.00	15.00
41.00	46.80	130.00	15.00

Output Results:

Settlement of Saturated Sands=0.75 in.
Settlement of Unsaturated Sands=0.00 in.
Total Settlement of Saturated and Unsaturated Sands=0.75 in.
Differential Settlement=0.375 to 0.495 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.29	5.00	0.75	0.00	0.75
5.00	2.00	0.29	5.00	0.75	0.00	0.75
10.00	2.00	0.35	5.00	0.75	0.00	0.75
15.00	2.00	0.38	5.00	0.75	0.00	0.75
20.00	0.37	0.40	0.92*	0.32	0.00	0.32
25.00	0.29	0.41	0.70*	0.18	0.00	0.18
30.00	2.00	0.42	4.74	0.00	0.00	0.00
35.00	2.00	0.41	4.84	0.00	0.00	0.00
40.00	2.00	0.40	4.97	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

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Input File Name: F:\Liquefy5\1680 SPT1 VB.liq
 Title: Whole Foods VBB SPT1
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=SPT1
 Depth of Hole=41.00 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 7.70 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	Gamma pcf	Fines %
0.00	32.40	130.00	15.00
8.50	32.40	130.00	15.00
11.00	20.40	130.00	15.00
13.50	20.40	130.00	15.00
16.00	20.40	130.00	20.00
18.50	7.20	130.00	57.00
21.00	15.60	130.00	38.00
23.00	15.60	130.00	38.00
25.50	10.80	130.00	67.00
28.50	32.40	130.00	15.00
31.00	32.40	130.00	15.00
36.00	38.40	130.00	15.00
41.00	46.80	130.00	15.00

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fs1	=CSRfs
0.00	130.00	0.236	130.00	0.236	1.00	0.000	0.450	0.29	1.00	0.29
5.00	130.00	0.543	67.60	0.543	0.99	0.000	0.450	0.29	1.00	0.29
10.00	130.00	0.851	67.60	0.703	0.98	0.000	0.450	0.35	1.00	0.35

15.00	130.00	1.158	67.60	0.863	0.97	0.000	0.450	0.38	1.00	0.38
20.00	130.00	1.465	67.60	1.023	0.95	0.000	0.450	0.40	1.00	0.40
25.00	130.00	1.772	67.60	1.182	0.94	0.000	0.450	0.41	1.00	0.41
30.00	130.00	2.079	67.60	1.342	0.93	0.000	0.450	0.42	1.00	0.42
35.00	130.00	2.386	67.60	1.502	0.89	0.000	0.450	0.41	1.00	0.41
40.00	130.00	2.694	67.60	1.661	0.85	0.000	0.450	0.40	1.00	0.40

CSR is based on water table at 5.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from SPT or BPT data:

Depth ft	SPT	Cebs	Cr atm	sigma'	Cn	(N1)60 %	Fines	d(N1)60	(N1)60f	CRR7.5
0.00	64.80	1.25	0.75	0.000	1.70	103.28	15.00	7.47	110.74	2.00
5.00	57.32	1.25	0.75	0.307	1.70	91.36	15.00	6.89	98.25	2.00
10.00	36.09	1.25	0.85	0.546	1.35	51.88	15.00	4.99	56.87	2.00
15.00	27.22	1.25	0.95	0.706	1.19	38.47	18.00	5.79	44.26	2.00
20.00	15.58	1.25	0.95	0.866	1.07	19.88	45.60	8.98	28.86	0.37
25.00	14.47	1.25	0.95	1.026	0.99	16.97	61.20	8.39	25.36	0.29
30.00	38.86	1.25	1.00	1.185	0.92	44.61	15.00	4.64	49.26	2.00
35.00	43.73	1.25	1.00	1.345	0.86	47.14	15.00	4.77	51.90	2.00
40.00	52.20	1.25	1.00	1.505	0.82	53.19	15.00	5.06	58.25	2.00

CRR is based on water table at 7.70 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.00	1.00	2.00	1.00	2.00	0.29	5.00
5.00	0.20	2.00	1.00	2.00	1.00	2.00	0.29	5.00
10.00	0.36	2.00	1.00	2.00	1.00	2.00	0.35	5.00
15.00	0.46	2.00	1.00	2.00	1.00	2.00	0.38	5.00
20.00	0.56	0.37	1.00	0.37	1.00	0.37	0.40	0.92 *
25.00	0.67	0.29	1.00	0.29	1.00	0.29	0.41	0.70 *
30.00	0.77	2.00	1.00	2.00	1.00	2.00	0.42	4.74
35.00	0.87	2.00	1.00	2.00	1.00	2.00	0.41	4.84
40.00	0.98	2.00	1.00	2.00	1.00	2.00	0.40	4.97

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)

^ No-liquefiable Soils or above Water Table.

(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60 (N1)60s
0.00	-	-	100.00	15.00	0.00	100.00
5.00	-	-	98.25	15.00	0.00	98.25
10.00	-	-	56.87	15.00	0.00	56.87
15.00	-	-	44.26	18.00	0.00	44.26
20.00	-	-	28.86	45.60	0.00	28.86
25.00	-	-	25.36	61.20	0.00	25.36
30.00	-	-	49.26	15.00	0.00	49.26
35.00	-	-	51.90	15.00	0.00	51.90
40.00	-	-	58.25	15.00	0.00	58.25

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
40.95	0.40	1.00	0.40	5.00	15.00	59.50	100.00	0.000	0.0E0	0.000	0.000
40.00	0.40	1.00	0.40	4.97	15.00	58.25	100.00	0.000	0.0E0	0.000	0.000
35.00	0.41	1.00	0.41	4.84	15.00	51.90	100.00	0.000	0.0E0	0.000	0.000
30.00	0.42	1.00	0.42	4.74	15.00	49.26	100.00	0.000	0.0E0	0.000	0.000

25.00	0.41	1.00	0.41	0.70	61.20	25.36	80.41	1.412	8.5E-3	0.176	0.176
20.00	0.40	1.00	0.40	0.92	45.60	28.86	87.53	0.652	3.9E-3	0.146	0.321
15.00	0.38	1.00	0.38	5.00	18.00	44.26	100.00	0.000	0.0E0	0.425	0.746
10.00	0.35	1.00	0.35	5.00	15.00	56.87	100.00	0.000	0.0E0	0.000	0.746
5.00	0.29	1.00	0.29	5.00	15.00	98.25	100.00	0.000	0.0E0	0.000	0.746

Settlement of Saturated Sands=0.746 in.
qc1 and (N1)60 is after fines correction in liquefaction analysis
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
4.95 0.000	0.30	0.20	98.67	0.29	917.36	9.6E-5	0.0152	0.0048	1.06	0.0051	6.07E-5	0.000	
0.00 0.004	0.00	0.00	100.00	0.29	5.28	5.5E-7	0.0010	0.0003	1.06	0.0003	4.07E-6	0.004	

Settlement of Unsaturated Sands=0.004 in.
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=0.750 in.
Differential Settlement=0.375 to 0.495 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed
- a_max. Peak Ground Acceleration (PGA) in ground surface
- mZ Linear acceleration reduction coefficient X depth
- a_min. Minimum acceleration under linear reduction, mZ
- CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
- CRR7.5 Cyclic resistance ratio (M=7.5)
- Ksig Overburden stress correction factor for CRR7.5
- CRRm After magnitude scaling correction CRRm=CRRv * MSF
- MSF Magnitude scaling factor from M=7.5 to user input M
- CSR Cyclic stress ratio induced by earthquake
- CSRfs CSRfs=CSR*fs1 (Default fs1=1)
- fs1 First CSR curve in graphic defined in #9 of Advanced page
- fs2 2nd CSR curve in graphic defined in #9 of Advanced page
- F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRfs
- Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
- Cr Rod Length Corrections
- Cn Overburden Pressure Correction
- (N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
- d(N1)60 Fines correction of SPT
- (N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
- Cq Overburden stress correction factor
- qc1 CPT after Overburden stress correction
- dqc1 Fines correction of CPT
- qc1f CPT after Fines and Overburden correction, qc1f=qc1 + dqc1

qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qc1f CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation $CSRm=CSRsf / MSF^*$
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, $MSF^*=1$, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, $dz=0.050$ ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, $ec=Cec * ec7.5$
NoLiq No-Liquefy Soils

References:

-
1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
 2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
 3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

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Input File Name: F:\Liquefy5\1680 SPT2 VB.liq
Title: Whole Foods VBB SPT2
Subtitle:

Surface Elev.=0
Hole No.=SPT2
Depth of Hole= 46.00 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 7.00 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=SPT2
Depth of Hole=46.00 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 7.00 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot two CSR (fs1=1, fs2=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	27.60	130.00	19.00
7.50	16.80	130.00	19.00
11.00	24.00	130.00	15.00
21.00	38.40	130.00	15.00
23.50	24.00	130.00	15.00
25.00	21.60	130.00	50.00
26.00	25.20	130.00	10.00
29.00	21.60	130.00	50.00
31.00	21.60	130.00	50.00
33.50	25.20	130.00	31.00
36.00	30.00	130.00	15.00
38.50	13.20	130.00	18.00
46.00	50.40	130.00	15.00

Output Results:

Settlement of Saturated Sands=0.46 in.
Settlement of Unsaturated Sands=0.00 in.
Total Settlement of Saturated and Unsaturated Sands=0.46 in.
Differential Settlement=0.231 to 0.305 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.29	5.00	0.46	0.00	0.46
5.00	2.00	0.29	5.00	0.46	0.00	0.46
10.00	2.00	0.35	5.00	0.46	0.00	0.46
15.00	2.00	0.38	5.00	0.46	0.00	0.46
20.00	2.00	0.40	5.00	0.46	0.00	0.46
25.00	2.00	0.41	4.84	0.46	0.00	0.46
30.00	2.00	0.42	4.74	0.46	0.00	0.46
35.00	2.00	0.41	4.84	0.46	0.00	0.46
40.00	0.38	0.40	0.95*	0.01	0.00	0.01
45.00	1.99	0.39	5.00	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

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Input File Name: F:\Liquefy5\1680 SPT2 VB.liq
 Title: Whole Foods VBB SPT2
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=SPT2
 Depth of Hole=46.00 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 7.00 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	Gamma pcf	Fines %
0.00	27.60	130.00	19.00
7.50	16.80	130.00	19.00
11.00	24.00	130.00	15.00
21.00	38.40	130.00	15.00
23.50	24.00	130.00	15.00
25.00	21.60	130.00	50.00
26.00	25.20	130.00	10.00
29.00	21.60	130.00	50.00
31.00	21.60	130.00	50.00
33.50	25.20	130.00	31.00
36.00	30.00	130.00	15.00
38.50	13.20	130.00	18.00
46.00	50.40	130.00	15.00

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fs1	=CSRfs
0.00	130.00	0.236	130.00	0.236	1.00	0.000	0.450	0.29	1.00	0.29
5.00	130.00	0.543	67.60	0.543	0.99	0.000	0.450	0.29	1.00	0.29
10.00	130.00	0.851	67.60	0.703	0.98	0.000	0.450	0.35	1.00	0.35

15.00	130.00	1.158	67.60	0.863	0.97	0.000	0.450	0.38	1.00	0.38
20.00	130.00	1.465	67.60	1.023	0.95	0.000	0.450	0.40	1.00	0.40
25.00	130.00	1.772	67.60	1.182	0.94	0.000	0.450	0.41	1.00	0.41
30.00	130.00	2.079	67.60	1.342	0.93	0.000	0.450	0.42	1.00	0.42
35.00	130.00	2.386	67.60	1.502	0.89	0.000	0.450	0.41	1.00	0.41
40.00	130.00	2.694	67.60	1.661	0.85	0.000	0.450	0.40	1.00	0.40
45.00	130.00	3.001	67.60	1.821	0.81	0.000	0.450	0.39	1.00	0.39

CSR is based on water table at 5.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from SPT or BPT data:

Depth ft	SPT	Cebs	Cr atm	sigma'	Cn	(N1)60 %	Fines	d(N1)60	(N1)60f	CRR7.5
0.00	55.20	1.25	0.75	0.000	1.70	87.98	19.00	9.84	97.82	2.00
5.00	36.09	1.25	0.75	0.307	1.70	57.52	19.00	7.62	65.14	2.00
10.00	31.80	1.25	0.85	0.526	1.38	46.60	16.14	5.36	51.96	2.00
15.00	40.02	1.25	0.95	0.686	1.21	57.39	15.00	5.26	62.65	2.00
20.00	47.29	1.25	0.95	0.845	1.09	61.08	15.00	5.44	66.52	2.00
25.00	26.68	1.25	0.95	1.005	1.00	31.60	50.00	11.32	42.92	2.00
30.00	25.98	1.25	1.00	1.165	0.93	30.09	50.00	11.02	41.11	2.00
35.00	33.09	1.25	1.00	1.324	0.87	35.94	21.40	7.04	42.98	2.00
40.00	23.92	1.25	1.00	1.484	0.82	24.55	17.40	4.64	29.19	0.38
45.00	51.97	1.25	1.00	1.644	0.78	50.67	15.40	5.16	55.83	2.00

CRR is based on water table at 7.00 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.00	1.00	2.00	1.00	2.00	0.29	5.00
5.00	0.20	2.00	1.00	2.00	1.00	2.00	0.29	5.00
10.00	0.34	2.00	1.00	2.00	1.00	2.00	0.35	5.00
15.00	0.45	2.00	1.00	2.00	1.00	2.00	0.38	5.00
20.00	0.55	2.00	1.00	2.00	1.00	2.00	0.40	5.00
25.00	0.65	2.00	1.00	2.00	1.00	2.00	0.41	4.84
30.00	0.76	2.00	1.00	2.00	1.00	2.00	0.42	4.74
35.00	0.86	2.00	1.00	2.00	1.00	2.00	0.41	4.84
40.00	0.96	0.38	1.00	0.38	1.00	0.38	0.40	0.95 *
45.00	1.07	2.00	1.00	1.99	1.00	1.99	0.39	5.00

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)

^ No-liquefiable Soils or above Water Table.

(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qcl	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	-	-	97.82	19.00	0.00	97.82	
5.00	-	-	65.14	19.00	0.00	65.14	
10.00	-	-	51.96	16.14	0.00	51.96	
15.00	-	-	62.65	15.00	0.00	62.65	
20.00	-	-	66.52	15.00	0.00	66.52	
25.00	-	-	42.92	50.00	0.00	42.92	
30.00	-	-	41.11	50.00	0.00	41.11	
35.00	-	-	42.98	21.40	0.00	42.98	
40.00	-	-	29.19	17.40	0.00	29.19	
45.00	-	-	55.83	15.40	0.00	55.83	

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines %	(N1)60s Dr %	ec in.	dsz in.	dsp in.	S
-------------	-------	--------	-------	-----------	------------	-----------------	-----------	------------	------------	---

45.95	0.39	1.00	0.39	5.00	15.02	60.45	100.00	0.000	0.0E0	0.000	0.000
45.00	0.39	1.00	0.39	5.00	15.40	55.83	100.00	0.000	0.0E0	0.000	0.000
40.00	0.40	1.00	0.40	0.95	17.40	29.19	88.25	0.581	3.5E-3	0.011	0.011
35.00	0.41	1.00	0.41	4.84	21.40	42.98	100.00	0.000	0.0E0	0.447	0.458
30.00	0.42	1.00	0.42	4.74	50.00	41.11	100.00	0.000	0.0E0	0.000	0.458
25.00	0.41	1.00	0.41	4.84	50.00	42.92	100.00	0.000	0.0E0	0.000	0.458
20.00	0.40	1.00	0.40	5.00	15.00	66.52	100.00	0.000	0.0E0	0.000	0.458
15.00	0.38	1.00	0.38	5.00	15.00	62.65	100.00	0.000	0.0E0	0.000	0.458
10.00	0.35	1.00	0.35	5.00	16.14	51.96	100.00	0.000	0.0E0	0.000	0.458
5.00	0.29	1.00	0.29	5.00	19.00	65.14	100.00	0.000	0.0E0	0.000	0.458

Settlement of Saturated Sands=0.458 in.
qcl and (N1)60 is after fines correction in liquefaction analysis
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
4.95 0.000 0.00 0.004	0.30	0.20	65.63	0.29	800.90	1.1E-4	0.0179	0.0057	1.06	0.0060	7.18E-5	0.000	
	0.00	0.00	97.82	0.29	5.25	5.6E-7	0.0010	0.0003	1.06	0.0003	4.07E-6	0.004	

Settlement of Unsaturated Sands=0.004 in.
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=0.462 in.
Differential Settlement=0.231 to 0.305 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed
- a_max. Peak Ground Acceleration (PGA) in ground surface
- mZ Linear acceleration reduction coefficient X depth
- a_min. Minimum acceleration under linear reduction, mZ
- CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
- CRR7.5 Cyclic resistance ratio (M=7.5)
- Ksig Overburden stress correction factor for CRR7.5
- CRRm After magnitude scaling correction CRRm=CRRv * MSF
- MSF Magnitude scaling factor from M=7.5 to user input M
- CSR Cyclic stress ratio induced by earthquake
- CSRfs CSRfs=CSR*fsl (Default fsl=1)
- fsl First CSR curve in graphic defined in #9 of Advanced page
- fs2 2nd CSR curve in graphic defined in #9 of Advanced page
- F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
- Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
- Cr Rod Length Corrections
- Cn Overburden Pressure Correction
- (N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
- d(N1)60 Fines correction of SPT

(N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
Cq Overburden stress correction factor
qc1 CPT after Overburden stress correction
dqcl Fines correction of CPT
qclf CPT after Fines and Overburden correction, qclf=qc1 + dqcl
qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qclf CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation CSRm=CSRsf / MSF*
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).

LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 SPT3 VB.liq
 Title: Whole Foods VBB SPT3
 Subtitle:

Surface Elev.=0
 Hole No.=SPT3
 Depth of Hole= 41.00 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 8.00 ft
 Max. Acceleration= 0.45 g
 Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
 Hole No.=SPT3
 Depth of Hole=41.00 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 8.00 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	21.60	120.00	15.00
7.50	46.80	130.00	15.00
10.50	16.80	130.00	15.00
14.50	19.20	130.00	20.00
19.50	9.60	130.00	34.00
24.50	10.80	130.00	50.00
26.00	8.40	130.00	50.00
29.50	27.60	130.00	17.00
31.00	16.80	130.00	17.00
36.00	39.60	130.00	8.00
41.00	38.40	130.00	15.00

Output Results:

Settlement of Saturated Sands=1.85 in.
 Settlement of Unsaturated Sands=0.00 in.
 Total Settlement of Saturated and Unsaturated Sands=1.85 in.
 Differential Settlement=0.925 to 1.222 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
-------------	------	-------	-------------	---------------	--------------	-------

0.00	2.00	0.29	5.00	1.85	0.00	1.85
5.00	2.00	0.29	5.00	1.85	0.00	1.85
10.00	2.00	0.35	5.00	1.85	0.00	1.85
15.00	2.00	0.38	5.00	1.85	0.00	1.85
20.00	0.27	0.40	0.67*	1.55	0.00	1.55
25.00	0.25	0.41	0.59*	0.55	0.00	0.55
30.00	2.00	0.42	4.72	0.07	0.00	0.07
35.00	2.00	0.42	4.82	0.00	0.00	0.00
40.00	2.00	0.40	4.95	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 SPT3 VB.liq
 Title: Whole Foods VBB SPT3
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=SPT3
 Depth of Hole=41.00 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 8.00 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	Gamma pcf	Fines %
0.00	21.60	120.00	15.00
7.50	46.80	130.00	15.00
10.50	16.80	130.00	15.00
14.50	19.20	130.00	20.00
19.50	9.60	130.00	34.00
24.50	10.80	130.00	50.00
26.00	8.40	130.00	50.00
29.50	27.60	130.00	17.00
31.00	16.80	130.00	17.00
36.00	39.60	130.00	8.00
41.00	38.40	130.00	15.00

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fs1	=CSRfs
0.00	120.00	0.236	120.00	0.236	1.00	0.000	0.450	0.29	1.00	0.29
5.00	126.67	0.528	64.27	0.528	0.99	0.000	0.450	0.29	1.00	0.29
10.00	130.00	0.833	67.60	0.685	0.98	0.000	0.450	0.35	1.00	0.35
15.00	130.00	1.140	67.60	0.845	0.97	0.000	0.450	0.38	1.00	0.38
20.00	130.00	1.447	67.60	1.005	0.95	0.000	0.450	0.40	1.00	0.40

25.00	130.00	1.754	67.60	1.164	0.94	0.000	0.450	0.41	1.00	0.41
30.00	130.00	2.061	67.60	1.324	0.93	0.000	0.450	0.42	1.00	0.42
35.00	130.00	2.369	67.60	1.484	0.89	0.000	0.450	0.42	1.00	0.42
40.00	130.00	2.676	67.60	1.644	0.85	0.000	0.450	0.40	1.00	0.40

CSR is based on water table at 5.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from SPT or BPT data:

Depth ft	SPT	Cebs	Cr atm	sigma'	Cn	(N1)60 %	Fines	d(N1)60	(N1)60f	CRR7.5
0.00	43.20	1.25	0.75	0.000	1.70	68.85	15.00	5.81	74.66	2.00
5.00	69.54	1.25	0.75	0.291	1.70	110.83	15.00	7.83	118.66	2.00
10.00	31.38	1.25	0.85	0.538	1.36	45.48	15.00	4.69	50.17	2.00
15.00	24.42	1.25	0.95	0.697	1.20	34.73	21.40	6.93	41.66	2.00
20.00	12.40	1.25	0.95	0.857	1.08	15.91	35.60	8.18	24.09	0.27
25.00	12.32	1.25	0.95	1.017	0.99	14.51	50.00	7.90	22.42	0.25
30.00	28.82	1.25	1.00	1.176	0.92	33.22	17.00	5.01	38.22	2.00
35.00	41.24	1.25	1.00	1.336	0.87	44.59	9.80	1.73	46.32	2.00
40.00	44.74	1.25	1.00	1.496	0.82	45.73	13.60	3.92	49.65	2.00

CRR is based on water table at 8.00 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.00	1.00	2.00	1.00	2.00	0.29	5.00
5.00	0.19	2.00	1.00	2.00	1.00	2.00	0.29	5.00
10.00	0.35	2.00	1.00	2.00	1.00	2.00	0.35	5.00
15.00	0.45	2.00	1.00	2.00	1.00	2.00	0.38	5.00
20.00	0.56	0.27	1.00	0.27	1.00	0.27	0.40	0.67 *
25.00	0.66	0.25	1.00	0.25	1.00	0.25	0.41	0.59 *
30.00	0.76	2.00	1.00	2.00	1.00	2.00	0.42	4.72
35.00	0.87	2.00	1.00	2.00	1.00	2.00	0.42	4.82
40.00	0.97	2.00	1.00	2.00	1.00	2.00	0.40	4.95

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	-	-	74.66	15.00	0.00	74.66	
5.00	-	-	100.00	15.00	0.00	100.00	
10.00	-	-	50.17	15.00	0.00	50.17	
15.00	-	-	41.66	21.40	0.00	41.66	
20.00	-	-	24.09	35.60	0.00	24.09	
25.00	-	-	22.42	50.00	0.00	22.42	
30.00	-	-	38.22	17.00	0.00	38.22	
35.00	-	-	46.32	9.80	0.00	46.32	
40.00	-	-	49.65	13.60	0.00	49.65	

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s	Dr %	ec in.	dsz in.	dsp in.	S
40.95	0.40	1.00	0.40	4.98	14.93	49.50	100.00	0.000	0.0E0	0.000	0.000
40.00	0.40	1.00	0.40	4.95	13.60	49.65	100.00	0.000	0.0E0	0.000	0.000
35.00	0.42	1.00	0.42	4.82	9.80	46.32	100.00	0.000	0.0E0	0.000	0.000
30.00	0.42	1.00	0.42	4.72	17.00	38.22	100.00	0.000	0.0E0	0.073	0.073
25.00	0.41	1.00	0.41	0.59	50.00	22.42	74.91	1.940	1.2E-2	0.473	0.546
20.00	0.40	1.00	0.40	0.67	35.60	24.09	77.99	1.636	9.8E-3	1.009	1.554

15.00	0.38	1.00	0.38	5.00	21.40	41.66	100.00	0.000	0.0E0	0.293	1.847
10.00	0.35	1.00	0.35	5.00	15.00	50.17	100.00	0.000	0.0E0	0.000	1.847
5.00	0.29	1.00	0.29	5.00	15.00	100.00	100.00	0.000	0.0E0	0.000	1.847

Settlement of Saturated Sands=1.847 in.
 qcl and (N1)60 is after fines correction in liquefaction analysis
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
4.95 0.000	0.29	0.19	100.00	0.29	897.28	9.3E-5	0.0146	0.0046	1.06	0.0049	5.84E-5	0.000	
0.00 0.004	0.00	0.00	74.66	0.29	4.79	6.1E-7	0.0010	0.0003	1.06	0.0003	4.07E-6	0.004	

Settlement of Unsaturated Sands=0.004 in.
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=1.851 in.
 Differential Settlement=0.925 to 1.222 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf (1 tsf = 1 ton/ft² = 2 kip/ft²)
- 1 atm (atmosphere) = 101.325 kPa (1 kPa = 1 kN/m² = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed
- a_max. Peak Ground Acceleration (PGA) in ground surface
- mZ Linear acceleration reduction coefficient X depth
- a_min. Minimum acceleration under linear reduction, mZ
- CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
- CRR7.5 Cyclic resistance ratio (M=7.5)
- Ksig Overburden stress correction factor for CRR7.5
- CRRm After magnitude scaling correction CRRm=CRRv * MSF
- MSF Magnitude scaling factor from M=7.5 to user input M
- CSR Cyclic stress ratio induced by earthquake
- CSRfs CSRfs=CSR*fsl (Default fsl=1)
- fsl First CSR curve in graphic defined in #9 of Advanced page
- fs2 2nd CSR curve in graphic defined in #9 of Advanced page
- F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
- Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
- Cr Rod Length Corrections
- Cn Overburden Pressure Correction
- (N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
- d(N1)60 Fines correction of SPT
- (N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
- Cq Overburden stress correction factor
- qcl CPT after Overburden stress correction
- dqcl Fines correction of CPT
- qclf CPT after Fines and Overburden correction, qclf=qcl + dqcl
- qcln CPT after normalization in Robertson's method
- Kc Fine correction factor in Robertson's Method

qclf CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation $CSRm=CSRsf / MSF^*$
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, $MSF^*=1$, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, $ec=Cec * ec7.5$
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).

LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 SPT4 VB.liq
Title: Whole Foods VBB SPT-4
Subtitle:

Surface Elev.=0
Hole No.=B4
Depth of Hole= 50.50 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 8.70 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=B4
Depth of Hole=50.50 ft
Water Table during Earthquake= 5.00 ft
Water Table during In-Situ Testing= 8.70 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1.05
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot two CSR (fs1=1, fs2=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	9.60	110.00	16.00
7.50	15.60	130.00	16.00
10.50	26.40	130.00	15.00
12.50	31.20	130.00	15.00
16.00	46.80	130.00	15.00
17.50	27.60	130.00	15.00
22.50	12.00	130.00	27.00
26.00	21.60	130.00	34.00
27.50	16.80	130.00	36.00
31.00	8.40	130.00	63.00
32.50	16.80	130.00	50.00
36.00	9.60	130.00	50.00
37.50	21.60	130.00	50.00
41.00	21.60	130.00	50.00
42.50	18.00	130.00	60.00
46.00	12.00	130.00	50.00
50.50	25.20	130.00	37.00

Output Results:

Settlement of Saturated Sands=2.20 in.

Settlement of Unsaturated Sands=0.01 in.
 Total Settlement of Saturated and Unsaturated Sands=2.20 in.
 Differential Settlement=1.102 to 1.455 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.29	5.00	2.20	0.01	2.20
5.00	2.00	0.29	5.00	2.20	0.00	2.20
10.00	2.00	0.35	5.00	2.20	0.00	2.20
15.00	2.00	0.38	5.00	2.20	0.00	2.20
20.00	2.00	0.40	4.95	2.20	0.00	2.20
25.00	2.00	0.42	4.79	2.06	0.00	2.06
30.00	0.26	0.43	0.62*	1.88	0.00	1.88
35.00	0.26	0.42	0.63*	1.19	0.00	1.19
40.00	2.00	0.41	4.93	0.81	0.00	0.81
45.00	0.27	0.39	0.68*	0.55	0.00	0.55
50.00	1.96	0.38	5.00	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 SPT4 VB.liq
 Title: Whole Foods VBB SPT-4
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=B4
 Depth of Hole=50.50 ft
 Water Table during Earthquake= 5.00 ft
 Water Table during In-Situ Testing= 8.70 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1.05
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	Gamma pcf	Fines %
0.00	9.60	110.00	16.00
7.50	15.60	130.00	16.00
10.50	26.40	130.00	15.00
12.50	31.20	130.00	15.00
16.00	46.80	130.00	15.00
17.50	27.60	130.00	15.00
22.50	12.00	130.00	27.00
26.00	21.60	130.00	34.00
27.50	16.80	130.00	36.00
31.00	8.40	130.00	63.00
32.50	16.80	130.00	50.00
36.00	9.60	130.00	50.00
37.50	21.60	130.00	50.00
41.00	21.60	130.00	50.00
42.50	18.00	130.00	60.00
46.00	12.00	130.00	50.00
50.50	25.20	130.00	37.00

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fs1	=CSRfs
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0.00	110.00	0.236	110.00	0.236	1.00	0.000	0.450	0.29	1.00	0.29
5.00	123.33	0.512	60.93	0.512	0.99	0.000	0.450	0.29	1.00	0.29
10.00	130.00	0.815	67.60	0.667	0.98	0.000	0.450	0.35	1.00	0.35
15.00	130.00	1.122	67.60	0.827	0.97	0.000	0.450	0.38	1.00	0.38
20.00	130.00	1.429	67.60	0.987	0.95	0.000	0.450	0.40	1.00	0.40
25.00	130.00	1.736	67.60	1.147	0.94	0.000	0.450	0.42	1.00	0.42
30.00	130.00	2.044	67.60	1.306	0.93	0.000	0.450	0.43	1.00	0.43
35.00	130.00	2.351	67.60	1.466	0.89	0.000	0.450	0.42	1.00	0.42
40.00	130.00	2.658	67.60	1.626	0.85	0.000	0.450	0.41	1.00	0.41
45.00	130.00	2.965	67.60	1.786	0.81	0.000	0.450	0.39	1.00	0.39
50.00	130.00	3.272	67.60	1.945	0.77	0.000	0.450	0.38	1.00	0.38

CSR is based on water table at 5.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from SPT or BPT data:

Depth ft	SPT	Cebs	Cr atm	sigma'	Cn	(N1)60 %	Fines	d(N1)60	(N1)60f	CRR7.5
0.00	19.20	1.31	0.75	0.000	1.70	32.13	16.00	4.50	36.63	2.00
5.00	25.26	1.31	0.75	0.276	1.70	42.28	16.00	5.05	47.33	2.00
10.00	35.36	1.31	0.85	0.540	1.36	53.66	15.17	5.18	58.84	2.00
15.00	56.63	1.31	0.95	0.700	1.20	84.40	15.00	6.56	90.96	2.00
20.00	25.24	1.31	0.95	0.860	1.08	33.94	21.00	6.70	40.65	2.00
25.00	23.23	1.31	0.95	1.019	0.99	28.68	32.00	9.73	38.42	2.00
30.00	12.96	1.31	1.00	1.179	0.92	15.67	55.28	8.13	23.80	0.26
35.00	13.71	1.31	1.00	1.339	0.86	15.56	50.00	8.11	23.67	0.26
40.00	25.01	1.31	1.00	1.499	0.82	26.81	50.00	10.36	37.17	2.00
45.00	15.67	1.31	1.00	1.658	0.78	15.97	52.86	8.19	24.16	0.27
50.00	26.82	1.31	1.00	1.818	0.74	26.10	38.45	10.22	36.32	2.00

CRR is based on water table at 8.70 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.00	1.00	2.00	1.00	2.00	0.29	5.00
5.00	0.18	2.00	1.00	2.00	1.00	2.00	0.29	5.00
10.00	0.35	2.00	1.00	2.00	1.00	2.00	0.35	5.00
15.00	0.46	2.00	1.00	2.00	1.00	2.00	0.38	5.00
20.00	0.56	2.00	1.00	2.00	1.00	2.00	0.40	4.95
25.00	0.66	2.00	1.00	2.00	1.00	2.00	0.42	4.79
30.00	0.77	0.26	1.00	0.26	1.00	0.26	0.43	0.62 *
35.00	0.87	0.26	1.00	0.26	1.00	0.26	0.42	0.63 *
40.00	0.97	2.00	1.00	2.00	1.00	2.00	0.41	4.93
45.00	1.08	0.27	0.99	0.27	1.00	0.27	0.39	0.68 *
50.00	1.18	2.00	0.98	1.96	1.00	1.96	0.38	5.00

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qcl	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	-	-	36.63	16.00	0.00	36.63	
5.00	-	-	47.33	16.00	0.00	47.33	
10.00	-	-	58.84	15.17	0.00	58.84	
15.00	-	-	90.96	15.00	0.00	90.96	
20.00	-	-	40.65	21.00	0.00	40.65	
25.00	-	-	38.42	32.00	0.00	38.42	
30.00	-	-	23.80	55.28	0.00	23.80	
35.00	-	-	23.67	50.00	0.00	23.67	
40.00	-	-	37.17	50.00	0.00	37.17	
45.00	-	-	24.16	52.86	0.00	24.16	
50.00	-	-	36.32	38.45	0.00	36.32	

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.

Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
50.45	0.38	1.00	0.38	5.00	37.15	37.91	100.00	0.000	0.0E0	0.000	0.000
50.00	0.38	1.00	0.38	5.00	38.45	36.32	100.00	0.000	0.0E0	0.000	0.000
45.00	0.39	1.00	0.39	0.68	52.86	24.16	78.13	1.597	9.6E-3	0.553	0.553
40.00	0.41	1.00	0.41	4.93	50.00	37.17	100.00	0.000	0.0E0	0.255	0.808
35.00	0.42	1.00	0.42	0.63	50.00	23.67	77.21	1.760	1.1E-2	0.381	1.190
30.00	0.43	1.00	0.43	0.62	55.28	23.80	77.46	1.761	1.1E-2	0.688	1.878
25.00	0.42	1.00	0.42	4.79	32.00	38.42	100.00	0.000	0.0E0	0.180	2.057
20.00	0.40	1.00	0.40	4.95	21.00	40.65	100.00	0.000	0.0E0	0.141	2.198
15.00	0.38	1.00	0.38	5.00	15.00	90.96	100.00	0.000	0.0E0	0.000	2.198
10.00	0.35	1.00	0.35	5.00	15.17	58.84	100.00	0.000	0.0E0	0.000	2.198
5.00	0.29	1.00	0.29	5.00	16.00	47.33	100.00	0.000	0.0E0	0.000	2.198

Settlement of Saturated Sands=2.198 in.

qc1 and (N1)60 is after fines correction in liquefaction analysis

dsz is per each segment, dz=0.05 ft

dsp is per each print interval, dp=5.00 ft

S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
4.95	0.27	0.18	47.41	0.29	680.47	1.2E-4	0.0191	0.0061	1.06	0.0064	7.67E-5	0.000	
0.000													
0.00	0.00	0.00	36.63	0.29	3.78	7.7E-7	0.0010	0.0004	1.06	0.0004	5.09E-6	0.005	
0.005													

Settlement of Unsaturated Sands=0.005 in.

dsz is per each segment, dz=0.05 ft

dsp is per each print interval, dp=5.00 ft

S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=2.204 in.

Differential Settlement=1.102 to 1.455 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed
- a_max. Peak Ground Acceleration (PGA) in ground surface
- mZ Linear acceleration reduction coefficient X depth
- a_min. Minimum acceleration under linear reduction, mZ
- CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
- CRR7.5 Cyclic resistance ratio (M=7.5)
- Ksig Overburden stress correction factor for CRR7.5
- CRRm After magnitude scaling correction CRRm=CRRv * MSF
- MSF Magnitude scaling factor from M=7.5 to user input M
- CSR Cyclic stress ratio induced by earthquake

CSRfs CSRfs=CSR*fs1 (Default fs1=1)
fs1 First CSR curve in graphic defined in #9 of Advanced page
fs2 2nd CSR curve in graphic defined in #9 of Advanced page
F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr Rod Length Corrections
Cn Overburden Pressure Correction
(N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
d(N1)60 Fines correction of SPT
(N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
Cq Overburden stress correction factor
qc1 CPT after Overburden stress correction
dqcl Fines correction of CPT
qc1f CPT after Fines and Overburden correction, qc1f=qc1 + dqcl
qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qc1f CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation CSRm=CSRsf / MSF*
CSRfs Cyclic stress ratio induced by earthquake with user inputted fs
MSF* Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).

The following liquefaction Induced Settlement (in) with Grade Raised 4 Feet and Groundwater Level Raised to Existing Surface.

 LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 CPT1A VB.liq
 Title: Whole Foods VBB CPT-1A
 Subtitle:

Surface Elev.=0
 Hole No.=CPT1A
 Depth of Hole= 49.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 7.60 ft
 Max. Acceleration= 0.45 g
 Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
 Hole No.=CPT1A
 Depth of Hole=49.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 7.60 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf pcf	gamma %	Fines mm	D50
0.00	56.64	0.45	0.80	130.00	0.00	0.50
5.50	100.00	0.63	0.63	130.00	0.00	0.50
10.50	68.10	0.77	1.13	130.00	0.00	0.50
15.50	150.90	2.27	1.50	130.00	0.00	0.50
20.50	238.50	1.93	0.81	130.00	0.00	0.50
25.50	8.75	0.24	2.77	130.00	0.00	0.50
30.50	42.96	1.12	2.60	130.00	0.00	0.50
35.50	135.00	1.08	0.80	130.00	0.00	0.50
40.50	297.80	3.00	1.01	130.00	0.00	0.50
45.50	281.30	2.18	0.77	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=2.26 in.
 Settlement of Unsaturated Sands=0.00 in.
 Total Settlement of Saturated and Unsaturated Sands=2.26 in.
 Differential Settlement=1.131 to 1.493 in.

Depth CRRm CSRfs F.S. S_sat. S_dry S_all

ft			in.			
0.00	2.00	0.44	5.00	2.26	0.00	2.26
5.00	2.08	0.60	3.49	2.26	0.00	2.26
10.00	0.54	0.66	0.83*	1.95	0.00	1.95
15.00	1.64	0.69	2.39	1.69	0.00	1.69
20.00	2.08	0.70	2.97	1.69	0.00	1.69
25.00	0.12	0.71	0.17*	1.38	0.00	1.38
30.00	0.45	0.71	0.63*	1.31	0.00	1.31
35.00	0.35	0.69	0.52*	0.74	0.00	0.74
40.00	1.47	0.66	2.22	0.28	0.00	0.28
45.00	2.07	0.64	3.25	0.28	0.00	0.28

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 CPT1A VB.liq
 Title: Whole Foods VBB CPT-1A
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=CPT1A
 Depth of Hole=49.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 7.60 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf %	Gamma pcf	Fines %	D50 mm
0.00	56.64	0.45	0.80	130.00	0.00	0.50
5.50	100.00	0.63	0.63	130.00	0.00	0.50
10.50	68.10	0.77	1.13	130.00	0.00	0.50
15.50	150.90	2.27	1.50	130.00	0.00	0.50
20.50	238.50	1.93	0.81	130.00	0.00	0.50
25.50	8.75	0.24	2.77	130.00	0.00	0.50
30.50	42.96	1.12	2.60	130.00	0.00	0.50
35.50	135.00	1.08	0.80	130.00	0.00	0.50
40.50	297.80	3.00	1.01	130.00	0.00	0.50
45.50	281.30	2.18	0.77	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fsl	=CSRfs
0.00	67.60	0.236	67.60	0.236	1.00	0.000	0.450	0.29	1.50	0.44
5.00	130.00	0.543	67.60	0.396	0.99	0.000	0.450	0.40	1.50	0.60
10.00	130.00	0.851	67.60	0.556	0.98	0.000	0.450	0.44	1.50	0.66
15.00	130.00	1.158	67.60	0.715	0.97	0.000	0.450	0.46	1.50	0.69
20.00	130.00	1.465	67.60	0.875	0.95	0.000	0.450	0.47	1.50	0.70
25.00	130.00	1.772	67.60	1.035	0.94	0.000	0.450	0.47	1.50	0.71
30.00	130.00	2.079	67.60	1.195	0.93	0.000	0.450	0.47	1.50	0.71
35.00	130.00	2.386	67.60	1.354	0.89	0.000	0.450	0.46	1.50	0.69

40.00	130.00	2.694	67.60	1.514	0.85	0.000	0.450	0.44	1.50	0.66
45.00	130.00	3.001	67.60	1.674	0.81	0.000	0.450	0.42	1.50	0.64

CSR is based on water table at 0.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from CPT data, using Modify Robertson's Method:
(Fines content is determined by qc and fric.)

Depth ft	atm	qc atm	fric.	n	Q	Rf	Ic %	Cq	Fines atm	Kc atm	qcln	qclf	CRR7.5
0.00			1.00	1.13E7	0.80	3.76							
0.00	113.28	0.90	1.00	1.13E7	0.80	3.76	1.00	NoLiq	1.00	113.28	113.28	2.08	
5.00			1.00	5.51E2	0.69	1.28							
5.00			0.50	3.06E2	0.69	1.44							
5.00	169.67	1.16	0.50	3.06E2	0.69	1.44	1.80	2.07	0.00	306.13	306.13	2.08	
10.00			1.00	2.15E2	1.05	1.68							
10.00			0.50	1.59E2	1.05	1.77							
10.00	117.31	1.22	0.50	1.59E2	1.05	1.77	1.77	1.36	7.58	0.07	159.11	170.88	0.54
15.00			1.00	2.90E2	1.35	1.69							
15.00			0.50	2.44E2	1.35	1.73							
15.00	204.94	2.76	0.50	2.44E2	1.35	1.73	1.73	1.19	6.71	0.05	244.37	256.07	1.64
20.00			1.00	3.42E2	0.73	1.43							
20.00			0.50	3.19E2	0.73	1.45							
20.00	296.35	2.16	0.50	3.19E2	0.73	1.45	1.45	1.08	2.19	0.00	319.00	319.00	2.08
25.00			1.00	3.03E1	1.41	2.41							
25.00			0.50	3.21E1	1.41	2.39							
25.00	32.51	0.44	0.50	3.21E1	1.41	2.39	2.39	0.99	26.15	0.56	32.14	73.82	0.12
30.00			1.00	3.47E1	3.26	2.59							
30.00			0.50	3.95E1	3.26	2.55							
30.00	42.91	1.34	0.50	3.95E1	3.26	2.55	2.55	0.92	33.10	0.75	39.46	158.03	0.45
35.00			1.00	1.14E2	0.85	1.82							
35.00			0.50	1.34E2	0.85	1.77							
35.00	155.18	1.31	0.50	1.34E2	0.85	1.77	1.77	0.86	7.47	0.07	133.94	143.39	0.35
40.00			1.00	1.99E2	0.90	1.66							
40.00			0.50	2.46E2	0.90	1.59							
40.00	301.92	2.68	0.50	2.46E2	0.90	1.59	1.59	0.82	4.25	0.00	246.36	246.36	1.47
45.00			1.00	2.51E2	0.90	1.59							
45.00			0.50	3.25E2	0.90	1.52							
45.00	419.55	3.77	0.50	3.25E2	0.90	1.52	1.52	0.78	3.07	0.00	325.48	325.48	2.08

Fines have been calculated, and correction is made by Modify Robertson Method.
Fines=NoLiq means the soils are not liquefiable.

CRR is based on water table at 7.60 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.08	1.00	2.08	1.00	2.00	0.44	5.00 ^
5.00	0.20	2.08	1.00	2.08	1.00	2.08	0.60	3.49
10.00	0.35	0.54	1.00	0.54	1.00	0.54	0.66	0.83 *
15.00	0.46	1.64	1.00	1.64	1.00	1.64	0.69	2.39
20.00	0.56	2.08	1.00	2.08	1.00	2.08	0.70	2.97
25.00	0.66	0.12	1.00	0.12	1.00	0.12	0.71	0.17 *
30.00	0.77	0.45	1.00	0.45	1.00	0.45	0.71	0.63 *
35.00	0.87	0.35	1.00	0.35	1.00	0.35	0.69	0.52 *
40.00	0.98	1.47	1.00	1.47	1.00	1.47	0.66	2.22
45.00	1.08	2.08	0.99	2.07	1.00	2.07	0.64	3.25

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)

^ No-liquefiable Soils or above Water Table.

(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qcl	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	3.76	1.56	113.28	72.58	NoLiq	0.00	72.58
5.00	1.44	5.83	306.13	52.49	2.07	0.00	52.49
10.00	1.77	5.22	170.88	32.73	7.58	0.00	32.73

15.00	1.73	5.30	256.07	48.30	6.71	0.00	48.30
20.00	1.45	5.82	319.00	54.85	2.19	0.00	54.85
25.00	2.39	4.08	73.82	18.11	26.15	0.00	18.11
30.00	2.55	3.78	158.03	41.78	33.10	0.00	41.78
35.00	1.77	5.23	143.39	27.41	7.47	0.00	27.41
40.00	1.59	5.56	246.36	44.34	4.25	0.00	44.34
45.00	1.52	5.70	325.48	57.12	3.07	0.00	57.12

(Nl)60s has been fines corrected in liquefaction analysis, therefore d(Nl)60=0.
(Nl)60 is converted from qc1, (Nl)60s is after fines correction
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRs _f	/ MSF*	=CSR _m	F.S. %	Fines %	(Nl)60s %	Dr %	ec in.	dsz in.	dsp in.	S
49.45	0.61	1.00	0.61	3.34	0.06	65.86	100.00	0.000	0.0E0	0.000	0.000
45.00	0.64	1.00	0.64	3.25	3.07	57.12	100.00	0.000	0.0E0	0.277	0.277
40.00	0.66	1.00	0.66	2.22	4.25	44.34	100.00	0.000	0.0E0	0.000	0.277
35.00	0.69	1.00	0.69	0.52	7.47	27.41	84.49	1.525	9.2E-3	0.466	0.742
30.00	0.71	1.00	0.71	0.63	33.10	41.78	100.00	0.000	0.0E0	0.572	1.315
25.00	0.71	1.00	0.71	0.17	26.15	18.11	67.11	2.372	1.4E-2	0.064	1.378
20.00	0.70	1.00	0.70	2.97	2.19	54.85	100.00	0.000	0.0E0	0.315	1.693
15.00	0.69	1.00	0.69	2.39	6.71	48.30	100.00	0.000	0.0E0	0.000	1.693
10.00	0.66	1.00	0.66	0.83	7.58	32.73	96.57	0.250	1.5E-3	0.258	1.952
5.00	0.60	1.00	0.60	3.49	2.07	52.49	100.00	0.000	0.0E0	0.311	2.262
0.00	0.44	1.00	0.44	5.00	NoLiq	72.58	100.00	0.000	0.0E0	0.000	2.262

Settlement of Saturated Sands=2.262 in.
qc1 and (Nl)60 is after fines correction in liquefaction analysis
(Nl)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(Nl)60s	CSRs _f	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
0.00 0.000	0.00	1.17	0.00	0.44	5.25	5.6E-7	0.0000	0.0000	0.00	0.0000	0.00E0	0.000	

Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.
(Nl)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=2.262 in.
Differential Settlement=1.131 to 1.493 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]

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sigC'      Effective confining pressure [atm]
rd         Acceleration reduction coefficient by Seed
a_max.    Peak Ground Acceleration (PGA) in ground surface
mZ        Linear acceleration reduction coefficient X depth
a_min.    Minimum acceleration under linear reduction, mZ
CRRv      CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
  CRR7.5  Cyclic resistance ratio (M=7.5)
  Ksig    Overburden stress correction factor for CRR7.5
CRRm      After magnitude scaling correction CRRm=CRRv * MSF
  MSF    Magnitude scaling factor from M=7.5 to user input M
CSR       Cyclic stress ratio induced by earthquake
CSRfs     CSRfs=CSR*fs1 (Default fs1=1)
  fs1    First CSR curve in graphic defined in #9 of Advanced page
  fs2    2nd CSR curve in graphic defined in #9 of Advanced page
F.S.      Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
Cebs      Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr        Rod Length Corrections
Cn        Overburden Pressure Correction
(N1)60    SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
d(N1)60   Fines correction of SPT
(N1)60f   (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
Cq        Overburden stress correction factor
qc1       CPT after Overburden stress correction
dqcl     Fines correction of CPT
qc1f     CPT after Fines and Overburden correction, qc1f=qc1 + dqcl
qc1n     CPT after normalization in Robertson's method
Kc        Fine correction factor in Robertson's Method
qc1f     CPT after Fines correction in Robertson's Method
Ic        Soil type index in Suzuki's and Robertson's Methods
(N1)60s   (N1)60 after settlement fines corrections
CSRm      After magnitude scaling correction for Settlement calculation CSRm=CSRsf / MSF*
  CSRfs  Cyclic stress ratio induced by earthquake with user inputted fs
  MSF*   Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
ec        Volumetric strain for saturated sands
dz        Calculation segment, dz=0.050 ft
dsz       Settlement in each segment, dz
dp        User defined print interval
dsp       Settlement in each print interval, dp
Gmax      Shear Modulus at low strain
g_eff     gamma_eff, Effective shear Strain
g*Ge/Gm   gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5     Volumetric Strain for magnitude=7.5
Cec       Magnitude correction factor for any magnitude
ec        Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq    No-Liquefy Soils

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References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).

LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 CPT2 VB.liq
Title: Whole Foods VBB CPT-2
Subtitle:

Surface Elev.=0
Hole No.=CPT-2
Depth of Hole= 70.50 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 9.30 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=CPT-2
Depth of Hole=70.50 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 9.30 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot one CSR curve (fsl=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf pcf	gamma %	Fines mm	D50
0.00	4.72	0.09	2.01	130.00	0.00	0.50
5.50	71.32	0.57	0.79	130.00	0.00	0.50
10.50	343.30	6.84	1.99	130.00	0.00	0.50
15.50	222.40	1.56	0.70	130.00	0.00	0.50
20.50	11.30	0.39	3.42	130.00	0.00	0.50
25.50	8.30	0.26	3.08	130.00	0.00	0.50
30.50	173.30	1.16	0.67	130.00	0.00	0.50
35.50	103.80	0.54	0.52	130.00	0.00	0.50
40.50	31.30	0.81	2.58	130.00	0.00	0.50
45.50	20.64	0.64	3.11	130.00	0.00	0.50
50.50	26.43	0.75	2.84	130.00	0.00	0.50
55.50	15.37	0.31	1.99	130.00	0.00	0.50
60.50	103.80	1.55	1.49	130.00	0.00	0.50
65.50	42.62	1.83	4.30	130.00	0.00	0.50
70.50	571.20	0.00	0.00	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=3.95 in.
Settlement of Unsaturated Sands=0.00 in.
Total Settlement of Saturated and Unsaturated Sands=3.95 in.
Differential Settlement=1.975 to 2.607 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.44	5.00	3.95	0.00	3.95
5.00	1.04	0.60	1.75	3.82	0.00	3.82
10.00	2.08	0.66	3.17	3.82	0.00	3.82
15.00	2.08	0.69	3.03	3.82	0.00	3.82
20.00	2.00	0.70	5.00	3.63	0.00	3.63
25.00	2.00	0.71	5.00	3.63	0.00	3.63
30.00	0.40	0.71	0.57*	3.03	0.00	3.03
35.00	0.21	0.69	0.31*	2.24	0.00	2.24
40.00	0.17	0.66	0.26*	1.04	0.00	1.04
45.00	2.00	0.64	5.00	0.46	0.00	0.46
50.00	2.00	0.61	5.00	0.42	0.00	0.42
55.00	2.00	0.58	5.00	0.42	0.00	0.42
60.00	0.24	0.55	0.43*	0.40	0.00	0.40
65.00	2.00	0.52	5.00	0.00	0.00	0.00
70.00	1.90	0.49	3.91	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft2)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 CPT2 VB.liq
 Title: Whole Foods VBB CPT-2
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=CPT-2
 Depth of Hole=70.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 9.30 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf %	Gamma pcf	Fines %	D50 mm
0.00	4.72	0.09	2.01	130.00	0.00	0.50
5.50	71.32	0.57	0.79	130.00	0.00	0.50
10.50	343.30	6.84	1.99	130.00	0.00	0.50
15.50	222.40	1.56	0.70	130.00	0.00	0.50
20.50	11.30	0.39	3.42	130.00	0.00	0.50
25.50	8.30	0.26	3.08	130.00	0.00	0.50
30.50	173.30	1.16	0.67	130.00	0.00	0.50
35.50	103.80	0.54	0.52	130.00	0.00	0.50
40.50	31.30	0.81	2.58	130.00	0.00	0.50
45.50	20.64	0.64	3.11	130.00	0.00	0.50
50.50	26.43	0.75	2.84	130.00	0.00	0.50
55.50	15.37	0.31	1.99	130.00	0.00	0.50
60.50	103.80	1.55	1.49	130.00	0.00	0.50
65.50	42.62	1.83	4.30	130.00	0.00	0.50
70.50	571.20	0.00	0.00	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fsl	=CSRfs
0.00	67.60	0.236	67.60	0.236	1.00	0.000	0.450	0.29	1.50	0.44
5.00	130.00	0.543	67.60	0.396	0.99	0.000	0.450	0.40	1.50	0.60
10.00	130.00	0.851	67.60	0.556	0.98	0.000	0.450	0.44	1.50	0.66

15.00	130.00	1.158	67.60	0.715	0.97	0.000	0.450	0.46	1.50	0.69
20.00	130.00	1.465	67.60	0.875	0.95	0.000	0.450	0.47	1.50	0.70
25.00	130.00	1.772	67.60	1.035	0.94	0.000	0.450	0.47	1.50	0.71
30.00	130.00	2.079	67.60	1.195	0.93	0.000	0.450	0.47	1.50	0.71
35.00	130.00	2.386	67.60	1.354	0.89	0.000	0.450	0.46	1.50	0.69
40.00	130.00	2.694	67.60	1.514	0.85	0.000	0.450	0.44	1.50	0.66
45.00	130.00	3.001	67.60	1.674	0.81	0.000	0.450	0.42	1.50	0.64
50.00	130.00	3.308	67.60	1.833	0.77	0.000	0.450	0.40	1.50	0.61
55.00	130.00	3.615	67.60	1.993	0.73	0.000	0.450	0.39	1.50	0.58
60.00	130.00	3.922	67.60	2.153	0.69	0.000	0.450	0.37	1.50	0.55
65.00	130.00	4.229	67.60	2.313	0.65	0.000	0.450	0.35	1.50	0.52
70.00	130.00	4.536	67.60	2.472	0.60	0.000	0.450	0.32	1.50	0.49

CSR is based on water table at 0.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from CPT data, using Modify Robertson's Method:
(Fines content is determined by qc and fric.)

Depth ft	qc atm	fric. atm	n	Q	Rf	Ic %	Cq	Fines atm	Kc atm	qc1n	qc1f	CRR7.5
0.00		1.00	9.44E5	2.01	2.93							
0.00	9.44	0.19	9.44E5	2.01	2.93	1.00	NoLiq	1.00	9.44	9.44	2.08	
5.00		1.00	3.92E2	0.91	1.47							
5.00		0.50	2.18E2	0.91	1.63							
5.00	120.77	1.09	2.18E2	0.91	1.63	1.80	4.92	0.00	217.90	217.90	1.04	
10.00		1.00	7.67E2	1.69	1.56							
10.00		0.50	5.92E2	1.69	1.61							
10.00	455.95	7.69	0.50	5.92E2	1.69	1.61	1.30	4.48	0.00	500.00	500.00	2.08
15.00		1.00	4.25E2	0.70	1.36							
15.00		0.50	3.70E2	0.70	1.40							
15.00	320.85	2.25	0.50	3.70E2	0.70	1.40	1.15	1.49	0.00	369.64	369.64	2.08
20.00		1.00	1.46E1	3.67	2.92							
20.00	14.54	0.49	1.00	1.46E1	3.67	2.92	1.00	NoLiq	1.00	14.54	14.54	2.08
25.00		1.00	8.16E0	3.92	3.14							
25.00	10.29	0.34	1.00	8.16E0	3.92	3.14	1.00	NoLiq	1.00	10.29	10.29	2.08
30.00		1.00	1.15E2	1.30	1.94							
30.00		0.50	1.29E2	1.30	1.90							
30.00	143.73	1.84	0.50	1.29E2	1.30	1.90	0.90	10.46	0.15	129.46	151.57	0.40
35.00		1.00	8.93E1	0.56	1.80							
35.00		0.50	1.07E2	0.56	1.73							
35.00	126.45	0.69	0.50	1.07E2	0.56	1.73	0.85	6.77	0.05	107.16	112.49	0.21
40.00		1.00	6.25E1	0.96	2.06							
40.00		0.50	7.99E1	0.96	1.97							
40.00	99.48	0.93	0.50	7.99E1	0.96	1.97	0.80	12.27	0.19	79.85	99.09	0.17
45.00		1.00	2.10E1	2.50	2.69							
45.00	38.78	0.90	1.00	2.10E1	2.50	2.69	1.00	NoLiq	1.00	38.78	38.78	2.08
50.00		1.00	2.18E1	2.73	2.70							
50.00	43.92	1.11	1.00	2.18E1	2.73	2.70	1.00	NoLiq	1.00	43.92	43.92	2.08
55.00		1.00	6.52E0	2.36	3.10							
55.00	16.63	0.31	1.00	6.52E0	2.36	3.10	1.00	NoLiq	1.00	16.63	16.63	2.08
60.00		1.00	3.88E1	2.51	2.48							
60.00		0.50	5.99E1	2.51	2.34							
60.00	88.68	2.13	0.50	5.99E1	2.51	2.34	0.68	24.14	0.51	59.91	122.54	0.25
65.00		1.00	1.93E1	4.39	2.87							
65.00	49.43	2.00	1.00	1.93E1	4.39	2.87	1.00	NoLiq	1.00	49.43	49.43	2.08
70.00		1.00	2.43E2	0.39	1.36							
70.00		0.50	3.88E2	0.39	1.20							
70.00	614.73	2.41	0.50	3.88E2	0.39	1.20	0.63	0.00	0.00	387.99	387.99	2.08

Fines have been calculated, and correction is made by Modify Robertson Method.
Fines=NoLiq means the soils are not liquefiable.

CRR is based on water table at 9.30 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.08	1.00	2.08	1.00	2.00	0.44	5.00 ^
5.00	0.20	1.04	1.00	1.04	1.00	1.04	0.60	1.75
10.00	0.39	2.08	1.00	2.08	1.00	2.08	0.66	3.17
15.00	0.49	2.08	1.00	2.08	1.00	2.08	0.69	3.03
20.00	0.59	2.08	1.00	2.08	1.00	2.00	0.70	5.00 ^

25.00	0.70	2.08	1.00	2.08	1.00	2.00	0.71	5.00	^
30.00	0.80	0.40	1.00	0.40	1.00	0.40	0.71	0.57	*
35.00	0.90	0.21	1.00	0.21	1.00	0.21	0.69	0.31	*
40.00	1.01	0.17	1.00	0.17	1.00	0.17	0.66	0.26	*
45.00	1.11	2.08	0.99	2.06	1.00	2.00	0.64	5.00	^
50.00	1.22	2.08	0.97	2.02	1.00	2.00	0.61	5.00	^
55.00	1.32	2.08	0.96	1.99	1.00	2.00	0.58	5.00	^
60.00	1.42	0.25	0.94	0.24	1.00	0.24	0.55	0.43	*
65.00	1.53	2.08	0.93	1.93	1.00	2.00	0.52	5.00	^
70.00	1.63	2.08	0.92	1.90	1.00	1.90	0.49	3.91	

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	2.93	3.08	9.44	3.06	NoLiq	0.00	3.06
5.00	1.63	5.48	217.90	39.75	4.92	0.00	39.75
10.00	1.61	5.53	500.00	90.41	4.48	0.00	90.41
15.00	1.40	5.92	369.64	62.46	1.49	0.00	62.46
20.00	2.92	3.11	14.54	4.67	NoLiq	0.00	4.67
25.00	3.14	2.71	10.29	3.80	NoLiq	0.00	3.80
30.00	1.90	4.98	151.57	30.41	10.46	0.00	30.41
35.00	1.73	5.30	112.49	21.24	6.77	0.00	21.24
40.00	1.97	4.85	99.09	20.42	12.27	0.00	20.42
45.00	2.69	3.53	38.78	10.98	NoLiq	0.00	10.98
50.00	2.70	3.51	43.92	12.50	NoLiq	0.00	12.50
55.00	3.10	2.78	16.63	5.99	NoLiq	0.00	5.99
60.00	2.34	4.17	122.54	29.38	24.14	0.00	29.38
65.00	2.87	3.20	49.43	15.47	NoLiq	0.00	15.47
70.00	1.20	6.28	387.99	61.78	0.00	0.00	61.78

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
(N1)60 is converted from qc1, (N1)60s is after fines correction
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
70.45	0.48	1.00	0.48	3.93	0.00	57.35	100.00	0.000	0.0E0	0.000	0.000
70.00	0.49	1.00	0.49	3.91	0.00	61.78	100.00	0.000	0.0E0	0.000	0.000
65.00	0.52	1.00	0.52	5.00	NoLiq	15.47	62.18	0.000	0.0E0	0.000	0.000
60.00	0.55	1.00	0.55	0.43	24.14	29.38	88.67	1.372	8.2E-3	0.404	0.404
55.00	0.58	1.00	0.58	5.00	NoLiq	5.99	39.79	0.000	0.0E0	0.013	0.418
50.00	0.61	1.00	0.61	5.00	NoLiq	12.50	56.19	0.000	0.0E0	0.000	0.418
45.00	0.64	1.00	0.64	5.00	NoLiq	10.98	52.83	0.000	0.0E0	0.042	0.459
40.00	0.66	1.00	0.66	0.26	12.27	20.42	71.30	2.137	1.3E-2	0.576	1.036
35.00	0.69	1.00	0.69	0.31	6.77	21.24	72.77	2.071	1.2E-2	1.208	2.243
30.00	0.71	1.00	0.71	0.57	10.46	30.41	91.00	1.053	6.3E-3	0.786	3.029
25.00	0.71	1.00	0.71	5.00	NoLiq	3.80	32.82	0.000	0.0E0	0.604	3.633
20.00	0.70	1.00	0.70	5.00	NoLiq	4.67	35.71	0.000	0.0E0	0.000	3.633
15.00	0.69	1.00	0.69	3.03	1.49	62.46	100.00	0.000	0.0E0	0.183	3.816
10.00	0.66	1.00	0.66	3.17	4.48	90.41	100.00	0.000	0.0E0	0.000	3.816
5.00	0.60	1.00	0.60	1.75	4.92	39.75	100.00	0.000	0.0E0	0.000	3.816
0.00	0.44	1.00	0.44	5.00	NoLiq	3.06	30.24	0.000	0.0E0	0.134	3.949

Settlement of Saturated Sands=3.949 in.
qc1 and (N1)60 is after fines correction in liquefaction analysis
(N1)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
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in.

0.00	0.00	1.64	0.00	0.44	5.25	5.6E-7	0.0000	0.0000	0.00	0.0000	0.00E0	0.000
0.000												

Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.
 (N1)60s is converted from qc1 and after fines correction
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=3.949 in.
 Differential Settlement=1.975 to 2.607 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere)	= 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
1 atm (atmosphere)	= 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
SPT	Field data from Standard Penetration Test (SPT)
BPT	Field data from Becker Penetration Test (BPT)
qc	Field data from Cone Penetration Test (CPT) [atm (tsf)]
fs	Friction from CPT testing [atm (tsf)]
Rf	Ratio of fs/qc (%)
gamma	Total unit weight of soil
gamma'	Effective unit weight of soil
Fines	Fines content [%]
D50	Mean grain size
Dr	Relative Density
sigma	Total vertical stress [atm]
sigma'	Effective vertical stress [atm]
sigC'	Effective confining pressure [atm]
rd	Acceleration reduction coefficient by Seed
a_max.	Peak Ground Acceleration (PGA) in ground surface
mZ	Linear acceleration reduction coefficient X depth
a_min.	Minimum acceleration under linear reduction, mZ
CRRv	CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
CRR7.5	Cyclic resistance ratio (M=7.5)
Ksig	Overburden stress correction factor for CRR7.5
CRRm	After magnitude scaling correction CRRm=CRRv * MSF
MSF	Magnitude scaling factor from M=7.5 to user input M
CSR	Cyclic stress ratio induced by earthquake
CSRfs	CSRfs=CSR*fs1 (Default fs1=1)
fs1	First CSR curve in graphic defined in #9 of Advanced page
fs2	2nd CSR curve in graphic defined in #9 of Advanced page
F.S.	Calculated factor of safety against liquefaction F.S.=CRRm/CSRfs
Cebs	Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr	Rod Length Corrections
Cn	Overburden Pressure Correction
(N1)60	SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
d(N1)60	Fines correction of SPT
(N1)60f	(N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
Cq	Overburden stress correction factor
qc1	CPT after Overburden stress correction
dqc1	Fines correction of CPT
qc1f	CPT after Fines and Overburden correction, qc1f=qc1 + dqc1
qc1n	CPT after normalization in Robertson's method
Kc	Fine correction factor in Robertson's Method
qc1f	CPT after Fines correction in Robertson's Method
Ic	Soil type index in Suzuki's and Robertson's Methods
(N1)60s	(N1)60 after settlement fines corrections
CSRm	After magnitude scaling correction for Settlement calculation CSRm=CSRfs / MSF*
CSRfs	Cyclic stress ratio induced by earthquake with user inputed fs
MSF*	Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
ec	Volumetric strain for saturated sands
dz	Calculation segment, dz=0.050 ft
dsz	Settlement in each segment, dz
dp	User defined print interval
dsp	Settlement in each print interval, dp
Gmax	Shear Modulus at low strain
g_eff	gamma_eff, Effective shear Strain

g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
 SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.

2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.

3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

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LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 CPT3 VB.liq
 Title: Whole Foods VBB CPT-3
 Subtitle:

Surface Elev.=0
 Hole No.=CPT 3
 Depth of Hole= 49.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 8.80 ft
 Max. Acceleration= 0.45 g
 Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
 Hole No.=CPT 3
 Depth of Hole=49.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 8.80 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf pcf	gamma %	Fines mm	D50
0.00	46.24	0.39	0.84	130.00	0.00	0.50
5.50	18.30	0.48	2.62	130.00	0.00	0.50
10.50	122.80	0.63	0.51	130.00	0.00	0.50
15.50	11.49	0.35	3.05	130.00	0.00	0.50
20.50	8.96	0.31	3.45	130.00	0.00	0.50
25.50	13.40	0.46	3.46	130.00	0.00	0.50
30.50	260.80	2.17	0.83	130.00	0.00	0.50
35.50	27.24	1.01	3.71	130.00	0.00	0.50
40.50	110.10	2.83	2.57	130.00	0.00	0.50
45.50	275.60	2.35	0.85	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=2.18 in.
 Settlement of Unsaturated Sands=0.00 in.
 Total Settlement of Saturated and Unsaturated Sands=2.18 in.
 Differential Settlement=1.088 to 1.437 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.44	5.00	2.18	0.00	2.18
5.00	0.20	0.60	0.34*	1.67	0.00	1.67

10.00	1.85	0.66	2.82	1.03	0.00	1.03
15.00	0.49	0.69	0.71*	0.73	0.00	0.73
20.00	2.00	0.70	5.00	0.65	0.00	0.65
25.00	2.00	0.71	5.00	0.65	0.00	0.65
30.00	1.61	0.71	2.27	0.37	0.00	0.37
35.00	2.00	0.69	5.00	0.10	0.00	0.10
40.00	0.37	0.66	0.57*	0.10	0.00	0.10
45.00	1.33	0.64	2.09	0.07	0.00	0.07

* F.S.<1, Liquefaction Potential Zone
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft2)
CRRm Cyclic resistance ratio from soils
CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
S_sat Settlement from saturated sands
S_dry Settlement from Unsaturated Sands
S_all Total Settlement from Saturated and Unsaturated Sands
NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 CPT3 VB.liq
 Title: Whole Foods VBB CPT-3
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=CPT 3
 Depth of Hole=49.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 8.80 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf %	Gamma pcf	Fines %	D50 mm
0.00	46.24	0.39	0.84	130.00	0.00	0.50
5.50	18.30	0.48	2.62	130.00	0.00	0.50
10.50	122.80	0.63	0.51	130.00	0.00	0.50
15.50	11.49	0.35	3.05	130.00	0.00	0.50
20.50	8.96	0.31	3.45	130.00	0.00	0.50
25.50	13.40	0.46	3.46	130.00	0.00	0.50
30.50	260.80	2.17	0.83	130.00	0.00	0.50
35.50	27.24	1.01	3.71	130.00	0.00	0.50
40.50	110.10	2.83	2.57	130.00	0.00	0.50
45.50	275.60	2.35	0.85	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fsl	=CSRfs
0.00	67.60	0.236	67.60	0.236	1.00	0.000	0.450	0.29	1.50	0.44
5.00	130.00	0.543	67.60	0.396	0.99	0.000	0.450	0.40	1.50	0.60
10.00	130.00	0.851	67.60	0.556	0.98	0.000	0.450	0.44	1.50	0.66
15.00	130.00	1.158	67.60	0.715	0.97	0.000	0.450	0.46	1.50	0.69
20.00	130.00	1.465	67.60	0.875	0.95	0.000	0.450	0.47	1.50	0.70
25.00	130.00	1.772	67.60	1.035	0.94	0.000	0.450	0.47	1.50	0.71
30.00	130.00	2.079	67.60	1.195	0.93	0.000	0.450	0.47	1.50	0.71
35.00	130.00	2.386	67.60	1.354	0.89	0.000	0.450	0.46	1.50	0.69

40.00	130.00	2.694	67.60	1.514	0.85	0.000	0.450	0.44	1.50	0.66
45.00	130.00	3.001	67.60	1.674	0.81	0.000	0.450	0.42	1.50	0.64

CSR is based on water table at 0.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from CPT data, using Modify Robertson's Method:
(Fines content is determined by qc and fric.)

Depth ft	atm	qc atm	fric.	n	Q	Rf	Ic %	Cq	Fines atm	Kc atm	qcln	qclf	CRR7.5
0.00			1.00	9.25E6	0.84	3.68							
0.00	92.48	0.78	1.00	9.25E6	0.84	3.68	1.00	NoLiq	1.00	92.48	92.48	2.08	
5.00			1.00	1.19E2	1.87	2.04							
5.00			0.50	6.67E1	1.87	2.22							
5.00	36.99	0.69	0.50	6.67E1	1.87	2.22	1.80	19.73	0.39	66.73	110.01	0.20	
10.00			1.00	3.35E2	1.38	1.66							
10.00			0.50	2.55E2	1.38	1.73							
10.00	194.39	2.68	0.50	2.55E2	1.38	1.73	1.73	1.31	6.62	0.04	255.48	267.00	1.85
15.00			1.00	3.46E1	3.25	2.59							
15.00			0.50	3.08E1	3.25	2.63							
15.00			0.70	3.28E1	3.25	2.61							
15.00	26.50	0.83	0.70	3.28E1	3.25	2.61	2.61	1.24	35.94	0.80	32.75	163.77	0.49
20.00			1.00	1.12E1	3.87	3.02							
20.00	11.26	0.39	1.00	1.12E1	3.87	3.02	3.02	1.00	NoLiq	1.00	11.26	11.26	2.08
25.00			1.00	1.17E1	4.08	3.02							
25.00	13.93	0.51	1.00	1.17E1	4.08	3.02	3.02	1.00	NoLiq	1.00	13.93	13.93	2.08
30.00			1.00	2.29E2	0.66	1.52							
30.00			0.50	2.54E2	0.66	1.49							
30.00	280.70	1.83	0.50	2.54E2	0.66	1.49	1.49	0.91	2.65	0.00	254.36	254.36	1.61
35.00			1.00	2.50E1	3.56	2.73							
35.00	36.65	1.23	1.00	2.50E1	3.56	2.73	2.73	1.00	NoLiq	1.00	36.65	36.65	2.08
40.00			1.00	5.84E1	2.94	2.40							
40.00			0.50	7.44E1	2.94	2.33							
40.00	92.27	2.65	0.50	7.44E1	2.94	2.33	2.33	0.81	23.47	0.49	74.42	146.87	0.37
45.00			1.00	1.81E2	0.75	1.63							
45.00			0.50	2.38E2	0.75	1.55							
45.00	310.55	2.31	0.50	2.38E2	0.75	1.55	1.55	0.77	3.52	0.00	238.40	238.40	1.34

Fines have been calculated, and correction is made by Modify Robertson Method.
Fines=NoLiq means the soils are not liquefiable.

CRR is based on water table at 8.80 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.08	1.00	2.08	1.00	2.00	0.44	5.00 ^
5.00	0.20	0.20	1.00	0.20	1.00	0.20	0.60	0.34 *
10.00	0.38	1.85	1.00	1.85	1.00	1.85	0.66	2.82
15.00	0.48	0.49	1.00	0.49	1.00	0.49	0.69	0.71 *
20.00	0.58	2.08	1.00	2.08	1.00	2.00	0.70	5.00 ^
25.00	0.69	2.08	1.00	2.08	1.00	2.00	0.71	5.00 ^
30.00	0.79	1.61	1.00	1.61	1.00	1.61	0.71	2.27
35.00	0.90	2.08	1.00	2.08	1.00	2.00	0.69	5.00 ^
40.00	1.00	0.37	1.00	0.37	1.00	0.37	0.66	0.57 *
45.00	1.10	1.34	0.99	1.33	1.00	1.33	0.64	2.09

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qcl	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	3.68	1.70	92.48	54.35	NoLiq	0.00	54.35
5.00	2.22	4.39	110.01	25.03	19.73	0.00	25.03
10.00	1.73	5.31	267.00	50.28	6.62	0.00	50.28
15.00	2.61	3.67	163.77	44.58	35.94	0.00	44.58
20.00	3.02	2.92	11.26	3.86	NoLiq	0.00	3.86

25.00	3.02	2.92	13.93	4.77	NoLiq	0.00	4.77
30.00	1.49	5.75	254.36	44.21	2.65	0.00	44.21
35.00	2.73	3.46	36.65	10.58	NoLiq	0.00	10.58
40.00	2.33	4.20	146.87	34.94	23.47	0.00	34.94
45.00	1.55	5.64	238.40	42.25	3.52	0.00	42.25

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
(N1)60 is converted from qc1, (N1)60s is after fines correction
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
49.45	0.61	1.00	0.61	3.32	3.80	56.00	100.00	0.000	0.0E0	0.000	0.000
45.00	0.64	1.00	0.64	2.09	3.52	42.25	100.00	0.000	0.0E0	0.070	0.070
40.00	0.66	1.00	0.66	0.57	23.47	34.94	100.00	0.000	0.0E0	0.026	0.095
35.00	0.69	1.00	0.69	5.00	NoLiq	10.58	51.91	0.000	0.0E0	0.000	0.095
30.00	0.71	1.00	0.71	2.27	2.65	44.21	100.00	0.000	0.0E0	0.272	0.367
25.00	0.71	1.00	0.71	5.00	NoLiq	4.77	36.02	0.000	0.0E0	0.281	0.648
20.00	0.70	1.00	0.70	5.00	NoLiq	3.86	33.03	0.000	0.0E0	0.000	0.648
15.00	0.69	1.00	0.69	0.71	35.94	44.58	100.00	0.000	0.0E0	0.085	0.734
10.00	0.66	1.00	0.66	2.82	6.62	50.28	100.00	0.000	0.0E0	0.299	1.033
5.00	0.60	1.00	0.60	0.34	19.73	25.03	79.78	1.756	1.1E-2	0.633	1.666
0.00	0.44	1.00	0.44	5.00	NoLiq	54.35	100.00	0.000	0.0E0	0.510	2.177

Settlement of Saturated Sands=2.177 in.

qc1 and (N1)60 is after fines correction in liquefaction analysis

(N1)60s is converted from qc1 and after fines correction

dsz is per each segment, dz=0.05 ft

dsp is per each print interval, dp=5.00 ft

S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
0.00 0.000	0.00	1.20	0.00	0.44	5.25	5.6E-7	0.0000	0.0000	0.00	0.0000	0.00E0	0.000	

Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.

(N1)60s is converted from qc1 and after fines correction

dsz is per each segment, dz=0.05 ft

dsp is per each print interval, dp=5.00 ft

S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=2.177 in.

Differential Settlement=1.088 to 1.437 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed

a_max. Peak Ground Acceleration (PGA) in ground surface
mZ Linear acceleration reduction coefficient X depth
a_min. Minimum acceleration under linear reduction, mZ
CRRv CRR after overburden stress correction, $CRRv=CRR7.5 * Ksig$
CRR7.5 Cyclic resistance ratio (M=7.5)
Ksig Overburden stress correction factor for CRR7.5
CRRm After magnitude scaling correction $CRRm=CRRv * MSF$
MSF Magnitude scaling factor from M=7.5 to user input M
CSR Cyclic stress ratio induced by earthquake
CSRfs $CSRfs=CSR*fs1$ (Default fs1=1)
fs1 First CSR curve in graphic defined in #9 of Advanced page
fs2 2nd CSR curve in graphic defined in #9 of Advanced page
F.S. Calculated factor of safety against liquefaction $F.S.=CRRm/CSRsf$
Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr Rod Length Corrections
Cn Overburden Pressure Correction
(N1)60 SPT after corrections, $(N1)60=SPT * Cr * Cn * Cebs$
d(N1)60 Fines correction of SPT
(N1)60f $(N1)60f=(N1)60 + d(N1)60$
Cq Overburden stress correction factor
qc1 CPT after Overburden stress correction
dqcl Fines correction of CPT
qc1f CPT after Fines and Overburden correction, $qc1f=qc1 + dqcl$
qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qc1f CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s $(N1)60$ after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation $CSRm=CSRsf / MSF*$
CSRfs Cyclic stress ratio induced by earthquake with user input fs
MSF* Scaling factor from CSR, $MSF*=1$, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, $ec=Cec * ec7.5$
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

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LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 CPT4 VB.liq
Title: Whole Foods VBB CPT-4
Subtitle:

Surface Elev.=0
Hole No.=CPT-4
Depth of Hole= 70.50 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 8.00 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=CPT-4
Depth of Hole=70.50 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 8.00 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot one CSR curve (fsl=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf pcf	gamma %	Fines mm	D50
0.00	47.57	0.32	0.68	130.00	0.00	0.50
5.50	29.80	0.20	0.69	130.00	0.00	0.50
10.50	74.03	0.28	0.38	130.00	0.00	0.50
15.50	272.10	1.71	0.63	130.00	0.00	0.50
20.50	54.27	1.10	2.03	130.00	0.00	0.50
25.50	67.61	0.78	1.15	130.00	0.00	0.50
30.50	8.94	0.14	1.56	130.00	0.00	0.50
35.50	13.08	0.18	1.40	130.00	0.00	0.50
40.50	79.52	0.60	0.75	130.00	0.00	0.50
45.50	27.23	0.82	3.02	130.00	0.00	0.50
50.50	30.64	0.95	3.11	130.00	0.00	0.50
55.50	14.90	0.32	2.17	130.00	0.00	0.50
60.50	43.44	1.31	3.01	130.00	0.00	0.50
65.50	277.20	2.18	0.79	130.00	0.00	0.50
70.50	336.50	0.66	0.20	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=4.82 in.
Settlement of Unsaturated Sands=0.00 in.
Total Settlement of Saturated and Unsaturated Sands=4.82 in.
Differential Settlement=2.408 to 3.179 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.44	5.00	4.82	0.00	4.82
5.00	2.08	0.60	3.49	4.82	0.00	4.82
10.00	0.22	0.66	0.34*	3.65	0.00	3.65
15.00	2.08	0.69	3.03	3.00	0.00	3.00
20.00	0.59	0.70	0.84*	2.97	0.00	2.97
25.00	0.18	0.71	0.25*	2.28	0.00	2.28
30.00	2.00	0.71	5.00	1.29	0.00	1.29
35.00	2.00	0.69	5.00	0.99	0.00	0.99
40.00	0.11	0.66	0.17*	0.90	0.00	0.90
45.00	2.00	0.64	5.00	0.27	0.00	0.27
50.00	2.00	0.61	5.00	0.27	0.00	0.27
55.00	2.00	0.58	5.00	0.27	0.00	0.27
60.00	2.00	0.55	5.00	0.27	0.00	0.27
65.00	0.73	0.52	1.40	0.00	0.00	0.00
70.00	1.15	0.49	2.37	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft2)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 CPT4 VB.liq
 Title: Whole Foods VBB CPT-4
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=CPT-4
 Depth of Hole=70.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 8.00 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. CPT Calculation Method: Modify Robertson*
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Stark/Olson et al.*
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot one CSR curve (fsl=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	qc atm	fs atm	Rf %	Gamma pcf	Fines %	D50 mm
0.00	47.57	0.32	0.68	130.00	0.00	0.50
5.50	29.80	0.20	0.69	130.00	0.00	0.50
10.50	74.03	0.28	0.38	130.00	0.00	0.50
15.50	272.10	1.71	0.63	130.00	0.00	0.50
20.50	54.27	1.10	2.03	130.00	0.00	0.50
25.50	67.61	0.78	1.15	130.00	0.00	0.50
30.50	8.94	0.14	1.56	130.00	0.00	0.50
35.50	13.08	0.18	1.40	130.00	0.00	0.50
40.50	79.52	0.60	0.75	130.00	0.00	0.50
45.50	27.23	0.82	3.02	130.00	0.00	0.50
50.50	30.64	0.95	3.11	130.00	0.00	0.50
55.50	14.90	0.32	2.17	130.00	0.00	0.50
60.50	43.44	1.31	3.01	130.00	0.00	0.50
65.50	277.20	2.18	0.79	130.00	0.00	0.50
70.50	336.50	0.66	0.20	130.00	0.00	0.50

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fsl	=CSRfs
0.00	67.60	0.236	67.60	0.236	1.00	0.000	0.450	0.29	1.50	0.44
5.00	130.00	0.543	67.60	0.396	0.99	0.000	0.450	0.40	1.50	0.60
10.00	130.00	0.851	67.60	0.556	0.98	0.000	0.450	0.44	1.50	0.66

15.00	130.00	1.158	67.60	0.715	0.97	0.000	0.450	0.46	1.50	0.69
20.00	130.00	1.465	67.60	0.875	0.95	0.000	0.450	0.47	1.50	0.70
25.00	130.00	1.772	67.60	1.035	0.94	0.000	0.450	0.47	1.50	0.71
30.00	130.00	2.079	67.60	1.195	0.93	0.000	0.450	0.47	1.50	0.71
35.00	130.00	2.386	67.60	1.354	0.89	0.000	0.450	0.46	1.50	0.69
40.00	130.00	2.694	67.60	1.514	0.85	0.000	0.450	0.44	1.50	0.66
45.00	130.00	3.001	67.60	1.674	0.81	0.000	0.450	0.42	1.50	0.64
50.00	130.00	3.308	67.60	1.833	0.77	0.000	0.450	0.40	1.50	0.61
55.00	130.00	3.615	67.60	1.993	0.73	0.000	0.450	0.39	1.50	0.58
60.00	130.00	3.922	67.60	2.153	0.69	0.000	0.450	0.37	1.50	0.55
65.00	130.00	4.229	67.60	2.313	0.65	0.000	0.450	0.35	1.50	0.52
70.00	130.00	4.536	67.60	2.472	0.60	0.000	0.450	0.32	1.50	0.49

CSR is based on water table at 0.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from CPT data, using Modify Robertson's Method:
(Fines content is determined by qc and fric.)

Depth ft	qc atm	fric. atm	n	Q	Rf	Ic %	Cq	Fines atm	Kc atm	qc1n	qc1f	CRR7.5
0.00		1.00	9.51E6	0.68	3.66							
0.00	95.14	0.65	9.51E6	0.68	3.66	1.00	NoLiq	1.00	95.14	95.14	2.08	
5.00		1.00	8.47E4	0.00	2.17							
5.00		0.50	4.70E4	0.00	2.01							
5.00	26025.67	0.38	0.50	4.70E4	0.00	2.01	1.80	13.22	0.22	500.00	640.59	2.08
10.00		1.00	1.51E2	0.46	1.56							
10.00		0.50	1.13E2	0.46	1.67							
10.00	84.37	0.38	0.50	1.13E2	0.46	1.67	1.34	5.50	0.01	113.22	114.75	0.22
15.00		1.00	4.19E2	0.63	1.33							
15.00		0.50	3.55E2	0.63	1.37							
15.00	300.61	1.89	0.50	3.55E2	0.63	1.37	1.18	1.20	0.00	355.50	355.50	2.08
20.00		1.00	1.74E2	1.08	1.76							
20.00		0.50	1.64E2	1.08	1.77							
20.00	153.41	1.65	0.50	1.64E2	1.08	1.77	1.07	7.59	0.07	164.02	176.19	0.59
25.00		1.00	7.10E1	1.25	2.09							
25.00		0.50	7.37E1	1.25	2.08							
25.00	74.97	0.92	0.50	7.37E1	1.25	2.08	0.98	15.07	0.27	73.71	100.81	0.18
30.00		1.00	1.65E1	1.47	2.65							
30.00	21.50	0.29	1.00	1.65E1	1.47	2.65	1.00	NoLiq	1.00	21.50	21.50	2.08
35.00		1.00	9.12E0	1.82	2.91							
35.00	14.50	0.22	1.00	9.12E0	1.82	2.91	1.00	NoLiq	1.00	14.50	14.50	2.08
40.00		1.00	3.49E1	1.03	2.29							
40.00		0.50	4.49E1	1.03	2.20							
40.00	55.21	0.54	0.50	4.49E1	1.03	2.20	0.81	18.87	0.37	44.87	71.27	0.11
45.00		1.00	1.27E1	3.10	2.92							
45.00	24.04	0.66	1.00	1.27E1	3.10	2.92	1.00	NoLiq	1.00	24.04	24.04	2.08
50.00		1.00	2.00E1	3.12	2.76							
50.00	39.79	1.15	1.00	2.00E1	3.12	2.76	1.00	NoLiq	1.00	39.79	39.79	2.08
55.00		1.00	6.43E0	2.65	3.13							
55.00	16.20	0.34	1.00	6.43E0	2.65	3.13	1.00	NoLiq	1.00	16.20	16.20	2.08
60.00		1.00	1.91E1	3.23	2.79							
60.00	44.79	1.33	1.00	1.91E1	3.23	2.79	1.00	NoLiq	1.00	44.79	44.79	2.08
65.00		1.00	1.26E2	0.86	1.79							
65.00		0.50	1.94E2	0.86	1.65							
65.00	295.65	2.52	0.50	1.94E2	0.86	1.65	0.66	5.26	0.01	194.43	195.79	0.78
70.00		1.00	1.46E2	0.56	1.62							
70.00		0.50	2.33E2	0.56	1.47							
70.00	366.31	2.01	0.50	2.33E2	0.56	1.47	0.64	2.36	0.00	232.98	232.98	1.26

Fines have been calculated, and correction is made by Modify Robertson Method.
Fines=NoLiq means the soils are not liquefiable.

CRR is based on water table at 8.00 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.08	1.00	2.08	1.00	2.00	0.44	5.00 ^
5.00	0.20	2.08	1.00	2.08	1.00	2.08	0.60	3.49
10.00	0.36	0.22	1.00	0.22	1.00	0.22	0.66	0.34 *
15.00	0.46	2.08	1.00	2.08	1.00	2.08	0.69	3.03
20.00	0.57	0.59	1.00	0.59	1.00	0.59	0.70	0.84 *

25.00	0.67	0.18	1.00	0.18	1.00	0.18	0.71	0.25	*
30.00	0.78	2.08	1.00	2.08	1.00	2.00	0.71	5.00	^
35.00	0.88	2.08	1.00	2.08	1.00	2.00	0.69	5.00	^
40.00	0.98	0.11	1.00	0.11	1.00	0.11	0.66	0.17	*
45.00	1.09	2.08	0.99	2.06	1.00	2.00	0.64	5.00	^
50.00	1.19	2.08	0.98	2.03	1.00	2.00	0.61	5.00	^
55.00	1.30	2.08	0.96	2.00	1.00	2.00	0.58	5.00	^
60.00	1.40	2.08	0.95	1.97	1.00	2.00	0.55	5.00	^
65.00	1.50	0.78	0.93	0.73	1.00	0.73	0.52	1.40	
70.00	1.61	1.26	0.92	1.15	1.00	1.15	0.49	2.37	

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	3.66	1.73	95.14	54.97	NoLiq	0.00	54.97
5.00	2.01	4.79	640.59	100.00	13.22	0.00	100.00
10.00	1.67	5.42	114.75	21.17	5.50	0.00	21.17
15.00	1.37	5.96	355.50	59.62	1.20	0.00	59.62
20.00	1.77	5.22	176.19	33.75	7.59	0.00	33.75
25.00	2.08	4.67	100.81	21.61	15.07	0.00	21.61
30.00	2.65	3.61	21.50	5.96	NoLiq	0.00	5.96
35.00	2.91	3.12	14.50	4.65	NoLiq	0.00	4.65
40.00	2.20	4.44	71.27	16.05	18.87	0.00	16.05
45.00	2.92	3.10	24.04	7.74	NoLiq	0.00	7.74
50.00	2.76	3.39	39.79	11.73	NoLiq	0.00	11.73
55.00	3.13	2.72	16.20	5.95	NoLiq	0.00	5.95
60.00	2.79	3.34	44.79	13.39	NoLiq	0.00	13.39
65.00	1.65	5.45	195.79	35.95	5.26	0.00	35.95
70.00	1.47	5.79	232.98	40.22	2.36	0.00	40.22

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
(N1)60 is converted from qc1, (N1)60s is after fines correction
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
70.45	0.48	1.00	0.48	2.40	0.00	37.73	100.00	0.000	0.0E0	0.000	0.000
70.00	0.49	1.00	0.49	2.37	2.36	40.22	100.00	0.000	0.0E0	0.000	0.000
65.00	0.52	1.00	0.52	1.40	5.26	35.95	100.00	0.000	0.0E0	0.001	0.001
60.00	0.55	1.00	0.55	5.00	NoLiq	13.39	58.05	0.000	0.0E0	0.267	0.268
55.00	0.58	1.00	0.58	5.00	NoLiq	5.95	39.70	0.000	0.0E0	0.000	0.268
50.00	0.61	1.00	0.61	5.00	NoLiq	11.73	54.51	0.000	0.0E0	0.000	0.268
45.00	0.64	1.00	0.64	5.00	NoLiq	7.74	44.80	0.000	0.0E0	0.000	0.268
40.00	0.66	1.00	0.66	0.17	18.87	16.05	63.29	2.604	1.6E-2	0.631	0.899
35.00	0.69	1.00	0.69	5.00	NoLiq	4.65	35.65	0.000	0.0E0	0.090	0.989
30.00	0.71	1.00	0.71	5.00	NoLiq	5.96	39.71	0.000	0.0E0	0.301	1.289
25.00	0.71	1.00	0.71	0.25	15.07	21.61	73.44	2.041	1.2E-2	0.993	2.283
20.00	0.70	1.00	0.70	0.84	7.59	33.75	99.21	0.056	3.4E-4	0.687	2.969
15.00	0.69	1.00	0.69	3.03	1.20	59.62	100.00	0.000	0.0E0	0.028	2.998
10.00	0.66	1.00	0.66	0.34	5.50	21.17	72.64	2.077	1.2E-2	0.650	3.648
5.00	0.60	1.00	0.60	3.49	13.22	100.00	100.00	0.000	0.0E0	1.168	4.815
0.00	0.44	1.00	0.44	5.00	NoLiq	54.97	100.00	0.000	0.0E0	0.001	4.816

Settlement of Saturated Sands=4.816 in.
qc1 and (N1)60 is after fines correction in liquefaction analysis
(N1)60s is converted from qc1 and after fines correction
dsz is per each segment, dz=0.05 ft
dsp is per each print interval, dp=5.00 ft
S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
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in.

0.00	0.00	1.62	0.00	0.44	5.25	5.6E-7	0.0000	0.0000	0.00	0.0000	0.00E0	0.000
0.000												

Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.
 (N1)60s is converted from qc1 and after fines correction
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=4.816 in.
 Differential Settlement=2.408 to 3.179 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere)	= 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
1 atm (atmosphere)	= 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
SPT	Field data from Standard Penetration Test (SPT)
BPT	Field data from Becker Penetration Test (BPT)
qc	Field data from Cone Penetration Test (CPT) [atm (tsf)]
fs	Friction from CPT testing [atm (tsf)]
Rf	Ratio of fs/qc (%)
gamma	Total unit weight of soil
gamma'	Effective unit weight of soil
Fines	Fines content [%]
D50	Mean grain size
Dr	Relative Density
sigma	Total vertical stress [atm]
sigma'	Effective vertical stress [atm]
sigC'	Effective confining pressure [atm]
rd	Acceleration reduction coefficient by Seed
a_max.	Peak Ground Acceleration (PGA) in ground surface
mZ	Linear acceleration reduction coefficient X depth
a_min.	Minimum acceleration under linear reduction, mZ
CRRv	CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
CRR7.5	Cyclic resistance ratio (M=7.5)
Ksig	Overburden stress correction factor for CRR7.5
CRRm	After magnitude scaling correction CRRm=CRRv * MSF
MSF	Magnitude scaling factor from M=7.5 to user input M
CSR	Cyclic stress ratio induced by earthquake
CSRfs	CSRfs=CSR*fs1 (Default fs1=1)
fs1	First CSR curve in graphic defined in #9 of Advanced page
fs2	2nd CSR curve in graphic defined in #9 of Advanced page
F.S.	Calculated factor of safety against liquefaction F.S.=CRRm/CSRfs
Cebs	Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr	Rod Length Corrections
Cn	Overburden Pressure Correction
(N1)60	SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
d(N1)60	Fines correction of SPT
(N1)60f	(N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
Cq	Overburden stress correction factor
qc1	CPT after Overburden stress correction
dqc1	Fines correction of CPT
qc1f	CPT after Fines and Overburden correction, qc1f=qc1 + dqc1
qc1n	CPT after normalization in Robertson's method
Kc	Fine correction factor in Robertson's Method
qc1f	CPT after Fines correction in Robertson's Method
Ic	Soil type index in Suzuki's and Robertson's Methods
(N1)60s	(N1)60 after settlement fines corrections
CSRm	After magnitude scaling correction for Settlement calculation CSRm=CSRfs / MSF*
CSRfs	Cyclic stress ratio induced by earthquake with user inputed fs
MSF*	Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
ec	Volumetric strain for saturated sands
dz	Calculation segment, dz=0.050 ft
dsz	Settlement in each segment, dz
dp	User defined print interval
dsp	Settlement in each print interval, dp
Gmax	Shear Modulus at low strain
g_eff	gamma_eff, Effective shear Strain

g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq No-Liquefy Soils

References:

-
1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
 2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
 3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

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LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 SPT1 VB.liq
Title: Whole Foods VBB SPT1
Subtitle:

Surface Elev.=0
Hole No.=SPT1
Depth of Hole= 41.00 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 7.70 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=SPT1
Depth of Hole=41.00 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 7.70 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot two CSR (fs1=1, fs2=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	32.40	130.00	15.00
8.50	32.40	130.00	15.00
11.00	20.40	130.00	15.00
13.50	20.40	130.00	15.00
16.00	20.40	130.00	20.00
18.50	7.20	130.00	57.00
21.00	15.60	130.00	38.00
23.00	15.60	130.00	38.00
25.50	10.80	130.00	67.00
28.50	32.40	130.00	15.00
31.00	32.40	130.00	15.00
36.00	38.40	130.00	15.00
41.00	46.80	130.00	15.00

Output Results:

Settlement of Saturated Sands=0.85 in.
Settlement of Unsaturated Sands=0.00 in.
Total Settlement of Saturated and Unsaturated Sands=0.85 in.
Differential Settlement=0.426 to 0.563 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.29	5.00	0.85	0.00	0.85
5.00	2.00	0.40	5.00	0.85	0.00	0.85
10.00	2.00	0.44	4.57	0.85	0.00	0.85
15.00	2.00	0.46	4.38	0.85	0.00	0.85
20.00	0.37	0.47	0.79*	0.38	0.00	0.38
25.00	0.29	0.47	0.61*	0.20	0.00	0.20
30.00	2.00	0.47	4.22	0.00	0.00	0.00
35.00	2.00	0.46	4.36	0.00	0.00	0.00
40.00	2.00	0.44	4.53	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 SPT1 VB.liq
 Title: Whole Foods VBB SPT1
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=SPT1
 Depth of Hole=41.00 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 7.70 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	Gamma pcf	Fines %
0.00	32.40	130.00	15.00
8.50	32.40	130.00	15.00
11.00	20.40	130.00	15.00
13.50	20.40	130.00	15.00
16.00	20.40	130.00	20.00
18.50	7.20	130.00	57.00
21.00	15.60	130.00	38.00
23.00	15.60	130.00	38.00
25.50	10.80	130.00	67.00
28.50	32.40	130.00	15.00
31.00	32.40	130.00	15.00
36.00	38.40	130.00	15.00
41.00	46.80	130.00	15.00

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fs1	=CSRfs
0.00	67.60	0.236	67.60	0.236	1.00	0.000	0.450	0.29	1.00	0.29
5.00	130.00	0.543	67.60	0.396	0.99	0.000	0.450	0.40	1.00	0.40
10.00	130.00	0.851	67.60	0.556	0.98	0.000	0.450	0.44	1.00	0.44

15.00	130.00	1.158	67.60	0.715	0.97	0.000	0.450	0.46	1.00	0.46
20.00	130.00	1.465	67.60	0.875	0.95	0.000	0.450	0.47	1.00	0.47
25.00	130.00	1.772	67.60	1.035	0.94	0.000	0.450	0.47	1.00	0.47
30.00	130.00	2.079	67.60	1.195	0.93	0.000	0.450	0.47	1.00	0.47
35.00	130.00	2.386	67.60	1.354	0.89	0.000	0.450	0.46	1.00	0.46
40.00	130.00	2.694	67.60	1.514	0.85	0.000	0.450	0.44	1.00	0.44

CSR is based on water table at 0.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from SPT or BPT data:

Depth ft	SPT	Cebs	Cr atm	sigma'	Cn	(N1)60 %	Fines	d(N1)60	(N1)60f	CRR7.5
0.00	64.80	1.25	0.75	0.000	1.70	103.28	15.00	7.47	110.74	2.00
5.00	57.32	1.25	0.75	0.307	1.70	91.36	15.00	6.89	98.25	2.00
10.00	36.09	1.25	0.85	0.546	1.35	51.88	15.00	4.99	56.87	2.00
15.00	27.22	1.25	0.95	0.706	1.19	38.47	18.00	5.79	44.26	2.00
20.00	15.58	1.25	0.95	0.866	1.07	19.88	45.60	8.98	28.86	0.37
25.00	14.47	1.25	0.95	1.026	0.99	16.97	61.20	8.39	25.36	0.29
30.00	38.86	1.25	1.00	1.185	0.92	44.61	15.00	4.64	49.26	2.00
35.00	43.73	1.25	1.00	1.345	0.86	47.14	15.00	4.77	51.90	2.00
40.00	52.20	1.25	1.00	1.505	0.82	53.19	15.00	5.06	58.25	2.00

CRR is based on water table at 7.70 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.00	1.00	2.00	1.00	2.00	0.29	5.00
5.00	0.20	2.00	1.00	2.00	1.00	2.00	0.40	5.00
10.00	0.36	2.00	1.00	2.00	1.00	2.00	0.44	4.57
15.00	0.46	2.00	1.00	2.00	1.00	2.00	0.46	4.38
20.00	0.56	0.37	1.00	0.37	1.00	0.37	0.47	0.79 *
25.00	0.67	0.29	1.00	0.29	1.00	0.29	0.47	0.61 *
30.00	0.77	2.00	1.00	2.00	1.00	2.00	0.47	4.22
35.00	0.87	2.00	1.00	2.00	1.00	2.00	0.46	4.36
40.00	0.98	2.00	1.00	2.00	1.00	2.00	0.44	4.53

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	-	-	100.00	15.00	0.00	100.00	
5.00	-	-	98.25	15.00	0.00	98.25	
10.00	-	-	56.87	15.00	0.00	56.87	
15.00	-	-	44.26	18.00	0.00	44.26	
20.00	-	-	28.86	45.60	0.00	28.86	
25.00	-	-	25.36	61.20	0.00	25.36	
30.00	-	-	49.26	15.00	0.00	49.26	
35.00	-	-	51.90	15.00	0.00	51.90	
40.00	-	-	58.25	15.00	0.00	58.25	

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
40.95	0.44	1.00	0.44	4.56	15.00	59.50	100.00	0.000	0.0E0	0.000	0.000
40.00	0.44	1.00	0.44	4.53	15.00	58.25	100.00	0.000	0.0E0	0.000	0.000
35.00	0.46	1.00	0.46	4.36	15.00	51.90	100.00	0.000	0.0E0	0.000	0.000
30.00	0.47	1.00	0.47	4.22	15.00	49.26	100.00	0.000	0.0E0	0.000	0.000

25.00	0.47	1.00	0.47	0.61	61.20	25.36	80.41	1.617	9.7E-3	0.198	0.198
20.00	0.47	1.00	0.47	0.79	45.60	28.86	87.53	0.883	5.3E-3	0.183	0.381
15.00	0.46	1.00	0.46	4.38	18.00	44.26	100.00	0.000	0.0E0	0.472	0.853
10.00	0.44	1.00	0.44	4.57	15.00	56.87	100.00	0.000	0.0E0	0.000	0.853
5.00	0.40	1.00	0.40	5.00	15.00	98.25	100.00	0.000	0.0E0	0.000	0.853
0.00	0.29	1.00	0.29	5.00	15.00	100.00	100.00	0.000	0.0E0	0.000	0.853

Settlement of Saturated Sands=0.853 in.
 qc1 and (N1)60 is after fines correction in liquefaction analysis
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
0.00 0.000	0.00	1.00	0.00	0.29	3.78	7.7E-7	0.0000	0.0000	0.00	0.0000	0.00E0	0.000	

Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=0.853 in.
 Differential Settlement=0.426 to 0.563 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed
- a_max. Peak Ground Acceleration (PGA) in ground surface
- mZ Linear acceleration reduction coefficient X depth
- a_min. Minimum acceleration under linear reduction, mZ
- CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
- CRR7.5 Cyclic resistance ratio (M=7.5)
- Ksig Overburden stress correction factor for CRR7.5
- CRRm After magnitude scaling correction CRRm=CRRv * MSF
- MSF Magnitude scaling factor from M=7.5 to user input M
- CSR Cyclic stress ratio induced by earthquake
- CSRfs CSRfs=CSR*fs1 (Default fs1=1)
- fs1 First CSR curve in graphic defined in #9 of Advanced page
- fs2 2nd CSR curve in graphic defined in #9 of Advanced page
- F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
- Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
- Cr Rod Length Corrections
- Cn Overburden Pressure Correction
- (N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
- d(N1)60 Fines correction of SPT
- (N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
- Cq Overburden stress correction factor
- qc1 CPT after Overburden stress correction
- dqc1 Fines correction of CPT
- qc1f CPT after Fines and Overburden correction, qc1f=qc1 + dqc1

qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qc1f CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation $CSRm=CSRsf / MSF^*$
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, $MSF^*=1$, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, $dz=0.050$ ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, $ec=Cec * ec7.5$
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

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select 'Segment' in Print Interval (Item 12, Page C).

LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 SPT2 VB.liq
Title: Whole Foods VBB SPT2
Subtitle:

Surface Elev.=0
Hole No.=SPT2
Depth of Hole= 46.00 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 7.00 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=SPT2
Depth of Hole=46.00 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 7.00 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot two CSR (fs1=1, fs2=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	27.60	130.00	19.00
7.50	16.80	130.00	19.00
11.00	24.00	130.00	15.00
21.00	38.40	130.00	15.00
23.50	24.00	130.00	15.00
25.00	21.60	130.00	50.00
26.00	25.20	130.00	10.00
29.00	21.60	130.00	50.00
31.00	21.60	130.00	50.00
33.50	25.20	130.00	31.00
36.00	30.00	130.00	15.00
38.50	13.20	130.00	18.00
46.00	50.40	130.00	15.00

Output Results:

Settlement of Saturated Sands=0.49 in.
Settlement of Unsaturated Sands=0.00 in.
Total Settlement of Saturated and Unsaturated Sands=0.49 in.
Differential Settlement=0.247 to 0.326 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.29	5.00	0.49	0.00	0.49
5.00	2.00	0.40	5.00	0.49	0.00	0.49
10.00	2.00	0.44	4.57	0.49	0.00	0.49
15.00	2.00	0.46	4.38	0.49	0.00	0.49
20.00	2.00	0.47	4.28	0.49	0.00	0.49
25.00	2.00	0.47	4.24	0.49	0.00	0.49
30.00	2.00	0.47	4.22	0.49	0.00	0.49
35.00	2.00	0.46	4.36	0.49	0.00	0.49
40.00	0.38	0.44	0.87*	0.01	0.00	0.01
45.00	1.99	0.42	4.70	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

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Input File Name: F:\Liquefy5\1680 SPT2 VB.liq
 Title: Whole Foods VBB SPT2
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=SPT2
 Depth of Hole=46.00 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 7.00 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	Gamma pcf	Fines %
0.00	27.60	130.00	19.00
7.50	16.80	130.00	19.00
11.00	24.00	130.00	15.00
21.00	38.40	130.00	15.00
23.50	24.00	130.00	15.00
25.00	21.60	130.00	50.00
26.00	25.20	130.00	10.00
29.00	21.60	130.00	50.00
31.00	21.60	130.00	50.00
33.50	25.20	130.00	31.00
36.00	30.00	130.00	15.00
38.50	13.20	130.00	18.00
46.00	50.40	130.00	15.00

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fs1	=CSRfs
0.00	67.60	0.236	67.60	0.236	1.00	0.000	0.450	0.29	1.00	0.29
5.00	130.00	0.543	67.60	0.396	0.99	0.000	0.450	0.40	1.00	0.40
10.00	130.00	0.851	67.60	0.556	0.98	0.000	0.450	0.44	1.00	0.44

15.00	130.00	1.158	67.60	0.715	0.97	0.000	0.450	0.46	1.00	0.46
20.00	130.00	1.465	67.60	0.875	0.95	0.000	0.450	0.47	1.00	0.47
25.00	130.00	1.772	67.60	1.035	0.94	0.000	0.450	0.47	1.00	0.47
30.00	130.00	2.079	67.60	1.195	0.93	0.000	0.450	0.47	1.00	0.47
35.00	130.00	2.386	67.60	1.354	0.89	0.000	0.450	0.46	1.00	0.46
40.00	130.00	2.694	67.60	1.514	0.85	0.000	0.450	0.44	1.00	0.44
45.00	130.00	3.001	67.60	1.674	0.81	0.000	0.450	0.42	1.00	0.42

CSR is based on water table at 0.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from SPT or BPT data:

Depth ft	SPT	Cebs	Cr atm	sigma'	Cn	(N1)60 %	Fines	d(N1)60	(N1)60f	CRR7.5
0.00	55.20	1.25	0.75	0.000	1.70	87.98	19.00	9.84	97.82	2.00
5.00	36.09	1.25	0.75	0.307	1.70	57.52	19.00	7.62	65.14	2.00
10.00	31.80	1.25	0.85	0.526	1.38	46.60	16.14	5.36	51.96	2.00
15.00	40.02	1.25	0.95	0.686	1.21	57.39	15.00	5.26	62.65	2.00
20.00	47.29	1.25	0.95	0.845	1.09	61.08	15.00	5.44	66.52	2.00
25.00	26.68	1.25	0.95	1.005	1.00	31.60	50.00	11.32	42.92	2.00
30.00	25.98	1.25	1.00	1.165	0.93	30.09	50.00	11.02	41.11	2.00
35.00	33.09	1.25	1.00	1.324	0.87	35.94	21.40	7.04	42.98	2.00
40.00	23.92	1.25	1.00	1.484	0.82	24.55	17.40	4.64	29.19	0.38
45.00	51.97	1.25	1.00	1.644	0.78	50.67	15.40	5.16	55.83	2.00

CRR is based on water table at 7.00 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.00	1.00	2.00	1.00	2.00	0.29	5.00
5.00	0.20	2.00	1.00	2.00	1.00	2.00	0.40	5.00
10.00	0.34	2.00	1.00	2.00	1.00	2.00	0.44	4.57
15.00	0.45	2.00	1.00	2.00	1.00	2.00	0.46	4.38
20.00	0.55	2.00	1.00	2.00	1.00	2.00	0.47	4.28
25.00	0.65	2.00	1.00	2.00	1.00	2.00	0.47	4.24
30.00	0.76	2.00	1.00	2.00	1.00	2.00	0.47	4.22
35.00	0.86	2.00	1.00	2.00	1.00	2.00	0.46	4.36
40.00	0.96	0.38	1.00	0.38	1.00	0.38	0.44	0.87 *
45.00	1.07	2.00	1.00	1.99	1.00	1.99	0.42	4.70

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)

^ No-liquefiable Soils or above Water Table.

(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qcl	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	-	-	97.82	19.00	0.00	97.82	
5.00	-	-	65.14	19.00	0.00	65.14	
10.00	-	-	51.96	16.14	0.00	51.96	
15.00	-	-	62.65	15.00	0.00	62.65	
20.00	-	-	66.52	15.00	0.00	66.52	
25.00	-	-	42.92	50.00	0.00	42.92	
30.00	-	-	41.11	50.00	0.00	41.11	
35.00	-	-	42.98	21.40	0.00	42.98	
40.00	-	-	29.19	17.40	0.00	29.19	
45.00	-	-	55.83	15.40	0.00	55.83	

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.

Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines %	(N1)60s Dr %	ec in.	dsz in.	dsp in.	S
-------------	-------	--------	-------	-----------	------------	-----------------	-----------	------------	------------	---

45.95	0.42	1.00	0.42	4.72	15.02	60.45	100.00	0.000	0.0E0	0.000	0.000
45.00	0.42	1.00	0.42	4.70	15.40	55.83	100.00	0.000	0.0E0	0.000	0.000
40.00	0.44	1.00	0.44	0.87	17.40	29.19	88.25	0.732	4.4E-3	0.014	0.014
35.00	0.46	1.00	0.46	4.36	21.40	42.98	100.00	0.000	0.0E0	0.481	0.494
30.00	0.47	1.00	0.47	4.22	50.00	41.11	100.00	0.000	0.0E0	0.000	0.494
25.00	0.47	1.00	0.47	4.24	50.00	42.92	100.00	0.000	0.0E0	0.000	0.494
20.00	0.47	1.00	0.47	4.28	15.00	66.52	100.00	0.000	0.0E0	0.000	0.494
15.00	0.46	1.00	0.46	4.38	15.00	62.65	100.00	0.000	0.0E0	0.000	0.494
10.00	0.44	1.00	0.44	4.57	16.14	51.96	100.00	0.000	0.0E0	0.000	0.494
5.00	0.40	1.00	0.40	5.00	19.00	65.14	100.00	0.000	0.0E0	0.000	0.494
0.00	0.29	1.00	0.29	5.00	19.00	97.82	100.00	0.000	0.0E0	0.000	0.494

Settlement of Saturated Sands=0.494 in.
 qc1 and (N1)60 is after fines correction in liquefaction analysis
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
--------------------	---------------	--------------	---------	-------	-------------	---------	-------	------------	-----	---------	------------	------------	---

0.00	0.00	1.09	0.00	0.29	5.25	5.6E-7	0.0000	0.0000	0.00	0.0000	0.00E0	0.000	
------	------	------	------	------	------	--------	--------	--------	------	--------	--------	-------	--

Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=0.494 in.
 Differential Settlement=0.247 to 0.326 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed
- a_max. Peak Ground Acceleration (PGA) in ground surface
- mZ Linear acceleration reduction coefficient X depth
- a_min. Minimum acceleration under linear reduction, mZ
- CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
- CRR7.5 Cyclic resistance ratio (M=7.5)
- Ksig Overburden stress correction factor for CRR7.5
- CRRm After magnitude scaling correction CRRm=CRRv * MSF
- MSF Magnitude scaling factor from M=7.5 to user input M
- CSR Cyclic stress ratio induced by earthquake
- CSRfs CSRfs=CSR*fsl (Default fsl=1)
- fsl First CSR curve in graphic defined in #9 of Advanced page
- fs2 2nd CSR curve in graphic defined in #9 of Advanced page
- F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
- Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
- Cr Rod Length Corrections
- Cn Overburden Pressure Correction
- (N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
- d(N1)60 Fines correction of SPT

(N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
Cq Overburden stress correction factor
qc1 CPT after Overburden stress correction
dqcl Fines correction of CPT
qclf CPT after Fines and Overburden correction, qclf=qc1 + dqcl
qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qclf CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation CSRm=CSRsf / MSF*
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).

LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 SPT3 VB.liq
 Title: Whole Foods VBB SPT3
 Subtitle:

Surface Elev.=0
 Hole No.=SPT3
 Depth of Hole= 41.00 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 8.00 ft
 Max. Acceleration= 0.45 g
 Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
 Hole No.=SPT3
 Depth of Hole=41.00 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 8.00 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	21.60	120.00	15.00
7.50	46.80	130.00	15.00
10.50	16.80	130.00	15.00
14.50	19.20	130.00	20.00
19.50	9.60	130.00	34.00
24.50	10.80	130.00	50.00
26.00	8.40	130.00	50.00
29.50	27.60	130.00	17.00
31.00	16.80	130.00	17.00
36.00	39.60	130.00	8.00
41.00	38.40	130.00	15.00

Output Results:

Settlement of Saturated Sands=2.02 in.
 Settlement of Unsaturated Sands=0.00 in.
 Total Settlement of Saturated and Unsaturated Sands=2.02 in.
 Differential Settlement=1.008 to 1.331 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
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0.00	2.00	0.29	5.00	2.02	0.00	2.02
5.00	2.00	0.40	4.98	2.02	0.00	2.02
10.00	2.00	0.44	4.52	2.02	0.00	2.02
15.00	2.00	0.46	4.33	2.02	0.00	2.02
20.00	0.27	0.47	0.57*	1.67	0.00	1.67
25.00	0.25	0.48	0.52*	0.58	0.00	0.58
30.00	2.00	0.48	4.20	0.09	0.00	0.09
35.00	2.00	0.46	4.34	0.00	0.00	0.00
40.00	2.00	0.44	4.50	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

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Input File Name: F:\Liquefy5\1680 SPT3 VB.liq
 Title: Whole Foods VBB SPT3
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=SPT3
 Depth of Hole=41.00 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 8.00 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	Gamma pcf	Fines %
0.00	21.60	120.00	15.00
7.50	46.80	130.00	15.00
10.50	16.80	130.00	15.00
14.50	19.20	130.00	20.00
19.50	9.60	130.00	34.00
24.50	10.80	130.00	50.00
26.00	8.40	130.00	50.00
29.50	27.60	130.00	17.00
31.00	16.80	130.00	17.00
36.00	39.60	130.00	8.00
41.00	38.40	130.00	15.00

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fs1	=CSRfs
0.00	57.60	0.236	57.60	0.236	1.00	0.000	0.450	0.29	1.00	0.29
5.00	126.67	0.528	64.27	0.380	0.99	0.000	0.450	0.40	1.00	0.40
10.00	130.00	0.833	67.60	0.538	0.98	0.000	0.450	0.44	1.00	0.44
15.00	130.00	1.140	67.60	0.698	0.97	0.000	0.450	0.46	1.00	0.46
20.00	130.00	1.447	67.60	0.857	0.95	0.000	0.450	0.47	1.00	0.47

25.00	130.00	1.754	67.60	1.017	0.94	0.000	0.450	0.48	1.00	0.48
30.00	130.00	2.061	67.60	1.177	0.93	0.000	0.450	0.48	1.00	0.48
35.00	130.00	2.369	67.60	1.336	0.89	0.000	0.450	0.46	1.00	0.46
40.00	130.00	2.676	67.60	1.496	0.85	0.000	0.450	0.44	1.00	0.44

CSR is based on water table at 0.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from SPT or BPT data:

Depth ft	SPT	Cebs	Cr atm	sigma'	Cn	(N1)60 %	Fines	d(N1)60	(N1)60f	CRR7.5
0.00	43.20	1.25	0.75	0.000	1.70	68.85	15.00	5.81	74.66	2.00
5.00	69.54	1.25	0.75	0.291	1.70	110.83	15.00	7.83	118.66	2.00
10.00	31.38	1.25	0.85	0.538	1.36	45.48	15.00	4.69	50.17	2.00
15.00	24.42	1.25	0.95	0.697	1.20	34.73	21.40	6.93	41.66	2.00
20.00	12.40	1.25	0.95	0.857	1.08	15.91	35.60	8.18	24.09	0.27
25.00	12.32	1.25	0.95	1.017	0.99	14.51	50.00	7.90	22.42	0.25
30.00	28.82	1.25	1.00	1.176	0.92	33.22	17.00	5.01	38.22	2.00
35.00	41.24	1.25	1.00	1.336	0.87	44.59	9.80	1.73	46.32	2.00
40.00	44.74	1.25	1.00	1.496	0.82	45.73	13.60	3.92	49.65	2.00

CRR is based on water table at 8.00 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.00	1.00	2.00	1.00	2.00	0.29	5.00
5.00	0.19	2.00	1.00	2.00	1.00	2.00	0.40	4.98
10.00	0.35	2.00	1.00	2.00	1.00	2.00	0.44	4.52
15.00	0.45	2.00	1.00	2.00	1.00	2.00	0.46	4.33
20.00	0.56	0.27	1.00	0.27	1.00	0.27	0.47	0.57 *
25.00	0.66	0.25	1.00	0.25	1.00	0.25	0.48	0.52 *
30.00	0.76	2.00	1.00	2.00	1.00	2.00	0.48	4.20
35.00	0.87	2.00	1.00	2.00	1.00	2.00	0.46	4.34
40.00	0.97	2.00	1.00	2.00	1.00	2.00	0.44	4.50

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qc1	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	-	-	74.66	15.00	0.00	74.66	
5.00	-	-	100.00	15.00	0.00	100.00	
10.00	-	-	50.17	15.00	0.00	50.17	
15.00	-	-	41.66	21.40	0.00	41.66	
20.00	-	-	24.09	35.60	0.00	24.09	
25.00	-	-	22.42	50.00	0.00	22.42	
30.00	-	-	38.22	17.00	0.00	38.22	
35.00	-	-	46.32	9.80	0.00	46.32	
40.00	-	-	49.65	13.60	0.00	49.65	

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.
Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s	Dr %	ec in.	dsz in.	dsp in.	S
40.95	0.44	1.00	0.44	4.54	14.93	49.50	100.00	0.000	0.0E0	0.000	0.000
40.00	0.44	1.00	0.44	4.50	13.60	49.65	100.00	0.000	0.0E0	0.000	0.000
35.00	0.46	1.00	0.46	4.34	9.80	46.32	100.00	0.000	0.0E0	0.000	0.000
30.00	0.48	1.00	0.48	4.20	17.00	38.22	100.00	0.000	0.0E0	0.090	0.090
25.00	0.48	1.00	0.48	0.52	50.00	22.42	74.91	1.969	1.2E-2	0.492	0.582
20.00	0.47	1.00	0.47	0.57	35.60	24.09	77.99	1.792	1.1E-2	1.084	1.666

15.00	0.46	1.00	0.46	4.33	21.40	41.66	100.00	0.000	0.0E0	0.351	2.017
10.00	0.44	1.00	0.44	4.52	15.00	50.17	100.00	0.000	0.0E0	0.000	2.017
5.00	0.40	1.00	0.40	4.98	15.00	100.00	100.00	0.000	0.0E0	0.000	2.017
0.00	0.29	1.00	0.29	5.00	15.00	74.66	100.00	0.000	0.0E0	0.000	2.017

Settlement of Saturated Sands=2.017 in.
 qc1 and (N1)60 is after fines correction in liquefaction analysis
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
0.00 0.000	0.00	0.99	0.00	0.29	5.25	5.6E-7	0.0000	0.0000	0.00	0.0000	0.00E0	0.000	

Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.
 dsz is per each segment, dz=0.05 ft
 dsp is per each print interval, dp=5.00 ft
 S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=2.017 in.
 Differential Settlement=1.008 to 1.331 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

- 1 atm (atmosphere) = 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
- 1 atm (atmosphere) = 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
- SPT Field data from Standard Penetration Test (SPT)
- BPT Field data from Becker Penetration Test (BPT)
- qc Field data from Cone Penetration Test (CPT) [atm (tsf)]
- fs Friction from CPT testing [atm (tsf)]
- Rf Ratio of fs/qc (%)
- gamma Total unit weight of soil
- gamma' Effective unit weight of soil
- Fines Fines content [%]
- D50 Mean grain size
- Dr Relative Density
- sigma Total vertical stress [atm]
- sigma' Effective vertical stress [atm]
- sigC' Effective confining pressure [atm]
- rd Acceleration reduction coefficient by Seed
- a_max. Peak Ground Acceleration (PGA) in ground surface
- mZ Linear acceleration reduction coefficient X depth
- a_min. Minimum acceleration under linear reduction, mZ
- CRRv CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
- CRR7.5 Cyclic resistance ratio (M=7.5)
- Ksig Overburden stress correction factor for CRR7.5
- CRRm After magnitude scaling correction CRRm=CRRv * MSF
- MSF Magnitude scaling factor from M=7.5 to user input M
- CSR Cyclic stress ratio induced by earthquake
- CSRfs CSRfs=CSR*fsl (Default fsl=1)
- fsl First CSR curve in graphic defined in #9 of Advanced page
- fs2 2nd CSR curve in graphic defined in #9 of Advanced page
- F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
- Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
- Cr Rod Length Corrections
- Cn Overburden Pressure Correction
- (N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
- d(N1)60 Fines correction of SPT
- (N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
- Cq Overburden stress correction factor
- qc1 CPT after Overburden stress correction
- dqc1 Fines correction of CPT
- qc1f CPT after Fines and Overburden correction, qc1f=qc1 + dqc1
- qc1n CPT after normalization in Robertson's method
- Kc Fine correction factor in Robertson's Method

qclf CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation $CSRm=CSRsf / MSF^*$
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, $MSF^*=1$, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, $ec=Cec * ec7.5$
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).

LIQUEFACTION ANALYSIS SUMMARY
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Input File Name: F:\Liquefy5\1680 SPT4 VB.liq
Title: Whole Foods VBB SPT-4
Subtitle:

Surface Elev.=0
Hole No.=B4
Depth of Hole= 50.50 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 8.70 ft
Max. Acceleration= 0.45 g
Earthquake Magnitude= 7.50

Input Data:

Surface Elev.=0
Hole No.=B4
Depth of Hole=50.50 ft
Water Table during Earthquake= 0.00 ft
Water Table during In-Situ Testing= 8.70 ft
Max. Acceleration=0.45 g
Earthquake Magnitude=7.50
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1.05
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
Plot two CSR (fs1=1, fs2=User)
 10. Use Curve Smoothing: Yes*
- * Recommended Options

Fill on Top= 4 ft Fill Unit Weight= 125 pcf
Depth of this report is based on original ground surface, not based on fill
1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	gamma pcf	Fines %
0.00	9.60	110.00	16.00
7.50	15.60	130.00	16.00
10.50	26.40	130.00	15.00
12.50	31.20	130.00	15.00
16.00	46.80	130.00	15.00
17.50	27.60	130.00	15.00
22.50	12.00	130.00	27.00
26.00	21.60	130.00	34.00
27.50	16.80	130.00	36.00
31.00	8.40	130.00	63.00
32.50	16.80	130.00	50.00
36.00	9.60	130.00	50.00
37.50	21.60	130.00	50.00
41.00	21.60	130.00	50.00
42.50	18.00	130.00	60.00
46.00	12.00	130.00	50.00
50.50	25.20	130.00	37.00

Output Results:

Settlement of Saturated Sands=2.41 in.

Settlement of Unsaturated Sands=0.00 in.
 Total Settlement of Saturated and Unsaturated Sands=2.41 in.
 Differential Settlement=1.204 to 1.590 in.

Depth ft	CRRm	CSRfs	F.S. in.	S_sat. in.	S_dry in.	S_all
0.00	2.00	0.29	5.00	2.41	0.00	2.41
5.00	2.00	0.41	4.92	2.41	0.00	2.41
10.00	2.00	0.45	4.47	2.41	0.00	2.41
15.00	2.00	0.47	4.29	2.41	0.00	2.41
20.00	2.00	0.47	4.21	2.41	0.00	2.41
25.00	2.00	0.48	4.18	2.23	0.00	2.23
30.00	0.26	0.48	0.55*	2.02	0.00	2.02
35.00	0.26	0.46	0.57*	1.28	0.00	1.28
40.00	2.00	0.45	4.48	0.89	0.00	0.89
45.00	0.27	0.43	0.63*	0.59	0.00	0.59
50.00	1.96	0.41	4.79	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
 (F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere) = 1 tsf (ton/ft²)
 CRRm Cyclic resistance ratio from soils
 CSRsf Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
 F.S. Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
 S_sat Settlement from saturated sands
 S_dry Settlement from Unsaturated Sands
 S_all Total Settlement from Saturated and Unsaturated Sands
 NoLiq No-Liquefy Soils

 LIQUEFACTION ANALYSIS CALCULATION DETAILS
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Input File Name: F:\Liquefy5\1680 SPT4 VB.liq
 Title: Whole Foods VBB SPT-4
 Subtitle:

Input Data:

Surface Elev.=0
 Hole No.=B4
 Depth of Hole=50.50 ft
 Water Table during Earthquake= 0.00 ft
 Water Table during In-Situ Testing= 8.70 ft
 Max. Acceleration=0.45 g
 Earthquake Magnitude=7.50
 No-Liquefiable Soils: CL, OL are Non-Liq. Soil
 1. SPT or BPT Calculation.
 2. Settlement Analysis Method: Ishihara / Yoshimine
 3. Fines Correction for Liquefaction: Idriss/Seed
 4. Fine Correction for Settlement: During Liquefaction*
 5. Settlement Calculation in: All zones*
 6. Hammer Energy Ratio, Ce = 1.25
 7. Borehole Diameter, Cb= 1.05
 8. Sampling Method, Cs= 1
 9. User request factor of safety (apply to CSR) , User= 1.5
 Plot two CSR (fs1=1, fs2=User)
 10. Average two input data between two Depths: Yes*
 * Recommended Options

Fill on Ground Surface= 4 ft Fill Unit Weight= 125 pcf
 Factor of soil strength (SPT or CPT) change due to fill= 1
 Depth of this report is based on original ground surface, not based on fill
 1 atm (atmosphere) = 1 tsf (ton/ft2)

In-Situ Test Data:

Depth ft	SPT	Gamma pcf	Fines %
0.00	9.60	110.00	16.00
7.50	15.60	130.00	16.00
10.50	26.40	130.00	15.00
12.50	31.20	130.00	15.00
16.00	46.80	130.00	15.00
17.50	27.60	130.00	15.00
22.50	12.00	130.00	27.00
26.00	21.60	130.00	34.00
27.50	16.80	130.00	36.00
31.00	8.40	130.00	63.00
32.50	16.80	130.00	50.00
36.00	9.60	130.00	50.00
37.50	21.60	130.00	50.00
41.00	21.60	130.00	50.00
42.50	18.00	130.00	60.00
46.00	12.00	130.00	50.00
50.50	25.20	130.00	37.00

Output Results:

Calculation segment, dz=0.050 ft
 User defined Print Interval, dp=5.00 ft

Peak Ground Acceleration (PGA), a_max = 0.45g

CSR Calculation:

Depth ft	gamma pcf	sigma atm	gamma' pcf	sigma' atm	rd	mZ g	a(z) g	CSR	x fs1	=CSRfs
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0.00	47.60	0.236	47.60	0.236	1.00	0.000	0.450	0.29	1.00	0.29
5.00	123.33	0.512	60.93	0.364	0.99	0.000	0.450	0.41	1.00	0.41
10.00	130.00	0.815	67.60	0.520	0.98	0.000	0.450	0.45	1.00	0.45
15.00	130.00	1.122	67.60	0.680	0.97	0.000	0.450	0.47	1.00	0.47
20.00	130.00	1.429	67.60	0.839	0.95	0.000	0.450	0.47	1.00	0.47
25.00	130.00	1.736	67.60	0.999	0.94	0.000	0.450	0.48	1.00	0.48
30.00	130.00	2.044	67.60	1.159	0.93	0.000	0.450	0.48	1.00	0.48
35.00	130.00	2.351	67.60	1.319	0.89	0.000	0.450	0.46	1.00	0.46
40.00	130.00	2.658	67.60	1.478	0.85	0.000	0.450	0.45	1.00	0.45
45.00	130.00	2.965	67.60	1.638	0.81	0.000	0.450	0.43	1.00	0.43
50.00	130.00	3.272	67.60	1.798	0.77	0.000	0.450	0.41	1.00	0.41

CSR is based on water table at 0.00 during earthquake
sigma and sigma' are based on fill on ground surface during earthquake

CRR Calculation from SPT or BPT data:

Depth ft	SPT	Cebs	Cr atm	sigma'	Cn	(N1)60 %	Fines	d(N1)60	(N1)60f	CRR7.5
0.00	19.20	1.31	0.75	0.000	1.70	32.13	16.00	4.50	36.63	2.00
5.00	25.26	1.31	0.75	0.276	1.70	42.28	16.00	5.05	47.33	2.00
10.00	35.36	1.31	0.85	0.540	1.36	53.66	15.17	5.18	58.84	2.00
15.00	56.63	1.31	0.95	0.700	1.20	84.40	15.00	6.56	90.96	2.00
20.00	25.24	1.31	0.95	0.860	1.08	33.94	21.00	6.70	40.65	2.00
25.00	23.23	1.31	0.95	1.019	0.99	28.68	32.00	9.73	38.42	2.00
30.00	12.96	1.31	1.00	1.179	0.92	15.67	55.28	8.13	23.80	0.26
35.00	13.71	1.31	1.00	1.339	0.86	15.56	50.00	8.11	23.67	0.26
40.00	25.01	1.31	1.00	1.499	0.82	26.81	50.00	10.36	37.17	2.00
45.00	15.67	1.31	1.00	1.658	0.78	15.97	52.86	8.19	24.16	0.27
50.00	26.82	1.31	1.00	1.818	0.74	26.10	38.45	10.22	36.32	2.00

CRR is based on water table at 8.70 during In-Situ Testing
SPT or CPT are increased due to increased overburden pressure

Factor of Safety, - Earthquake Magnitude= 7.50:

Depth ft	sigC' atm	CRR7.5	x Ksig	=CRRv	x MSF	=CRRm	CSRfs	F.S.=CRRm/CSRfs
0.00	0.00	2.00	1.00	2.00	1.00	2.00	0.29	5.00
5.00	0.18	2.00	1.00	2.00	1.00	2.00	0.41	4.92
10.00	0.35	2.00	1.00	2.00	1.00	2.00	0.45	4.47
15.00	0.46	2.00	1.00	2.00	1.00	2.00	0.47	4.29
20.00	0.56	2.00	1.00	2.00	1.00	2.00	0.47	4.21
25.00	0.66	2.00	1.00	2.00	1.00	2.00	0.48	4.18
30.00	0.77	0.26	1.00	0.26	1.00	0.26	0.48	0.55 *
35.00	0.87	0.26	1.00	0.26	1.00	0.26	0.46	0.57 *
40.00	0.97	2.00	1.00	2.00	1.00	2.00	0.45	4.48
45.00	1.08	0.27	0.99	0.27	1.00	0.27	0.43	0.63 *
50.00	1.18	2.00	0.98	1.96	1.00	1.96	0.41	4.79

* F.S.<1: Liquefaction Potential Zone. (If above water table: F.S.=5)
^ No-liquefiable Soils or above Water Table.
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

CPT convert to SPT for Settlement Analysis:

Fines Correction for Settlement Analysis:

Depth ft	Ic	qc/N60 atm	qcl	(N1)60 %	Fines	d(N1)60	(N1)60s
0.00	-	-	36.63	16.00	0.00	36.63	
5.00	-	-	47.33	16.00	0.00	47.33	
10.00	-	-	58.84	15.17	0.00	58.84	
15.00	-	-	90.96	15.00	0.00	90.96	
20.00	-	-	40.65	21.00	0.00	40.65	
25.00	-	-	38.42	32.00	0.00	38.42	
30.00	-	-	23.80	55.28	0.00	23.80	
35.00	-	-	23.67	50.00	0.00	23.67	
40.00	-	-	37.17	50.00	0.00	37.17	
45.00	-	-	24.16	52.86	0.00	24.16	
50.00	-	-	36.32	38.45	0.00	36.32	

(N1)60s has been fines corrected in liquefaction analysis, therefore d(N1)60=0.

Fines=NoLiq means the soils are not liquefiable.

Settlement of Saturated Sands:

Settlement Analysis Method: Ishihara / Yoshimine

Depth ft	CSRsf	/ MSF*	=CSRm	F.S. %	Fines	(N1)60s %	Dr %	ec in.	dsz in.	dsp in.	S
50.45	0.41	1.00	0.41	4.80	37.15	37.91	100.00	0.000	0.0E0	0.000	0.000
50.00	0.41	1.00	0.41	4.79	38.45	36.32	100.00	0.000	0.0E0	0.000	0.000
45.00	0.43	1.00	0.43	0.63	52.86	24.16	78.13	1.712	1.0E-2	0.593	0.593
40.00	0.45	1.00	0.45	4.48	50.00	37.17	100.00	0.000	0.0E0	0.293	0.886
35.00	0.46	1.00	0.46	0.57	50.00	23.67	77.21	1.834	1.1E-2	0.395	1.281
30.00	0.48	1.00	0.48	0.55	55.28	23.80	77.46	1.830	1.1E-2	0.739	2.019
25.00	0.48	1.00	0.48	4.18	32.00	38.42	100.00	0.000	0.0E0	0.208	2.227
20.00	0.47	1.00	0.47	4.21	21.00	40.65	100.00	0.000	0.0E0	0.182	2.409
15.00	0.47	1.00	0.47	4.29	15.00	90.96	100.00	0.000	0.0E0	0.000	2.409
10.00	0.45	1.00	0.45	4.47	15.17	58.84	100.00	0.000	0.0E0	0.000	2.409
5.00	0.41	1.00	0.41	4.92	16.00	47.33	100.00	0.000	0.0E0	0.000	2.409
0.00	0.29	1.00	0.29	5.00	16.00	36.63	100.00	0.000	0.0E0	0.000	2.409

Settlement of Saturated Sands=2.409 in.

qc1 and (N1)60 is after fines correction in liquefaction analysis

dsz is per each segment, dz=0.05 ft

dsp is per each print interval, dp=5.00 ft

S is cumulated settlement at this depth

Settlement of Unsaturated Sands:

Depth ft in.	sigma' atm	sigC' atm	(N1)60s	CSRsf	Gmax atm	g*Ge/Gm	g_eff	ec7.5 %	Cec	ec %	dsz in.	dsp in.	S
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0.00 0.000	0.00	1.19	0.00	0.29	5.25	5.6E-7	0.0000	0.0000	0.00	0.0000	0.00E0	0.000	
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Settlement of Unsaturated Sands

Settlement of Unsaturated Sands=0.000 in.

dsz is per each segment, dz=0.05 ft

dsp is per each print interval, dp=5.00 ft

S is cumulated settlement at this depth

Total Settlement of Saturated and Unsaturated Sands=2.409 in.

Differential Settlement=1.204 to 1.590 in.

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

1 atm (atmosphere)	= 1.0581 tsf(1 tsf = 1 ton/ft2 = 2 kip/ft2)
1 atm (atmosphere)	= 101.325 kPa(1 kPa = 1 kN/m2 = 0.001 Mpa)
SPT	Field data from Standard Penetration Test (SPT)
BPT	Field data from Becker Penetration Test (BPT)
qc	Field data from Cone Penetration Test (CPT) [atm (tsf)]
fs	Friction from CPT testing [atm (tsf)]
Rf	Ratio of fs/qc (%)
gamma	Total unit weight of soil
gamma'	Effective unit weight of soil
Fines	Fines content [%]
D50	Mean grain size
Dr	Relative Density
sigma	Total vertical stress [atm]
sigma'	Effective vertical stress [atm]
sigC'	Effective confining pressure [atm]
rd	Acceleration reduction coefficient by Seed
a_max.	Peak Ground Acceleration (PGA) in ground surface
mZ	Linear acceleration reduction coefficient X depth
a_min.	Minimum acceleration under linear reduction, mZ
CRRv	CRR after overburden stress correction, CRRv=CRR7.5 * Ksig
CRR7.5	Cyclic resistance ratio (M=7.5)
Ksig	Overburden stress correction factor for CRR7.5
CRRm	After magnitude scaling correction CRRm=CRRv * MSF
MSF	Magnitude scaling factor from M=7.5 to user input M
CSR	Cyclic stress ratio induced by earthquake

CSRfs CSRfs=CSR*fs1 (Default fs1=1)
fs1 First CSR curve in graphic defined in #9 of Advanced page
fs2 2nd CSR curve in graphic defined in #9 of Advanced page
F.S. Calculated factor of safety against liquefaction F.S.=CRRm/CSRsf
Cebs Energy Ratio, Borehole Dia., and Sampling Method Corrections
Cr Rod Length Corrections
Cn Overburden Pressure Correction
(N1)60 SPT after corrections, (N1)60=SPT * Cr * Cn * Cebs
d(N1)60 Fines correction of SPT
(N1)60f (N1)60 after fines corrections, (N1)60f=(N1)60 + d(N1)60
Cq Overburden stress correction factor
qc1 CPT after Overburden stress correction
dqcl Fines correction of CPT
qc1f CPT after Fines and Overburden correction, qc1f=qc1 + dqcl
qc1n CPT after normalization in Robertson's method
Kc Fine correction factor in Robertson's Method
qc1f CPT after Fines correction in Robertson's Method
Ic Soil type index in Suzuki's and Robertson's Methods
(N1)60s (N1)60 after settlement fines corrections
CSRm After magnitude scaling correction for Settlement calculation CSRm=CSRsf / MSF*
CSRfs Cyclic stress ratio induced by earthquake with user inputed fs
MSF* Scaling factor from CSR, MSF*=1, based on Item 2 of Page C.
ec Volumetric strain for saturated sands
dz Calculation segment, dz=0.050 ft
dsz Settlement in each segment, dz
dp User defined print interval
dsp Settlement in each print interval, dp
Gmax Shear Modulus at low strain
g_eff gamma_eff, Effective shear Strain
g*Ge/Gm gamma_eff * G_eff/G_max, Strain-modulus ratio
ec7.5 Volumetric Strain for magnitude=7.5
Cec Magnitude correction factor for any magnitude
ec Volumetric strain for unsaturated sands, ec=Cec * ec7.5
NoLiq No-Liquefy Soils

References:

1. NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.
SP117. Southern California Earthquake Center. Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California. University of Southern California. March 1999.
2. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING AND SEISMIC SITE RESPONSE EVALUATION, Paper No. SPL-2, PROCEEDINGS: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, CA, March 2001.
3. RECENT ADVANCES IN SOIL LIQUEFACTION ENGINEERING: A UNIFIED AND CONSISTENT FRAMEWORK, Earthquake Engineering Research Center, Report No. EERC 2003-06 by R.B Seed and etc. April 2003.

Note: Print Interval you selected does not show complete results. To get complete results, you should select 'Segment' in Print Interval (Item 12, Page C).



City of Malibu

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PLANNING REVIEW

GEOTECHNICAL REVIEW SHEET

<u>Project Information</u>			
Date:	October 19, 2010	Review Log #:	3142
Site Address:	23401 Civic Center Way	Planning #:	CDP 10-022
Lot/Tract/PM #:	n/a	BPC/GPC #:	
Applicant/Contact:	Marny Randall, marnyrandall@verizon.net	Planner:	Bonnie Blue
Contact Phone #:	310-395-2615	Fax #:	310-395-2368
Project Type:	Revised Project-Whole Foods Shopping Center		

<u>Submittal Information</u>	
Consultant(s) / Report Date(s): <i>(Current submittal(s) in Bold.)</i>	GeoConcepts, Inc. (Walter, CEG ; Sousa, CEG): 9-27-10 (revised 10-5-10) , 3-30-10 (revised 4-22-10) Precise Grading Plan prepared by P.C.C.E. Inc., dated September 20, 2010, three sheets. Whole Foods in the Park plans prepared by Goldman Firth Rossi Architects, dated September 20, 2010. Landscape and Irrigation plans prepared by ValleyCrest dated September 20, 2010. Ref: Van Beveren & Butelo, Inc.: 1-13-09, 8-7-07 Ref: GeoConcepts, Inc. : 3-27-03, 8-5-99, 6-21-99 Ref: Petra: 9-7-05 (PPC 99-003)
Previous Reviews:	5-27-10, Geotechnical Review Referral Sheet dated 5-11-10; Ref: 5-19-09, 9-22-08, Geology Review Referral Sheet dated 10-11-07; Ref: Hydrogeologic Review Sheet dated 3-2-06 (PPC 99-003), 4-29-03, 9-2-99, 7-22-99 (PPC 99-004)

<u>Review Findings</u>	
<u>Coastal Development Permit Review</u>	
<input type="checkbox"/>	APPROVED from a geotechnical perspective.
<input checked="" type="checkbox"/>	NOT APPROVED from a geotechnical perspective. The listed 'Review Comments' shall be addressed prior to approval.
<u>Building Plan-Check Stage Review</u>	
<input checked="" type="checkbox"/>	Awaiting Building plan check submittal. Please respond to the listed 'Building Plan-Check Stage Review Comments' AND review and incorporate the attached 'Geotechnical Notes for Building Plan Check' into the plans.
<input type="checkbox"/>	APPROVED from a geotechnical perspective. Please review the attached 'Geotechnical Notes for Building Plan Check' and incorporate into Building Plan-Check submittals.
<input type="checkbox"/>	NOT APPROVED from a geotechnical perspective. The listed 'Building Plan-Check Stage Review Comments' shall be addressed prior to Building Plan-Check Stage approval.

Remarks

The geotechnical response report and revised plans were reviewed by the City from a geotechnical perspective. The project comprises a new 38,425 square foot commercial development consisting of a 24,549 square foot Whole Foods Market building and four retail and food buildings totaling 13,876 square feet, parking lots, landscaping, decking, walls, and trellises.

Grading includes 7,612 yards of R & R; 4,429 yards of fill under structure (raising the elevations of the proposed development); 70 yards of cut and 5,321 yards of fill remedial; and 9,680 yards of import materials.

Based on a meeting with the applicant on February 8, 2010, the proposed development will be connected to the City's wastewater treatment plant. No onsite disposal of effluent is proposed with this development.

Review Comments:

1. Please show all the pertinent seismic trenches on the Geologic Map. Is there adequate coverage for the currently proposed development? Besides the findings in the seismic trenches, what additional evidence supports the Project Geotechnical Consultant's conclusion that, "...no known active fault is anticipated to daylight beneath the limits of the proposed structure."? Discussions regarding continuity and age of lithologic units under the site shall be provided, based on the boring data and pertinent reports on adjacent properties.
2. The response to comment # 3 is not complete, as David Gardner, CHG, is currently working with Kevin Poffenbarger of EPD Consultants regarding the water balance calculation between rainfall, irrigation, and evapotranspiration on the property to demonstrate that groundwater levels under the site or adjacent properties will not be adversely affected.

Building/Grading Plan-Check Stage Review Comments:

1. Please provide an electronic copy of the referenced report by Van Beveren & Butelo, Inc. dated 1-13-09 for the City's files.
2. A letter should be provided by the Project Structural Engineer indicating that: 1) they are aware of the anticipated displacements due to liquefaction related hazards, as determined by the Project Geotechnical Engineer; 2) that they acknowledge the geotechnical recommendations made by the Project Geotechnical Engineer for mitigation of potential seismic and liquefaction hazards; and 3) given the potential displacements, the proposed foundation design is adequate to provide support within the seismic tolerances required by the CBC (e.g., safeguard against major structural failures and loss of life).
3. The following note must appear on the grading and foundation plans: "*Shear testing shall be performed on the compacted fill materials to confirm the recommended bearing pressures and lateral resistances.*"
4. Please depict limits and depths of over-excavation and structural fill to be placed on the grading plan, and cross sectional view of the proposed building area. Cut and fill yardages are to be indicated on the cover sheet of the plans.
5. Two sets of grading, retaining wall, and commercial development plans (**APPROVED BY BUILDING AND SAFETY**) incorporating the Project Geotechnical Consultant's recommendations and items in this review sheet must be **reviewed and wet stamped and manually signed by the Project Engineering Geologist and Project Geotechnical Engineer**. City geotechnical staff will review the plans for conformance with the Project Geotechnical Consultants' recommendations and items in this review sheet over the counter at City Hall on Mondays through Thursdays between 8 AM and 10 AM.

City of Malibu

Geotechnical Review Sheet

Please direct questions regarding this review sheet to City Geotechnical staff listed below.

Engineering Geology Review by:

Christopher Dean

Christopher Dean, C.E.G. #1751, Exp. 9-30-12
Engineering Geology Reviewer (x306)

10/19/10
Date

Geotechnical Engineering Review by:

Leland M. Kraft, Jr.

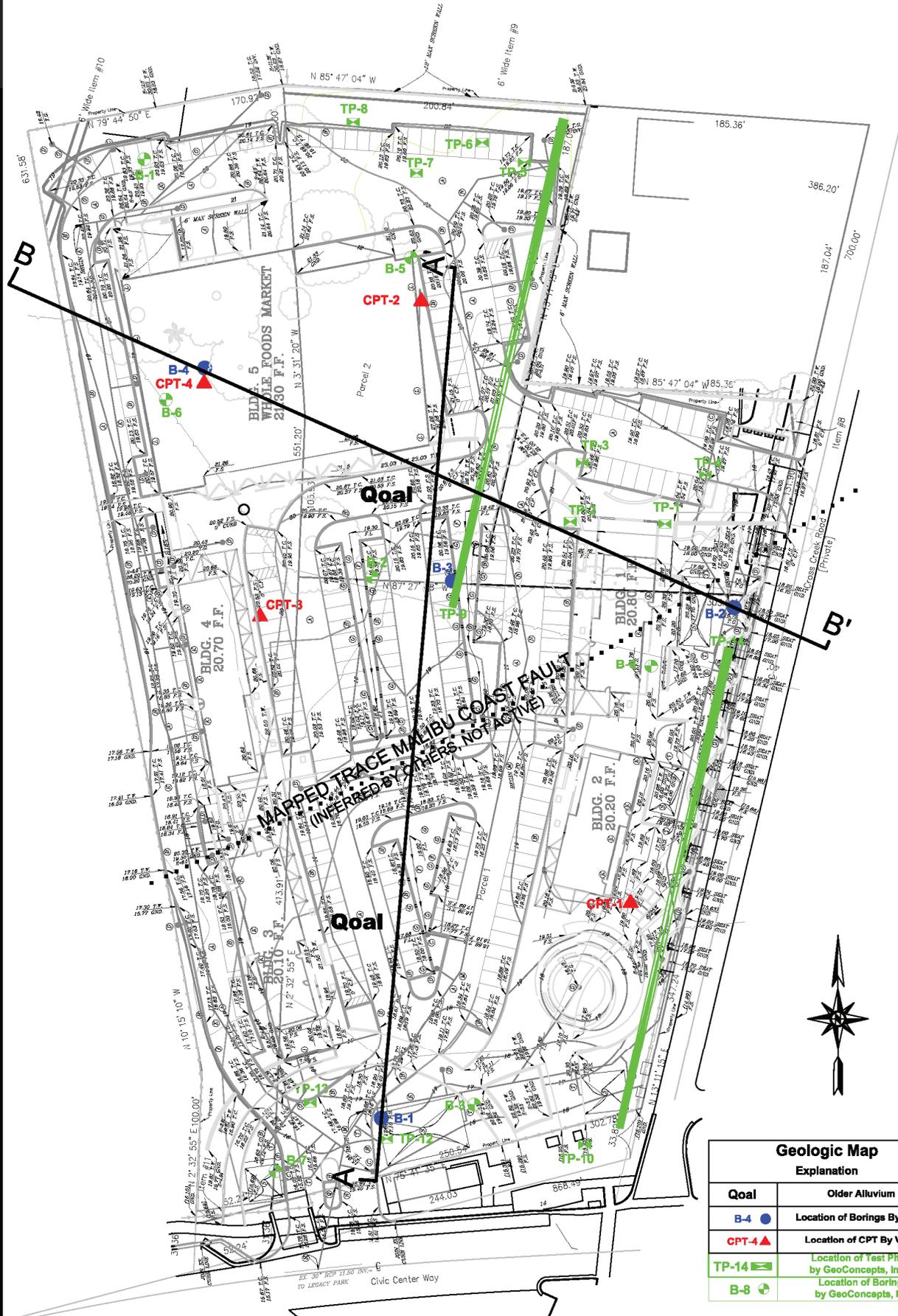
Leland M. Kraft, Jr., G.E. # 484, Exp. 6-30-12
Geotechnical Engineering Reviewer (805-444-1943)

10-19-10
Date

*This review sheet was prepared by City Geotechnical Staff
contracted with Fugro as an agent of the City of Malibu.*

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(805) 650-7000 (Ventura office)
(310) 456-2489, x306 (City of Malibu)





Geologic Map	
Explanation	
Goal	Older Alluvium
B-4 ●	Location of Borings by VB&B
CPT-4 ▲	Location of CPT By VB&B
TP-14	Location of Test Pits by GeoConcepts, Inc.
B-8 ●	Location of Borings by GeoConcepts, Inc.

Date: November, 2010
 Scale: 1" = 60'
 Job No. 1680-9

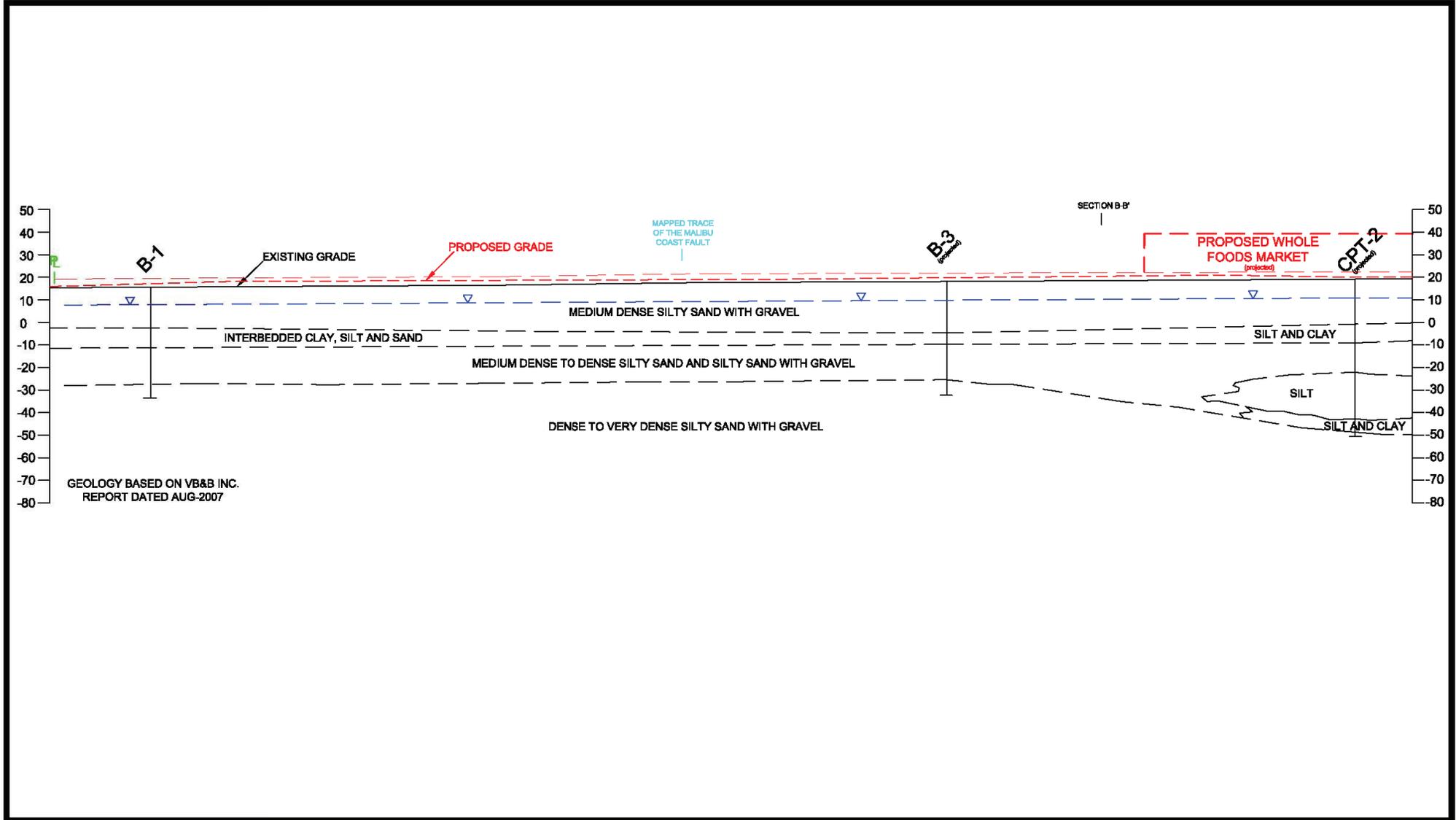
Project Address:
 23401 Civic Center Way
 Malibu, CA

Description:
 Geologic Map
 Issued For:
 Whole Foods

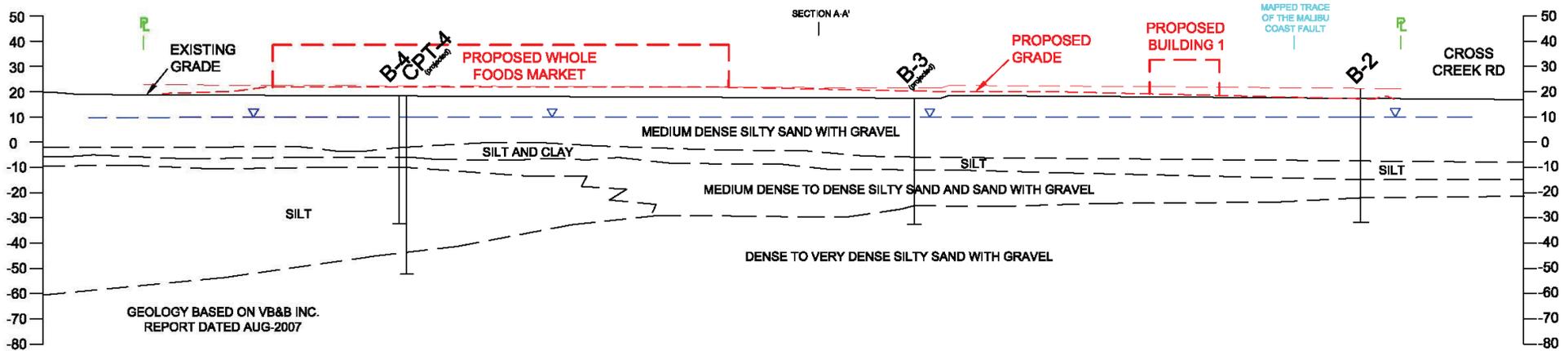
GeoConcepts, Inc.
 Geology & Geotechnical Engineering
 14428 Hamlin Street, Suite 200
 Van Nuys, CA 91401
 www.GeoConceptsinc.com



Issued By:



Issued By:  GeoConcepts, Inc. <i>Geology & Geotechnical Engineering</i> 14428 Hamlin Street, Suite 200 Office (818) 994-8895 Van Nuys, CA 91401 Fax (818) 994-8599 www.GeoConceptsinc.com	Description: SECTION A-A'	Project Address: 23401 Civic Center Way Malibu, CA	Date: Nov. 2010
	Issued For: Whole Foods		Scale: 1" = 40'



Issued By:



GeoConcepts, Inc.
Geology & Geotechnical Engineering

14428 Hamlin Street, Suite 200 Office (818) 994-8895
 Van Nuys, CA 91401 Fax (818) 994-8599
 www.GeoConceptsinc.com

Description:

SECTION B-B'

Issued For:

Whole Foods

Project Address:

**23401 Civic Center Way
 Malibu, CA**

Date:

Nov. 2010

Scale:

1" = 40'

Job No.

1680-9